THE

COMPLETE GOVERNESS:

A COURSE OF MENTAL INSTRUCTION
FOR LADIES;

WITH A NOTICE OF THE PRINCIPAL FEMALE
ACCOMPLISHMENTS.

INTENDED TO FACILITATE THE BUSINESS OF PUBLIC
ESTABLISHMENTS, AND ABRIDGE THE LABOUR
OF PRIVATE EDUCATION.

BY AN EXPERIENCED TEACHER.

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NOTICE.

The author of the following volume has neither the vanity to believe, nor the wish to desire, that it shall either supersede the necessity of teaching, or the use of those school books in which facts are detailed. The chief object has been to describe, in as plain language as possible, the leading principles of those subjects, the ordinary books upon which are, from their great size and learned appearance, repulsive rather than inviting.

In the course of more than twenty years, actively devoted to the giving of instruction on most of the subjects treated of in the several chapters, an opportunity of discovering what was essentially wanted must have occurred; and if the result of the labour of those years shall render the labours of other teachers less severe or more successful, the desire of the author will be accomplished.

Those strictures upon the practices of the ordinary schools for females, and more especially upon the books which are put into the hands of young ladies, which it has been deemed proper to make in the introduction, are meant in good part; and it is hoped, that if they be so taken, they may not be wholly useless.

In the composition of the body of the work, simplicity has been carefully studied; and where experiments had to be referred to, simple ones—those within every body's reach have uniformly been preferred;—in short, whether the desired result has been obtained or not, there has been no want of effort.

To offer an apology for the matter of the book, would be affectation; but the title may need some explanation; inasmuch as though a title be but a trifling matter, it should accord with the book, and be free from every appearance of ostentation or quackery. "The Governess," simply, would have been better than the title as it stands; but as that was appropriated, an epithet became necessary, and the word "complete" was introduced, merely from want of a better.

LONDON,
December 1, 1825.

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THE
COMPLETE GOVERNESS.

INTRODUCTION.

It is a fact, as singular and unaccountable as it is to be regretted, that the rapid increase of knowledge, and great attention to the education of all ranks and both sexes, that have, especially of late years, taken place in England, have not been accompanied by a corresponding improvement in the nature and style of school books. How this is to be accounted for, is a much less important inquiry than how it shall be remedied; but still, whoever has had occasion to examine the numerous publications (and they certainly are not deficient in point of number) must often have felt, that instead of being helps to knowledge, a very great number of them would be better described by being called impediments in its way. In by far the greater number of them, the object seems to be merely to save the trouble to the teacher, and to load the memory of the pupil with a mass of rules and formulæ, for which no application is found without the walls of the class-room.

The existing books may be divided into two classes: the pedantic and the silly; the former being handed down, with only slight changes in the form, from the days of the schoolmen; and the latter, chiefly the produce of ignorant persons, who have taken to education as a trade, and sought to increase the profits of that trade by becoming authors and booksellers.

In consequence of this, unless young men are fortunate enough (and that, as matters go, is not very frequently the case) to find in the tutor that which the books profess to furnish, but do not, they go into the world with no other school information than the mere arts of reading, writing, and casting accounts, with perhaps the capacity of reading or translating a language or two; and thus have not only to acquire in the world, after they are grown up, the technical knowledge of those particular arts and professions for which they are destined, but that general information which is essential for stamping upon them the characters of intelligent men, and making them useful members of society.

With females the case is still worse. Every one who has had occasion to attend to them must have perceived, that in capacity they are no ways behind the other sex, and that they far exceed that sex both in diligence and in docility. Yet it so happens that the education of females is, in most instances, an education of mere externals and of show,—that the fingers, the ears, the tongue, and the feet are schooled in all those little arts and elegancies that are calculated for momentary and external effect, but that the mind of the young lady, upon whom the most fashionable and expensive education has been bestowed, is left in nearly the same state of ignorance as that of her whose external education is limited to the business of housewifery and the drudgery of domestic life. A learned man is, mentally speaking, altogether a different being from a peasant; but a lady, except in the elegance of her person and manners, and the brilliance of her accomplishments, does not in many instances, at least in as far as depends upon her school education, differ materially from the menial who is deputed to attend upon her. This want of mental culture—of stamina in the matter of female education, not only destroys much of the pleasure that would otherwise be derived from female companionship, and exposes woman to many temptations and hapless results, from which a better informed mind would save her; but it re-acts upon society generally—the whole structure of which is injured in return for the injury done to its most amiable portion.

This will be very easily understood by any one who reflects that the very first steps which are taken by both sexes, are taken under the charge of the mother; that she watches over the first dawnings of intellect, and gives the earliest, and therefore the most important turn to the disposition and the habits. In consequence of this, whatever may be done in after life, there still remains a trace of this maternal education, which forms the substratum upon which all that is subsequently communicated is grounded. This is in itself a powerful influence, and regulates, far more than those who have not attended to the matter are apt to imagine, the intelligence and the conduct of society. The father is usually occupied in pursuits external of the family—in business, in profession, or in politics. These absorb his powers and engross his thinking; and the time that he spends in the society of his family is, in the great majority of cases, a time of relaxation and amusement, during which, especially when the children are young, he is just as likely to spoil them as to do them good; and under such circumstances, unless the mother be both able and disposed to attend to their mental culture, there is some danger that it shall be either improperly done, or altogether wanting. Servants, in general, neither can nor will be of any use in the matter: their own education and habits in life do not fit them for it; and when they are suffered to interfere, experience shows that the interference is selfish, and therefore mischievous. Even when the children, especially the female children, are sent to school, the persons to whose charge they are usually committed, even though they may happen to have every desire to be honest and conscientious, not only want that natural regard and affection, which none but a mother can feel, but have, in general, so many under their care, and are so much occupied with the business and bargaining of their profession, that they are forced to delegate that part of it, which is really the most important, to raw and half-educated girls, to interested tutors, and to other persons, equally incapable and unworthy of so nice and delicate a task. Nor does this apply only to girls: there are the same imperfections in the common academies to which young gentlemen are sent; and though the father may be pleased with the prize-exercises and other documents of success, which young master brings home in his box at the holidays, still the father is too much absorbed in looking after "the main chance," as it is called, for scrutinizing with requisite patience, and to the requisite extent, the mental and moral progress of his son. But the mother could in general find leisure and disposition for this scrutiny; and therefore the very best interests of society demand that she should be qualified for it. It is not meant to be argued that every lady should be a linguist, a mathematician, a mechanical philosopher, a chemist, an historian, or a politician, in the sense in which these terms are usually received—making an exclusive business or study of one or other of them; but it is desirable, and eminently desirable, that every lady should know something of the great and general principles of all these matters, and also of the relations which they bear to each other, and the use that all of them may be of in the intelligent business of life. This is necessary, not merely for qualifying her to act her part well in that most honourable of all female relations, the mother of a well-informed and virtuous offspring; but to give to her influence upon the other sex that power and that direction which are the best calculated for advancing all the good qualities of human nature and repressing the bad.

The influence of females, though silent and unpretending, compared with that of the other sex, is not upon these accounts the less; and if a due portion of mental culture be not bestowed upon them, the re-action will go to destroy the mental culture of the other sex. As long as it shall continue to be the ambition of men generally to win the applause and admiration of women· and it is by no means desirable that this (perhaps the surest and certainly the sweetest bond of virtue) should cease to operate, so long must every qualification of man, the value of which woman cannot appreciate, be retarded, and held as it were in disgrace, from the mere want of that applause which man is the most anxious to obtain. Nor is it only in so far as mere intellectual eminence is concerned, that the want of a reasonable portion of scientific information in females operates, for perhaps the greatest charm in life—social conversation, is thereby rendered both small in its range and tame in its nature, from the number of subjects which are proscribed in female society, in consequence of the foolish vanity of man, in supposing that he alone is capable of comprehending them, and of the mischievous consequences that arise from acting upon this vanity.

In thus contending for a little more sense and science in the matter of female education, it is not intended that those matters, which are called accomplishments, and which in most instances deserve so to be called, should be either lessened in their number or circumscribed in their application. As little is it desired that the least step should be made toward pedantry and an affectation of wisdom. Every charm that education can give to the form or the manners, and every elegant art that a female can practise, is not only compatible with a more substantial species of education, but, wherever they have been found together, has proved to be vastly heightened by it.

True, it has been said, with at least some shadow of just appeal to experience, that the learned ladies have not only given themselves unusual airs of superiority over the rest of their sex, but have affected to look with scorn upon those avocations and pursuits in which the utility and the interest of women are most conspicuous; but the fault of this is not in the excess of mental culture in females, but in the want of it. There was a time, not only when a woman, who had made such an advance in ordinary philosophy, as from the past to give a reasonable guess at the future, was denounced as being in collusion with the devil, and in great jeopardy of suffering martyrdom on that account; but when a man, possessing that small modicum of knowledge necessary for constructing a common almanack, incurred the same blame, and was exposed to the same hazard. These circumstances did not take place because the individuals had too much information; they did so merely because the rest of the world had too little; and the moment that philosophy had made her escape from the cloister, and diffused herself over society, her supposed connection with the infernal powers ceased, and her legitimacy was acknowledged as the proper portion of mankind—the gift, and under the guidance of heaven: and just in the same manner is the finger of suspicion—and why not of envy?—pointed at a lady who happens by accident (for as matters are usually managed, it can only be by accident) to have been permitted to take some range in the exercise of her rational powers. While only one or two in a parish are so informed as to be fit companions or antagonists for men of information, it is very natural that they should not only be looked upon with suspicion by the majority of both sexes, but that they should give themselves airs which a more general diffusion of the same kind of information would effectually prevent. In this respect there has of late years been a wonderful improvement, and a lady of literary or scientific acquirements is now admitted (at least in very well informed society) to make just as affectionate a wife, as attentive a mother, and as prudent a mistress of a family, as she whose knowledge is confined to the music saloon, the ball-room, or the larder. This, however, is the effect not of the system of female education, but the general progress of society; and those ladies who have thus become eminent, would, if appealed to, no doubt be able to trace their mental superiority to some other source than the boarding school.

The fact is, that they do so trace it; and that their so doing is one of the causes of that apprehension with which the unthinking still look upon learned females. It does not arise out of the system of tuition to which ladies are subjected; and therefore, any one who happens to smuggle herself into knowledge as it were, very naturally imputes her pre-eminence to the vast superiority of her own natural powers—to her transcendant vigour and buoyancy of intellect, which belong not to her sex in general, but which nature has given to her as a prime favourite, qualified and destined for nobler courses than the generality of her sex are capable of pursuing. That this is both a gross and a fatal error cannot be denied, because a very little education properly applied, would have raised others to precisely the same elevation; but it is also a natural error, inasmuch as the qualifications that are thus possessed, are not found among those which the customs of society have been pleased to dole out to women. In the isolated instances at present to be found there is peculiarity, and wherever there is peculiarity, there is danger; but make the same qualifications general, and the peculiarity and danger cease together.

The great point at which female education should aim, is the communicating to ladies as much of the general principles of knowledge as shall make it not rude to talk to them upon any ordinary subject of a literary or scientific nature, and also enable them to conduct the education of their whole families when very young, and that of the female part altogether, or to be perfectly able to estimate the manner in which these are done, according to circumstances. This, considering only the political economy of the mother, is the grand result; but the effects are not less valuable and happy as regards the lady herself: for, though it is not desirable that females should have to buffet the evils of the world, yet, as no one can tell what may lie even in the short road of human life, it is neither just nor safe to leave woman in so helpless and unprovided a state, as that she shall not be able to meet and to triumph over those evils in case they should be her lot. The resources of human nature are not so many that one half of the species should be shut out from any of them, and more especially from those which, being mental, are not liable to be destroyed by accidents and contingencies.

It has already been said, that there is herein no disposition whatever to quarrel with or undervalue, those external accomplishments which at present form so large a portion of female education. Let them still play, and sing, and dance, and paint, to their heart's content; but let them at the same time know, that there other acquirements, more valuable because more permanent than these. So far as these go they are delightful; and the world is all the better for them; but still they are only externals, mere arts, which while they please the senses for a moment, occupy not the mind, and inform not the judgment. Wherever females however, have had a fair trial, they have rewarded the cultivation in the most abundant manner; and that alone would be decisive of the matter.

Considering a great part of the present system, one cannot help observing, that ladies are educated, not as if they were one day to be women, but as if they were always to remain girls. It is singular that this should be the case; and perhaps, some would be disposed to account for the singularity by a theory not over flattering to those to whom female education is entrusted—namely, a desire that the pupils shall shine in the little convent of the school—a convent, the conduct, discipline, and employment of which are certainly not exactly like what is met with in the world. Whether this be or be not in reality the case, it begins in many instances to be acted upon; the number of ladies who instruct their daughters, and of elder sisters who instruct the younger ones, being increasing every day. Whatever interested persons may think of this practice, nothing can be more commendable; and not the least argument in its favour is, that the ladies who have adopted it have felt, or at least shown, no abatement either in their rational amusements, or in attention to their domestic concerns.

Those who are advocates of this domestic education, find other arguments in its favour than the delightful occupation that it affords to those that are engaged in it; but as these arguments are susceptible of being construed into charges against those who profess to educate ladies publicly, and who earn their bread by that profession, it would not be seemly to detail them at length, because, whatever may be the imperfections of the whole system, and the positive mischief in some instances, it were pity to repeat accusations which tend to throw suspicion upon the important profession of teachers. As society is constituted, there must always be many neither able nor willing to dispense with those establishments; and imperfect as many of them are, it is but too true that, if they did not exist, many females would stand a chance of going wholly without education. At the same time it must be confessed, that where a number of girls, at the most thoughtless and dangerous age, are collected together, and left at those hours of recreation to the conversation of each other, and of gossipping governesses, there is danger, even under the guidance of the most prudent, informed, and experienced head of the establishment; and when it is borne in mind that these qualities cannot be observed by all that are at the head of such establishments, then the danger is magnified to a considerable extent. Some have even gone so far as to say, that the desire of amusement, continual and varied, but still trifling amusement, is the chief thing acquired at boarding schools, and that if by chance a lady returns from any of them with one industrious habit, it is the habit of reading those romances of which the mistress confirmed by her example, that habit, which she forbade by her precepts. But there is no need for pushing the matter to that extremity; and perhaps, if full and candid inquiry were made, many of those faults which are attributed to the boarding school, would be found to have their origin in another quarter; and that which is attributed to the governess, would be found to belong to the injudicious, vulgar, or imprudently indulgent mother. Thus the child, which has been spoiled beyond recovery before ever it was sent to school, is cited as an instance of improper treatment on the part of the school-mistress. That this is very wrong, does not need to be pointed out, as little does it appear that there is any necessity for it; for really, the boarding school practice is, upon the whole, bad enough, without laying upon it any part of the blame which belongs not to it.

Perhaps here again, the evil may really be owing to the ignorance, and the inconsideration of parents who, every time that the child retires from school, collect their friends, and exhibit the little prodigy as a mere thing of show. This no doubt takes place also in the school; and there it takes place from less enviable, though not from more mischievous motives than those which lead the parent into error. But still, that it takes place in one instance, is no plea in favour of it in another; and that the teacher makes an exhibition of the child, for the purpose of pleasing the vanity of the parents, and augmenting the celebrity and the profits of the school, is no excuse for the parent, who encreases and confirms the mischief, by repeating the same kind of exhibition at home.

The author of the following pages, in the course of twenty years most assiduously devoted to the practice of education, had occasion to notice the defects of the existing systems; and though it would be regarded as arrogant to attempt, or even to recommend an alteration of them, there is one department which, as it is recorded in print, and may therefore be considered without any personal reference to individuals, may be very justly regarded as within the legitimate province of criticism; that department is the books, more especially, upon subjects in any way connected with science, that are put into the hands of girls for the alleged purpose of affording them information.

These books may, without almost a single exception, be regarded as belonging to that class which has been characterised as the silly—like the book that Hamlet was reading, they contain "words, words, words!" and as those words are collocated and used, one would require to alter the usual definition, "words are the signs of ideas"—to "words are the substitutes or apologies for ideas:"—the tendency, and if one may judge from appearances, the intention of those books being to communicate words, without any view to their explanation.

Whoever takes the trouble to examine the grammars, and epitomes, and catechisms, of the different arts and sciences that are introduced even into the most respectable female schools, must at once see how ill they are adapted for communicating any thing like valuable information. In their materials, they are as jejune as can well be imagined; and silly as those materials are, they are not selected on account of their being the most easy to understand, brought down to the date of the art or science of the time, or expressed in an agreeable manner. They have not a single attraction about them; but appear rather as so many scare-crows, to frighten young people from study, than as allurements to win them to it. If the matter in question happens to be so simple, and so capable of being rendered interesting, as the history of a particular country or state, then the body of the work is sure to consist of details, clipped out of the larger histories, disjointed and broken for want of the connection that exists there, and ever and anon interrupted by shreds of reflection; of which, for want of the portions which are omitted, not even adults could discover the meaning or the connection with the facts; and even then, as if there were still a danger that those miserable materials should awaken something like thinking and reflection, a very limited number of very silly questions is tacked to the end of every section; as though it were expressly said, that the pupil is upon no account to speculate beyond the most vague and common-place answers to these. Nor is even this all; for, in order to make the absence of thought perfectly secure, there is either a set of answers to those questions inserted in the book itself, or some such thing is furnished by the teacher, which reduces the whole matter to a very useless, and, therefore, a very cruel burdening of the memory.

In geography, which, when properly taught, is not only the most amusing but the most valuable of all branches of education—in consequence of the little disquisitions on natural history and the progress of the arts and of society, with which it should be accompanied, the same merely memorial process is resorted to; and though at a pretty early age a girl may be able to tell that such or such is the capital of a country, its principal river, or its most distinguished mountain or chain of mountains, she is utterly unable, even when she has "gone through the whole of her education," as it is not unaptly termed, to tell a single thing about any of them, or even to point out their situations upon a map.

In the other sciences, which consist more of principle and theory, and less of the detail of facts than these, matters are still worse managed; and all that is done, if the book only be read, and this is but too often the mode of proceeding, is to cheat the girl into a belief that she knows something of the matter, and by that means to prevent her from paying any attention to it afterwards. Indeed in the whole range of this species of juvenile library, and it is by no means limited either in breadth or in expense, there is nothing furnished but an unmeaning repetition, not only of idle words, but of words which are worse than idle; inasmuch as the mere committing of them to memory not only precludes thought upon the subject in the meantime, but effectually prevents all recurrence to it afterwards.

Such a succession of absurd and insignificant little books cannot be meant to save expense; for the total cost of them is considerably greater than would suffice for the purchase of a reasonable and rational quantity of information, upon the plain and general principles of all those subjects of which they profess to treat: the real cause is to be found in the incapacity or the indolence of those who take upon themselves the business of education; and the little book, which is conned and repeated like the chatter of a parrot, is really meant to hide either the ignorance or the indolence of the soi-disant and mercenary instructress. Those may be accounted hard words; but they are the result of long and diligent observation and inquiry; and, unless they are repeated again and again, there is no hope that the mischief against which they are levelled shall be diverted.

They are not meant as a mere apology for the production of the present volume; neither is it wished to be argued, that it is in any respect perfect, or calculated to communicate valuable information without due attention on the part of those who may use it. The principal thing aimed at is, to free the subjects that are treated of in its different chapters of that puerility and nonsense with which they are but too frequently encumbered; to furnish, in a small compass and at a moderate price, a book that shall, in plain language, set forth the simple elements of those matters which it would be most desirable to teach: in short, to present those, whether mothers, elder sisters, or ordinary governesses, to whom the important business of instructing English ladies is committed, with a text-book which it shall be impossible to commit to memory in the usual absurd mode; and which shall, at the same time, contain as much as shall suggest, as well to those who instruct, as to those who are instructed, the matters which are most worthy of their consideration.

In such a work it would have been impossible to introduce any thing upon the merely mechanical arts of reading and writing. These are, as it were, the tools that are used in the business of education; and the pupil must know them, and be able to use them before education, properly so called, can be begun.

It is difficult to adopt an arrangement altogether free from objection; because to the uninstructed all subjects are equally difficult. It has, however, been thought best to begin with the grammar of language, to follow that by a chapter on history, as an application of language, then to proceed with the other sciences, in such away as that that which is previously known may be useful in throwing light on that which follows; and such observations on the accomplishments are added as can be rendered intelligible without the assistance of graphic illustration. To have added that illustration would have greatly increased the expense of the volume, without a corresponding increase of utility. Perspicuity and plainness have been aimed at throughout the whole; but that they have been attained is not for the writer to determine.

CHAPTER I.

ENGLISH GRAMMAR.

LANGUAGE is certainly not by any means the simplest subject with which to begin a course of intellectual culture; but still, as language is the medium through which all knowledge is to be acquired, it is difficult to avoid placing it foremost in the arrangement; and, perhaps, if sufficient care were taken in the explanation of it, it might be understood at an earlier age than many are aware of. If this is to be the case, however, a very different course must be followed than that of merely committing definitions, rules, and examples to memory. There must be something more than a mere repeating in some half dozen of words, the nature and properties of that, which it would take pages to explain. In teaching grammar there ought always to be a reference made, not to the words merely, but to the beings, relations, and occurrences which the words are meant to represent. The most important part of grammar is that which is technically styled etymology; for if the nature and meaning of the different kinds of words be rightly understood, the proper method of using them follows as a matter of course.

Of words, nouns and verbs are to be considered as the leading and important classes;—the former as being the indications of whatever is, or is supposed to be; and the latter as being the indications of whatever happens or is supposed to happen. Every being or thing which can be supposed to exist, or can be contemplated, or thought of, without any reference to the existence of other beings or things, has a noun for its appellation. Those nouns are said to be in different cases according as they are related to other nouns, description of beings, or existences, or to verbs, as descriptive of the happening of events. When that which is expressed by a noun is merely named, or is described as the agent or performer of any action or change of the state either of itself or of another, it is said to be in the nominative case, which is considered as being the original and simple form of the noun. When the noun is so used as to express that something else which is named along with it belongs to it, then it is said to be in the genitive or possessive case; and when it is thus used, that which belongs to it is generally, though not always, the thing principally spoken of; and the noun which is in the possessive case, partakes of the nature of an adjective or name of a quality; inasmuch as to say, that a thing belongs to one rather than to another, is an explanation of it somewhat analogous to that which is obtained by mentioning its colour, its size, or any of its qualities. Thus for instance, when we say "a man's hand," we express a quality of the hand in the same manner, though not of the same kind, as if we said "a large hand," or "a strong hand." When that which is indicated by a name is described as being changed, in consequence of the operation of that which is expressed by another noun; then the noun expressing the thing so changed is said to be in the objective case. Every thing of which we speak must fall under one or another of these descriptions; we must barely name it, or say that it is in a particular state; or we must say that it produces a change, or that a change is produced upon it; for farther than this we can only mention to whom it belongs, and this is done by a possessive case, or what are its nature and qualities, and these are expressed by adjectives.

In like manner the other leading description of word, the verb expresses the state in which the noun is, the change which it is undergoing, or the change which it is producing on something else. It is not the state or the change taken in itself and abstractedly from the noun, however, that is expressed by the verb; it is the fact of the noun's being in the state, or of producing, or undergoing the change. In this way verbs are said to be of three kinds, or rather of two kinds; one of which, because two parties are concerned in it, admits of being considered and expressed in two different ways. When the state has reference only to the being expressed by one noun, the verb denoting it is said to be neuter, because that to which it refers interferes not with others. Those neuter verbs may express that which is really a state of the greatest energy and activity as well as the opposite; thus, "to fly," "to run," "to sleep," and "to die," all come under the class of neuter verbs. In the other class the verb is either active or passive according as the being or thing chiefly spoken of is the doer or the receiver of the action which the verb expresses, and the difference of form is brought about by using for the passive, the verb which signifies being generally, together with that form of the other one which expresses the quality resulting from the action done; and, which, on that account, is called the past or perfect participle; thus in the words "I strike," the person denoted by "I," which here stands for some name, and is therefore called a pronoun, denotes the striker, or person who does the striking; and the verb, which describes the kind of action or lets us know that it is striking and not any thing else that is done, is said to be active; but in the words "I am struck," the "I" denotes the person to whom the striking is done, and on that account the verb "am struck" is said to be passive. The last part of it, however, is obviously merely an adjective or the name of a quality—the quality which is impressed by the action alluded to, and might be expressed by saying, " I am a struck man," or " I am a struck woman." No doubt the striking is a quality of the striker, as well as the being struck is a quality of the receiver of the striking; and if nothing more than this were intended to be expressed, " I strike" might be denoted by the words, " I am a striking man" or " I am a striking woman." In these cases, however, the participles of the verb, " struck" and " striking" are merely adjectives, inasmuch as they have no reference to any other party; but when the words " I strike" are used, they are incomplete unless mention be made of that which I did strike; and when the words " I am struck" are used, they are incomplete without an allusion to that by which " I am struck." The active quality is perceptible only while the action is performing; the participle by which it is described as a quality, and which ends in *ing*, is said to be present as well as active; and as the quality which is produced by the action is not produced till the action be completed, and may remain impressed upon the object of the action afterwards; the participle by which it is described as a quality of the object, and which ends in *ed*, *ed* contracted into *t*, or *en*, is called past or perfect. Thus, in the case of a woodman who fells trees, the quality of *felling* is perceptible in him, and can with certainty be declared of him only while he is engaged in the operation; whereas the tree is not felled until the operation be completed, and it may be spoken of as such any time afterwards.

The being in any state, or the performing or the receiving of any action, when spoken of as an actual state of existence or event, must always have a reference to time, because every thing is, acts, or is acted upon in time.

Time generally consists of the past and the future, together with the present or instant at which these meet. The past and the future may be divided into as many portions as imagination pleases; and it is difficult clearly to imagine either the beginning of the former, or the termination of the latter; but the present is instantaneous and indivisible.

There are two ways of referring to a state of being or an action in each of those divisions of time,—one may speak of it as being going on, or as being terminated. It might be supposed also that it might be spoken of as being about to take place; but as nothing is perfect and certain that has not actually happened, or is not actually happening, this presumption and uncertainty is, in the English language at least, not expressed by a general form of the verb, but by a peculiarity called the subjunctive mood, in which the contingency—the possibility that after all the thing may not take place, is involved.

The three divisions of time, and the two ways of referring in each of those divisions to that which is expressed by a verb, produce six general modifications of the time of verbs,—or six tenses, as they are called,—two referring to the past, two referring to the present, and two referring to the future. The past tense, which refers to the doing of the action, but not the completion of it, is called the imperfect tense, and the word terminates in *ed*, *t*, or *en*. The tense which refers to an action as being completed in past time, is called the pluperfect tense, as denoting that the action was completed before the present time; and it is expressed by the imperfect tense of the verb, which expresses possession in general—the word *had* prefixed to the perfect participle. The tense which represents the action as presently happening, is styled the present, and it is the simplest form of the verb. When spoken of generally, as the name of the being in the state, or the performing of the action, without any reference to the particular being, actor, or party acted on, it is called the unlimited or infinitive form of the verb, and it is expressed by prefixing to the simple verb the word *to*, which in those cases is synonymous with *do*—the general sign of activity of performance. The same general form of the verb may be referred to past time, and it is then indicated by *to*, together with *have*—the imperfect tense of the verb of possession—prefixed to the past or perfect participle. The tense which represents an action or state of being as completed at the present time, is called the perfect tense; and it is expressed by prefixing the word *have* to the perfect participle. The future tense, which represents a state of being, or an action as to be in progress at a future time, is called the future imperfect, or occasionally the first future tense. It is expressed by prefixing *shall* or *will*, *may* or *can*, or some of their forms, to the present tense; and the particular prefix is regulated by the sense in which the verb is taken. That tense which denotes an action as to be completed in future, is called the future perfect tense, or the second future tense; and it is expressed by subjoining to the *shall*, *will*, &c. the word *have*, together with the perfect participle.

Besides those variations of the form and signification of the verb, as arising from differences of time, there are other differences that arise from the manner in which the state of being or the action is described; and these are called the *moods* or *modes* of the verb. They do not describe the manner or the quality of the action itself; they merely refer to the way in which it has happened, is happening, or is expected to happen. When the happening or not happening is declared as a simple proposition, without any doubt or contingency, the verb is said to be in the indicative mood. This is the most general form, and it applies to all the tenses. When the object is to declare that the agent has power, permission, or disposition to do, or the object to receive the action denoted by the verb, these circumstances are expressed by separate words prefixed to the corresponding portion of the indicative mood, and the compound thus made up is usually called the potential mood of the verb. When that which is expressed by the verb is represented as doubtful, and depending on something else, that upon which it depends is either expressed or understood in a separate verb, and the verb expressing the doubt or contingency is said to be in the subjunctive mood—inasmuch as it is contingent upon that which is subjoined to it. In past time there can be no contingency, neither, strictly speaking, can any thing present be contingent; therefore the subjunctive mood is always in its nature future with regard to that upon which it is contingent; but as the verb denoting that may, without impropriety, be past or present, a little confusion is introduced into the tenses of this mood. This confusion, indeed, springs from the fact of the reader's having two present times—two divisions of time before him—the present to which the author whom he reads refers, and the present at which he himself exists. Besides these, when a verb is used as a mode of address, either as commanding or as asking another to do an action, or to permit it to be done, the form of the verb is called the imperative mood, and, strictly speaking, the imperative mood always has reference to a party spoken to.

A further modification of verbs arises from the considerations of the speaker, the hearer, or party spoken to, and any third party to whom the verb may apply. If it applies to the speaker, it is said to be in the first person; if to the hearer, in the second person; and if to a third party, to the third person. Any of those persons may refer to one, or to more than one, and therefore may be either singular or plural: this, however, is no quality of the verb itself, for when we say, "one lady reads," and again, "ten ladies read," there is no more plurality in the action in the one case than in the other. If there be more than one action, each one must be expressed by its own verb; and hence that which is usually styled difference of number in verbs is nothing more than a reference, in the particular form of the verb, to the number of that noun which denotes the party to whom it refers. In like manner, though in some languages a difference of gender in the noun be accompanied by a different form of the verb, and in some instances, (such as that of the Basque language,) with a different word altogether; yet this difference of gender neither is, nor can be, an essential quality of the verb, inasmuch as states of being and actions neither have, nor can have, any distinction of sex. In some languages where, for the sake of a more agreeable sound, the words are put out of their natural order, by the interpolation of other words between those which are really connected, it becomes necessary to fix some mark upon the separated words by which their connection may be seen; and thus, in such languages, numbers and genders are applied to verbs, as well as other qualities to other words to which such qualities cannot belong. The English language, however, employs the words in their natural order, and therefore, though upon that account it may be sometimes harsher in its sound, it is free, both from the difficulty and the absurdity of these artificial contrivances.

These observations are given as a specimen of the mode in which the principles of grammar ought to be explained, even to ladies, after they shall have so far advanced as to be able to understand the explanations. Perhaps, indeed, the best plan would be at a reasonably early period of their education, to lead them over the general outlines of the subject, in some such manner as they are expressed in the following practical sketch; and afterwards, towards the close of their education, to enter into a full explanation of this most beautiful and philosophical, but most difficult of all studies.

It has not been thought necessary to embody, either in these observations, or in the sketch which follows them, any of the rules which are usually given for composition. Two brief ones are, perhaps, more useful than all the formulæ of the rhetoricians: understand perfectly the subject on which you are to write; and be, at the same time, perfectly mistress of the language you are to use.

PRACTICAL SKETCH OF ENGLISH GRAMMAR.

GRAMMAR teaches us to express our thoughts with propriety.

Universal grammar explains the principles which are common to all languages.

The grammar of any particular language (as the English grammar) lays down the rules of that language, and teaches the established usage and custom of it.

It treats of sentences, and the various parts of which they consist.

Sentences are composed of words; words of one or more syllables; syllables of one or more letters; so that the whole subject of grammar consists of letters, syllables, words, and sentences.

Grammar has generally been divided into two parts, Etymology and Syntax; to which some have added Orthography, Punctuation, and Prosody. We shall only treat of Etymology, Syntax, and Punctuation.

ETYMOLOGY,

OR THE RULES WHICH RELATE TO WORDS.

There are in the English language nine parts of speech, or different kinds of words; the Article, the Substantive or Noun, the Adjective, the Pronoun, the Verb, the Adverb, the Preposition, the Conjunction, and the Interjection.

1. An article is a word prefixed to substantives, to point out and limit the extent of their signification, as, "*a* pen," "*an* angel," "*the* man," "*the* words."

2. A substantive is the name of any thing, mental or material, which we know or imagine to exist; as, "Paris," "woman," "virtue," "warfare," "health."

3. An adjective is the name or sign of any quality, idea, or thing belonging to the substantive or noun to which it is joined; as, "a learned man," "a beautiful woman," "a hard road," "an iron bridge," "a black swan."

4. A pronoun is a word which is used instead of a noun, in order to prevent the too frequent repetition of it; as, "the faculty of speech is peculiar to man, though *it* be often perverted to the worst of purposes;" in which sentence the pronoun *it* supplies the place of "the faculty of speech."

5. A verb is a word which denotes some particular state of a thing, or which joins some particular circumstance to it, not necessarily belonging to it, as, "I read," "thou walkest," "he suffers," "they think."

6. An adverb is a word which is joined to a verb, adjective, or another adverb, to denote some quality or circumstance belonging to the subjects to which they refer; as, "he writes *well*," "a *truly* worthy man," "she sings *very* correctly."

7. A preposition is a word chiefly put before nouns and pronouns, to connect them with other words, and to show their natural relation; as, "she sent the book *from* London *to* Paris;" "I am much delighted *with* Cicero;" "he is *above* corruption."

8. A conjunction is a word used to connect sentences, or parts of sentences together: "he is wise *and* virtuous;" "she is miserable *because* she is wicked."

9. Interjections are words used to express any sudden

passion or emotion of the person who uses them; as "oh," "alas," &c.

ARTICLES.

An ARTICLE is a word prefixed to substantives, to point out and limit the extent of their signification. In English there are two articles; *a* and *the*. *A* becomes *an*, before a vowel, or silent *h*, as "an eagle," "an hour."

A, or *an*, is called the indefinite article; because when prefixed to a substantive, it does not determine the particular thing spoken of; as, "give me a pen;" "send me a penknife:" where, it will be observed, no particular pen or penknife is pointed out.

The is called the definite article, because it points out some particular object or objects; as, "give me the book," "lend me the folder;" in which expressions the article *the* points out the particular book and folder which are wanted.

Substantives are frequently used without any articles prefixed; in which case they are to be understood in their widest acceptation; as,

"The proper study of *mankind* is *man*:"

In which sentence the words *mankind* and *man*, might easily change places without altering the signification.

SUBSTANTIVES.

A SUBSTANTIVE is the name of any thing, mental or material, which we know or imagine to exist. Substantives are generally divided into two classes; proper and common. Proper substantives or names are those which we employ to designate individuals; as, "John," "Thomas," "London," "Paris." Common substantives or names are used to designate objects or things which contain many individuals under them; as "man," "woman," "house," &c.

Substantives are possessed of gender, number, and case.

Gender points out the sex of the object spoken of. Substantives which designate the male sex, are called masculine; those which designate the female sex, feminine; and those which have no sex are said to be neuter, or of no gender.

In English there are generally different words to express the male and female sex; as, "man," "woman," "bull," "cow," &c.

Sometimes, however, words of the feminine gender are distinguished from those of the masculine, by the addition of *ess* or *ix* to the latter; as "baron," "baroness;" "testator," "testatrix;" "heir," "heiress;" and where there is only one common name for both sexes, by prefixing to them some other word; as, "a man servant," "a he goat," "a she goat," "a male child."

NUMBER.

Number relates to the consideration of things, as one or more. When one object is only spoken of, the word used is said to be in the singular number; when two or more, it is in the plural number; as, "a bottle," a "candle;" "the bottles," or "candles."

The plural number of most nouns is formed by *s* being prefixed to them; as "cat, cats," "pear, pears," "boy, boys;" but when the singular number ends in *a*, *ch*, soft *sh*, *ss* or *s*, *es* must be added to form the plural; as "box, boxes," "arch, arches," "rush, rushes;" "marchioness, marchionesses," "bolus, boluses." When the *ch* in the end of a word is hard, *s* only is added; as "heresiarch, heresiarchs."

Substantives ending in *f*, *fe*, or *ff*, form their plural by changing these terminations into *ves*, as "leaf, leaves," "knife, knives," "staff, staves;" and those ending in *y*, if it is not preceded by another vowel, by changing it into *ies*, as "fly, flies." A few plurals end in *en*, as "oxen," "brethren."

Some nouns are the same in both numbers, as "sheep, "deer;" and some, from the nature of the things which they represent have no plural, as "gold," "cloth," "foam."

CASE.

The case of a substantive marks its connexion or relation to other words.

Substantives in English have but two cases, the nominative and genitive; or, as it is sometimes called, the possessive case. The nominative case, which may be either singular or plural, is simply the substantive itself, without any variation, as "man, men," "book, books."

The genitive or possessive case, which marks possession or property, is formed by adding *s* with an apostrophe to the nominative case of the singular number; as, "my cousin's book," "my father's house;" and in the plural of nouns ending in *s*, by simply adding an apostrophe ('), as "horses' power," "spiders' webs."

The *s* is but seldom added to form the possessive case of nouns, whose singular number ends in *s* or *x*, as "Festus' wrath," "Brutus' death," "righteousness' sake."

The two following examples will illustrate the declension of substantives:

	SINGULAR.	PLURAL.
Nominative case . .	A man.	Men.
Genitive case	A man's.	Men's.
Nominative case . .	The warrior.	The warriors.
Genitive case	The warrior's.	The warriors'.

ADJECTIVES.

An ADJECTIVE is the name or sign of any quality, idea, or thing belonging to the noun to which it is joined.

Adjectives only admit of degrees of comparison, of which, properly speaking, they have only two, the comparative and the superlative; the first, or positive degree, only expressing the quality of an object, without comparing it with any other; as "learned," "good."

The comparative degree of words of only one syllable is formed by adding *er;* and the superlative by adding *est;* as, "great, greater, greatest;" "small, smaller, smallest."

Words of more than one syllable generally form their comparative degree by *more,* and their superlative by *most;* as "learned, more learned, most learned."

Some words in most languages are irregular in the formation of their comparative and superlative, as "good, better, best;" "bad, worse, worst;" "little, less, least;" and several others.

PRONOUNS.

A PRONOUN is a word which is used instead of a noun, in order to prevent its too frequent repetition.

Pronouns have person, number, gender, and case; and are generally divided into personal, possessive, relative, and adjective.

Personal pronouns are thus declined:

SINGULAR.

		CASE.	
Person.	Nominative.	Possessive.	Objective.
First . .	I.	——	Me.
Second . .	Thou.	——	Thee.
Third . .	He.	His.	Him.
	She.	——	Her.
	It.	Its.	It.

PLURAL.

First . .	We.	——	Us.
Second .	Ye or you.	——	You.
Third . .	They	——	Them.

The first person *I* or *we*, always stands for the person or persons speaking; the second, *thou*, *ye*, or *you*, for the person or persons spoken to; and the third, *he*, *she*, *it*, and *they*, for the person or things spoken of.

It is used for things without sex; *they*, for persons or things; and *you* instead of *thou*, in common conversation.

The possessive pronouns are *my*, *thy*, *her*, *our*, *your*, *their*, and may be considered either as adjectives, or as the possessive cases of the personal pronouns. When separated from the noun, *my* and *thy* become *mine* and *thine;* the others have *s* added to them.

SINGULAR.

	With the Noun.	Without the Noun.
First person . .	My.	Mine.
Second person .	Thy.	Thine.
Third person feminine . .	Her.	Hers.

PLURAL.

	With the Noun.	Without the Noun.
First person . .	Our.	Ours.
Second person .	Your.	Yours.
Third person . .	Their.	Theirs.

Relative pronouns are so called because they refer to something which has been already related or mentioned; as "the man *who* died," "the bird *which* or *that* you gave to me."

Who is used when persons are spoken of; *which*, in regard to things; and *that*, both for persons and things. One of them only admits of declension.

Nominative . . .	Who.
Genitive	Whose.
Objective	Whom.

What is both a relative and demonstrative pronoun, and is used as an interrogative along with *who* and *which;* as, "this is *what* (or that which) I prayed for; *what* is it?—*who* cares?—*which* do you prefer?"

Adjective pronouns are so called, because there is always a substantive expressed or understood, where they are used. *This* is used to point out an object which is near; *that*, something which is at a greater distance. They form their plurals by *these* and *those.*

Some of the adjective pronouns are only used in the singular; as, *each, every*, &c.; and others only in the plural, as *both, all*, &c.; and some are used indifferently for either number; as, *any, none, some*, &c.

THE VERB.

A VERB is a word which denotes some particular state of a thing, or which joins some particular circumstance to it, not necessarily belonging to it.

No sentence can be formed without a verb, expressed or understood; as, " John reads," " Mary writes," " I speak."

Verbs have number, person, and tense; the numbers are two, singular and plural; and the persons three, the first, second, and third.

The tense is an inflection, or particular termination of the verb, to denote whether it refers to present, past, or future time.

The English verb has, properly speaking, only two tenses, the present and the past; all others being formed by means of the auxiliary verbs *be, do, shall, will, may, can, let,* and *must.* In both tenses the verb must be preceded by a noun or pronoun, which is called the nominative case to it; as " *Cæsar* fought," " *I* wrote.

The English verb has two participles, the present or imperfect, and the perfect, which are known by their ending, the one in *ing* and the other in *ed*; as, " I am *learning*," " he is *learned*." They are frequently used as adjectives, as " a *confiding* husband," " an *adored* wife."

The English regular verb is thus conjugated:

Infinitive.

Admire, or to admire.

PRESENT TENSE.

SINGULAR.	PLURAL.
1. *Person,* I admire.	1. *Person,* We admire.
2. ———, Thou admirest.	2. ———, Ye or you admire.
3. ———, He, she, or it admireth, or admires.	3. ———, They admire.

PAST TENSE.

SINGULAR.	PLURAL.
1. *Person,* I admired.	1. *Person,* We admired.
2. ———, Thou admirest.	2. ———, Ye or you admired
3. ———, He admired.	3. ———, They admired.

Present, or imperfect Participle.
Admiring.

Perfect Participle.
Admired.

The English auxiliary, or, as they are sometimes called, defective verbs, are *be, do, have, shall, will, may, can, let,* and *must,* and are conjugated as follows:

Infinitive Mood.

Be, or To be.

Indicative Mood.

PRESENT TENSE.

SINGULAR.	PLURAL.
1. *Per.* I am.	1. *Per.* We are.
2. —, Thou art.	2. —, Ye or you are.
3. —, He, she, or it is.	3. —, They are.

PAST TENSE.

SINGULAR.	PLURAL.
1. *Per.* I was.	1. *Per.* We were.
2. —, Thou wast.	2. —, Ye or you were.
3. —, He, she, or it was.	3. —, They were.

This verb has one variation, or mood, as it is called, peculiar to itself; the subjunctive, which expresses the event, or thing spoken of, as doubtful, or depending on something else, and has a conjunction *subjoined* to it; as "*If* James come to-morrow, *I were* to blame."

Subjunctive Mood.

PRESENT TENSE.

	SINGULAR.		PLURAL.
1. *Per.*	If I be.	1. *Per.*	If we be.
2. —,	If thou beest or be.	2. —,	If ye or you be.
3. —,	If he be.	3. —,	If they be.

PAST TENSE.

	SINGULAR.		PLURAL.
1. *Per.*	If I were.	1. *Per.*	If we were.
2. —,	If thou wert.	2. —,	If ye or you were.
3. —,	If he, she, or it were.	3. —	If they were.

Imperfect Participle.

Being.

Perfect Participle.

Been.

The only way in which the regular verbs can be employed in this indefinite or subjunctive mood, is by dropping the *s* in the second and third persons singular, as "If thou *admire* much," "if he *feel* deeply."

Infinitive.

Do, or to do.

PRESENT TENSE.

	SINGULAR.		PLURAL.
1. *Per.*	I do.	1. *Per.*	We do.
2. —,	Thou dost.	2. —,	Ye or you do.
3. —,	He does or doth.	3. —,	They do.

PAST TENSE.

	SINGULAR.		PLURAL.
1. *Per.*	I did.	1. *Per.*	We did.
2. —,	Thou didst.	2. —,	Ye or you did.
3. —,	He did.	3. —,	They did.

Present or imperfect Participle.

Doing.

Perfect Participle.

Done.

Infinitive.

Have, or to have.

PRESENT TENSE.

SINGULAR.	PLURAL.
1. *Per.* I have.	1. *Per.* We have.
2. —, Thou hast.	2. —, Ye or you have.
3. —, He has.	3. —, They have.

PAST TENSE.

SINGULAR.	PLURAL.
1. *Per.* I had.	1. *Per.* We had.
2. —, Thou hadst.	2. —, Ye or you had.
3. —, He had.	3. —, They had.

Imperfect Participle.

Having.

Perfect Participle.

Had.

The verbs *shall, may,* and *can,* have neither infinitive nor participle; and *will* has no perfect participle. They are thus conjugated.

Shall.

PRESENT TENSE.

SINGULAR.	PLURAL.
1. *Per.* I shall.	1. *Per* We shall.
2. —, Thou shalt.	2. —, Ye or you shall.
3. —, He shall.	3. —, They shall.

PAST TENSE.

	SINGULAR.		PLURAL.
1. *Per.*	I should.	1. *Per.*	We should.
2. —,	Thou shouldst.	2. —,	Ye or you should.
3. —,	He should.	3. —,	They should.

Infinitive.

Will, or to will.

PRESENT TENSE.

	SINGULAR.		PLURAL.
1. *Per.*	I will.	1. *Per.*	We will.
2. —,	Thou wilt.	2. —,	Ye or you will.
3. —,	He will.	3. —,	They will.

PAST TENSE.

	SINGULAR.		PLURAL.
1. *Per.*	I would.	1. *Per.*	We would.
2. —,	Thou wouldst.	2. —,	Ye or you would.
3. —,	He would.	3. —,	They would.

Present, or imperfect Participle.

Willing.

These two verbs, *shall* and *will*, have a totally different sense in the first person of the present tense from that which they have in the second and third. For example, if we merely mean to express an *intention* of learning, we ought to say I *shall* learn; but if we wish to express a *determination* to learn, it will be necessary to use the verb *will*, as I *will* learn. To exemplify their use, it may be proper to set them down at length in conjunction with a verb.

1. To express any thing as simply *future*.

	SINGULAR.		PLURAL.
1. *Per.*	I shall learn.	1. *Per.*	We shall learn.
2. —,	Thou wilt learn.	2. —,	Ye or you will learn.
3. —,	He will learn.	3. —,	They will learn.

To express *determination or command.*

	SINGULAR.		PLURAL.
1. *Per.*	I will learn.	1. *Per.*	We will learn.
2. —,	Thou shalt learn.	2. —,	Ye or you shall learn.
3. —,	He shall learn.	3. —,	They shall learn.

May.

PRESENT TENSE.

	SINGULAR.		PLURAL.
1. *Per.*	I may.	1. *Per.*	We may.
2. —,	Thou mayest.	2. —,	Ye or you may.
3. —,	He may.	3. —,	They may.

PAST TENSE.

	SINGULAR.		PLURAL.
1. *Per.*	I might.	1. *Per.*	We might.
2. —,	Thou mightest.	2. —,	Ye or you might.
3. —,	He might.	3. —,	They might.

Can.

PRESENT TENSE.

	SINGULAR.		PLURAL.
1. *Per.*	I can.	1. *Per.*	We can.
2. —,	Thou canst.	2. —,	Ye or you can.
3. —,	He can.	3. —,	They can.

PAST TENSE.

	SINGULAR.		PLURAL.
1. *Per.*	I could.	1. *Per.*	We could.
2. —,	Thou couldst.	2. —,	Ye or you could.
3. —,	He could.	3. —,	They could.

Remarks on the Auxiliary Verbs.

By the aid of these verbs, the various circumstances of mode and time may be expressed, without much variation of the verb to which they are joined. The signification of *shall* and *will* has been already pointed out. *Do* and *did* mark the action itself, or the time of doing it; as "I *do* love," "I *did* love." *Let* expresses permission, prayer, exhortation, and command: *May*, the possibility, or liberty, of doing a thing. *Do* and *have* mark the present time; *did* and *had* the past; *shall* and *will* the future; *may*, *might*, *could*, *would*, *should*, the subjunctive or contingent. *Must* admits of no variation, and denotes necessity.

Of the Passive of Verbs, and of Neuter Verbs.

It has been a usual practice with grammarians to divide verbs into active, passive, and neuter; the active verb, according to them, implying an agent and an object acted on, as, "I love Mary:" the passive, the receiving or the suffering of an action, as, "Mary is loved by me:" and the neuter, the coincidence of the agent and of the object acted upon, as, "I dream," "thou sleepest." But these are entirely distinctions of syntax or construction, and not of accidence. It is therefore only necessary to remark here, that the passive of verbs is merely the perfect participle joined to the verb *to be* through all its variations; as, "I am admired," "I was admired," &c.; and that the neuter verb is varied like the active in its tenses.

Irregular Verbs.

In English, both the past time active and the participle perfect are formed by adding to the verb *ed*, or *d* only when the verb ends in *e*, as *learn*, *learned*, *love*, *loved*. All those verbs which differ from this rule, in either, or in both cases, are called irregular; and as it is not easy either to give or to remember rules for their variations, we shall give a list of them at once.

Alphabetical List.

Present.	Past.	Participle.
Abide,	Abode,	Abode.
Am,	Was,	Been.
Arise,	Arose,	Arisen.
Awake,	Awoke, awaked,	Awoken.
Bear,	Bare or bore,	Borne.
Beat,	Beat,	Beaten.
Become,	Became,	Become.
Begin,	Began,	Begun.
Beget,	Begat,	Begotten.
Bend,	Bent,	Bent.
Behold,	Beheld,	Beheld.
Bid,	Bade, bid,	Bidden, bid.
Bereave,	Bereft, bereaved,	Bereft, bereaved.
Beseech,	Besought,	Besought.
Bind,	Bound,	Bound.
Bite,	Bit,	Bitten, bit.
Bleed,	Bled,	Bled.
Blow, (as the wind)	Blew,	Blown.
Break,	Broke,	Broken.
Breed,	Bred,	Bred.
Bring,	Brought,	Brought.
Build,	Built,	Built.
Burst,	Burst,	Burst.
Buy,	Bought,	Bought.
Cast,	Cast,	Cast.
Catch,	Caught,	Caught.
Chide,	Chid,	Chidden, chid.
Choose,	Chose,	Chosen.
Cleave (to adhere),	Clave,	Cleaved.
Cleave (to split),	Clove, cleft,	Cleft, cloven.
Cling,	Clung,	Clung.

Present.	Past.	Participle.
Clothe,	Clothed, clad,	Clad, clothed.
Come,	Came,	Come.
Cost,	Cost,	Cost.
Creep,	Crept,	Crept.
Crow,	Crew,	Crowed.
Cut,	Cut,	Cut.
Dare (to venture),	Durst,	Dared.
Deal,	Dealt,	Dealt.
Dig,	Dug, digged,	Dug, digged.
Do,	Did,	Done.
Draw,	Drew,	Drawn.
Drink,	Drank,	Drunk.
Drive,	Drove,	Driven.
Dwell,	Dwelt,	Dwelt.
Eat,	Ate,	Eaten.
Fall,	Fell,	Fallen.
Feed,	Fed,	Fed.
Feel,	Felt,	Felt.
Fight,	Fought,	Fought.
Find,	Found,	Found.
Flee,	Fled,	Fled.
Fling,	Flung,	Flung.
Fly,	Flew,	Flown.
Forget,	Forgot,	Forgotten, forgot.
Forgive,	Forgave,	Forgiven.
Forsake,	Forsook,	Forsaken.
Forego,	Forewent,	Foregone.
Freeze,	Froze,	Frozen.
Get,	Got,	Gotten, got.
Gild,	Gilt, gilded,	Gilt.
Gird,	Girt, girded,	Girt.
Give,	Gave,	Given.
Go,	Went,	Gone.

Present.	Past.	Participle.
Grave,	Graved,	Graven, graved.
Grind,	Ground,	Ground.
Grow,	Grew,	Grown.
Hang,	Hung, hanged,	Hung, hanged.
Have,	Had,	Had.
Hear,	Heard,	Heard.
Hew,	Hewed,	Hewen, hewed.
Hide,	Hid,	Hidden, hid.
Hit,	Hit,	Hit.
Hold,	Held,	Holden, held.
Hurt,	Hurt,	Hurt.
Keep,	Kept,	Kept.
Knit,	Knit,	Knit.
Know,	Knew,	Known.
Lade,	Laded,	Laden, laded.
Lay,	Laid,	Laid.
Lead,	Led,	Led.
Leave,	Left,	Left.
Lend,	Lent,	Lent.
Let,	Let,	Let.
Lie (to lie down),	Lay,	Lain.
Light,	Lit, lighted,	Lit, lighted.
Load,	Loaded,	Laden.
Lose,	Lost,	Lost.
Make,	Made,	Made.
Meet,	Met,	Met.
Mow,	Mowed,	Mown, mowed.
Pay,	Paid,	Paid.
Put,	Put,	Put.
Read,	Read,	Read.
Rend,	Rent,	Rent.
Rid,	Rid,	Rid.
Ride,	Rode,	Ridden.

Present.	Past.	Participle.
Ring,	Rung, rang,	Rung.
Rise,	Rose,	Risen.
Rived,	Rived,	Riven.
Run,	Ran,	Run.
Saw,	Sawed,	Sawn, sawed.
Say,	Said,	Said.
See,	Saw,	Seen.
Seek,	Sought,	Sought.
Seethe,	Seethed,	Sodden.
Sell,	Sold,	Sold.
Send,	Sent,	Sent.
Set,	Set,	Set.
Shake,	Shook,	Shaken.
Shape,	Shaped,	Shaped, shapen.
Shave,	Shaved,	Shaven, shaved.
Shear,	Sheared,	Shorn, sheared.
Shed,	Shed,	Shed.
Shine,	Shone,	Shone.
Shoe,	Shod,	Shod.
Shoot,	Shot,	Shot.
Show,	Showed,	Shown.
Shrink,	Shrunk, shrank,	Shrunk.
Shut,	Shut,	Shut.
Sing,	Sung, sang,	Sung.
Sink,	Sunk, sank,	Sunk.
Sit,	Sat,	Sat.
Slay,	Slew,	Slain.
Sleep,	Slept,	Slept.
Slide,	Slid,	Slidden.
Sling,	Slung,	Slung.
Slink,	Slunk, slank,	Slunk.
Slit,	Slit,	Slitted, slit.
Smite,	Smote,	Smitten.

Present.	Past.	Participle.
Sow,	Sowed,	Sown.
Speak,	Spoke,	Spoken.
Speed,	Sped,	Sped.
Spend,	Spent,	Spent.
Spill,	Spilt, spilled,	Spilt, spilled.
Spin,	Spun, span,	Spun.
Spit,	Spit, spat,	Spit, spitten.
Split,	Split,	Split.
Spread,	Spread,	Spread.
Spring,	Sprung, sprang,	Sprung.
Stand,	Stood,	Stood.
Steal,	Stole,	Stolen.
Stick,	Stuck,	Stuck.
Sting,	Stung,	Stung.
Strew,	Strewed,	Strewed, strewn.
Stride,	Strode, strid,	Stridden, strode.
Strike,	Struck,	Struck.
String,	Strung,	Strung.
Strive,	Strove,	Striven, strove.
Swear,	Swore,	Sworn.
Sweat,	Sweated, sweat,	Sweated, sweat.
Swell,	Swelled,	Swoln.
Swim,	Swum, swam,	Swum.
Swing,	Swung,	Swung.
Take,	Took,	Taken.
Teach,	Taught,	Taught.
Tear,	Tore,	Torn.
Tell,	Told,	Told.
Think,	Thought,	Thought.
Thrive,	Throve, thrived,	Thriven, thrived.
Throw,	Threw,	Thrown.
Thrust,	Thrust,	Thrust.
Tread,	Trod,	Trodden, trod.

Present.	Past.	Participle.
Wax,	Waxed,	Waxed, waxen.
Wear,	Wore,	Worn.
Weave,	Wove,	Woven.
Weep,	Wept,	Wept.
Win,	Won,	Won.
Wind,	Wound,	Wound.
Work,	Wrought, worked,	Wrought, worked.
Wring,	Wrung,	Wrung.
Write,	Wrote,	Written.

The whole number of words in the English language is about thirty-five thousand; of which about four thousand three hundred are verbs. Of these about one hundred and eighty are irregular and monosyllables; all the others, except twelve or thirteen, being regular, and words of more than one syllable.

ADVERBS.

AN ADVERB is a word which is joined to a verb, adjective, or to another adverb to denote some quality or circumstance belonging to the subjects to which they refer; and is, in general, formed from an adjective, by changing its termination. Most adverbs are formed by adding the syllable *ly* to the adjective, or changing its termination *le* into *ly;* as discreet, discreet*ly;* fair, fair*ly;* ab*le,* ab*ly;* possib*le,* possib*ly.*

An adverb may generally be known from its capability of answering all questions of *how, in what way, degree, manner, or form,* as also *when* and *where,* without the aid of any other word expressed; as, *how* does he teach? well. *When* will he come? immediately. *How* does she sing? delightfully, &c.

A few adverbs admit of comparison: as, *often, oftener,* *oftenest; soon, sooner, soonest.* Those ending in *ly* are compared by *more* and *most:* as, *correctly, more correctly, most correctly;* and those which are formed from adjectives, which are irregular in their comparison, are also irregular in the same way: as *well, better, best, &c.*

PREPOSITIONS.

A PREPOSITION is a word chiefly put before nouns and pronouns, to connect them with other words, and to point out their mutual relation. This relation is, in many languages marked by the cases, or different terminations of the noun.

Prepositions appear originally to have denoted the relation of place; which in many prepositions is still evident, in whatever way they are employed; such as, *out, in, by, through, about, &c.*

Prepositions are also frequently prefixed to verbs, for the purpose of forming other verbs: as, *to value*, to *under*value; to *take*, to *under*take, &c.

The principal prepositions are,

Of
to
for
by
with
in
into
from
within
without
over
under
through
above
below
between
beneath
beyond
except
before
behind
save
at
near
up
down
off
on
upon
among
after
about
against.

CONJUNCTIONS.

A CONJUNCTION is a word used to connect sentences, or parts of sentences together: as, you, *and* I, *and* Robert were learning French.

Conjunctions are divided into copulative or connecting, and disjunctive or separating.

The copulative conjunctions connect sentences and continue their meaning: the disjunctive likewise connect sentences, but show an opposition or disagreement between them; as, " Augustus, Vespasian, *and* Titus were emperors," " he is learned *but* ugly," " he was rich in wisdom, *but* not in that wisdom which cometh from above."

The copulative conjunctions always express addition, cause, motive, or inference; the disjunctive, opposition, condition, supposition, or diminution, as may be seen by the following list of the principal ones of both kinds.

COPULATIVE.

And, for, because, therefore, wherefore, that, both, since, as, if, &c.

DISJUNCTIVE.

But, unless, or, nor, neither, either, yet, then, lest, though, notwithstanding, provided, &c.

INTERJECTIONS.

INTERJECTIONS are words used to express any sudden passion or emotion of the person who uses them: as, " the power of speech is an invaluable faculty, but, *alas!* how often do we abuse it."

The first interjections employed by mankind appear to have been involuntary emissions of the voice; as, " Oh! ah! sht!" &c.; but many common words are now used as interjections, as, " lo! behold!" &c.

OF SYNTAX.

Syntax is, properly speaking, the art of combining words, in speaking or writing, agreeably to the customary use of the language.

Parsing, or the analysis or resolution of sentences, has been also very generally considered as a part of Syntax, and we shall therefore give the rules for the analysis of sentences, before proceeding to those by which they are constructed.

1. A sentence is an assemblage of words, arranged in such order as to make a complete sense or meaning.

2. Sentences are either simple or compound.

3. A simple sentence has but one subject and one finite verb; as, "I live," "James walks," "the horse gallops."

4. A compound sentence contains two or more clauses; as, "I rode and he walked," "they read and we listened."

5. When the verb is active, it requires a substantive, pronoun, or an infinitive verb, as an objective case; as, "Alexander conquered *Darius*," "I govern the *school*," "my brother learns *to write*."

6. When the verb is one of the auxiliary verbs, it requires to be followed by an infinitive, a participle, adjective, or pronoun; as, "I do *write*," "we are *talking*," "he is *merry*," "it is *I*."

7. The verb *to be* admits of a substantive after it when it relates to the same person or thing as the agent of the verb; as, "Cæsar was an excellent *writer*, as well as good general."

8. The nominative or objective noun may govern a possessive or genitive case; as, "James is Thomas's

brother," "I keep my *sister's* school," "William's mother is a good woman."

9. Any of the members or parts of a simple sentence may be qualified by an adverb; as, "she dances *elegantly*," "*very* worthy characters are *rarely* found," "she is *much* loved."

10. In a compound sentence, the main or principal clause always exhibits the assertion, or subject matter of the whole. All the other clauses are called parenthetical, because they do not render the construction of the principal one imperfect; as, "I was ignorant of grammar, *till I was sent to school*;" "Augustus, *a wily politician*, overthrew the republic;" "*while the Carthaginians were dissolved in luxury at Capua,* the Romans were preparing for the renewal of the war."

11. Sentences have also been divided into *phrases*, as well as clauses; but there seems little ground for the division. As examples of what has been denominated a *phrase*, we give the following; "He came *with authority*;" "He said it *with a loud voice*," &c. in which it is evident that the words constituting what has been called a phrase, partake of the nature of an adverb.

OF THE LAWS OF SYNTAX.

1. A sentence is either explicatory, interrogative, or imperative.

A *sentence* is called *explicative*, when a thing is said to be, or not to be, &c. as "the most advantageous situation of life for gaining wisdom is the middle."

A sentence is called interrogative, when a question is asked in it; as "Who did it?" "Was it James?"

A sentence is called imperative, when it commands a thing to be done, or not to be done, &c.; as, "Depart, traitor!" "Let us begone!" "Be ye aware!"

2. An article is joined to a substantive; as, "A book;" and also to participles; as, "By the observing of this rule."

3. A substantive, or pronoun personal or relative, in the possessive case, is governed by a substantive; as, "*James's* book;" "*His* flute;" "I saw the woman *whose* property was lost."

4. Substantives, or pronouns personal or relative, when they are not in the possessive case, are *nominative* to a verb, or *objective* to some verb or preposition; as, "*Who* wrote this *grammar?*" "The *man whom* you saw with me, is my brother;" unless they are put in *apposition*, that is to say, for the purpose of explaining, when they agree with them in case, gender, and number; as, "Pitt and Fox, *celebrated orators;* "The Romans were great *warriors;*" "It is I."

5. A substantive of multitude, or, as it is commonly called, a collective noun, will have the verb and pronoun to which it relates in the singular or plural number, according as the idea which it represents happens to be singular or plural; as, "My people is foolish; they have not known me;" "The assembly was numerous;" "Parliament was dissolved."

6. Two or more nouns in the singular number, joined together by one or more copulative conjunctions, make the verbs, nouns, and pronouns to which they relate, plural; as, "Epaminondas and Xenophon *were* distinguished generals; *they* were likewise eminent in many other respects;" "*She* and *I* are both poor."

7. Two substantives, or pronouns personal or relative, in the singular number, if not joined together by the conjunction *and*, do not make the verbs, nouns, or pronouns to

which they relate, plural; as, "Ignorance *or* wickedness *is* the cause;" "Not only his good temper, *but* his fortitude *was* tried;" "Either the master *or* the scholar *was* in fault."

8. Two or more substantives, or pronouns personal or relative, connected by a conjunction, are either nominative or objective to the same verb or preposition; as, "*Bacon* and *Newton were* eminent philosophers;" "I esteem both you and him:" "He has gone to *Rome* and *Naples*."

9. A pronoun personal, possessive, or relative, must agree with the substantive whose place it supplies, in gender and number. This substantive is called the *antecedent* of the pronoun.

10. The demonstrative pronouns agree in number with the substantives to which they are joined, or to which they refer; as, "This man;" "Those women."

11. When the demonstrative pronouns refer to something previously mentioned, *this* and *these* always apply to the last member or term; *that* and *those* to the first; as,

"Some place their bliss in action, some in ease,
Those call it pleasure, and contentment *these*."

12. A verb in the infinitive may be the nominative to another verb; as, "*To walk* often is necessary for the preservation of health."

13. When one verb governs another verb, the verb governed is in the infinitive, and, with a few exceptions, requires to be preceded by *to*; as, "I love *to* play;" "He *dares* not do it."

14. A participle, preceded by an article, and followed by *of*, partakes of the nature of a substantive; as, "Happiness is only to be obtained by *the* avoiding *of* evil."

15. An imperfect participle may also be used as a substantive, and is then subject to the same construction; as, "*Dancing* is an agreeable exercise."

16. Participles have, for the most part, the construction of adjectives, and qualify the substantives or pronouns to which they relate in the same manner; as, "A burning mountain;" "A loving husband;" "A married lady," &c.

17. An imperfect participle generally governs the objective case, if it be the participle of an active verb; as, "I came *preaching* peace."

18. Adverbs have no government, and are generally placed close to the word which they are intended to qualify; as, "He gave a *truly* excellent sermon;" "She spoke *very* perspicuously."

19. Two negatives in English have the same meaning as an affirmative; as, "*nor* did they *not* perceive the evil plight."

20. Prepositions govern the nouns, or pronouns, to which they belong, in the objective case; as, "the lady *to whom* you gave the book, returned it *to me, with her respects.*"

21. A Preposition, in common conversation, may be separated from the relative pronoun which it governs; as, "Shakespeare is a writer, *whom* I am always pleased *with;*" but in a more elevated style, it is much more graceful to join it to the relative; as, "The man, *with whom* it rested to execute the work, is," &c.

22. Conjunctions expressing a condition, possibility, doubt, concession, &c. require the verb to which they belong to be in the subjunctive; as, "*If* thou *be* the Son of the Most High!" "Except, or unless it *were* given him from above."

23. When conjunctions are merely connective, or do

not express a doubt or contingency, the verb is put in the indicative; as, "he did it, *because* it was wise."

24. Interjections have no government.

Having now laid down the most common rules for the construction of sentences, it may not be altogether useless to give a few examples of the most usual inaccuracies in this respect.

I. The most common error is the substitution of the objective cases of pronouns for the nominative; as, "it is *me*," for "it is *I*." "Who is there?" *me*, for *I*. "He is taller than *me*," for, "he is taller than I." "She is more distressed than *him*," for *he*. "*Whom* do you imagine is the author?" for *Who*.

In all such instances, if the sentence is completed, by supplying the part which is understood, the proper case of the pronoun will be determined at once; as, "You are not so learned as *I* (*am*);" "She is not handsomer than *she* (*is*)." "You conceive him to be more intelligent than (*you conceive*) *her*." "It was well expressed by Socrates; but more elegantly by Solomon than (*by*) *him*."

II. Verbs are frequently put, by mistake, in the singular number, although preceded or followed by two or more nominatives; as,

"Virtue, prudence, and fortitude *belongs* to the Christian;" for "belong."

"Of what value *is* the fondness, anxiety, and regard of parents?" for "*are*."

III. Adjectives in the same way are frequently employed instead of adverbs; as "*exceeding* well," for "exceeding*ly*;" "*horrible* ugly," for "horrib*ly*." "He conducted himself *agreeable* to his instructions;" for "agreeab*ly*."

IV. The pronouns *this* and *that*, are frequently confounded; and *this* frequently used instead of *these*; as, "*this* six weeks," for "*these*." *This* refers to something near; *that* to something at a greater distance.

PUNCTUATION.

Punctuation is the art of dividing written composition by points and stops, so as to mark the different pauses required, in a just and accurate pronunciation.

The points or marks generally used for this purpose are four in number; the comma, the semicolon, the colon, and period or full stop.

The comma separates those parts of a sentence which require the shortest possible pause in speaking.

The semicolon marks a longer pause, and is used to divide sentences into parts less dependant on one another than those which are separated by the comma.

The colon always marks the largest and most complete part into which a sentence can properly be divided.

The period, or full stop, marks the end of the sentence.

These points are thus written:

The period	(.)	The semicolon	(;)
The colon	(:)	The comma	(,)

The proportional quantity or time of the points, with respect to one another, is determined by the following general rule. The period is a pause double that of the colon in point of duration: the colon is double that of the semicolon; and the semicolon is double that of the comma. The precise duration of each pause cannot be learned otherwise than by oral instruction; as it depends in every instance on the degree of connexion between the different divisions, and the nature of the composition. Neither is it possible to lay down rules with any degree of certainty, for the division of sentences by means of points. The only way to acquire this necessary art, is to study examples of composition properly divided; and we accordingly set down the following, as the most suitable for the purpose:

"The passion for praise produces excellent effects in women of sense."

This sentence being simple, and uninterrupted by any parenthetical adjunct or expression, admits of no division by comma, or any other point.

"The passion for praise, *which is so very vehement in the fair sex,* produces excellent effects in women of sense."

In this sentence a new clause is introduced, which is not necessarily connected with the one which follows it, and which therefore requires to be separated by commas from it, as well as from the first.

"The passion for praise is, when restrained within proper bounds, productive of the very best effects; but, when allowed to become a primary principle of action, frequently gives rise to acts of the most criminal nature."

Though the sense be, in a manner, complete at "effects," yet the connexion between the first and second half of the sentence is so intimate, that a colon or full division, would have been improper. A very trifling variation would, however, render it absolutely necessary, as—

"The passion for praise is, when restrained within proper bounds, productive of the very best effects, and has impelled many to the performance of the most noble and heroic deeds, who would not have been guided by any other motive: but it cannot be too strongly impressed upon the mind, that this passion, when allowed to become a primary principle of action, frequently gives rise to acts of the most criminal nature."

The necessity of the colon to divide this sentence, and all which are of a similar nature, is so evident as to require no illustration.

We shall next give a few examples of the use of the comma, in which its necessity might not be so apparent as in those already adduced.

1. *Substantives.*

"Raptures, transports, and extasies, are the rewards which they confer: sighs, tears, prayers, broken hearts, are the offerings which are paid to them."

2. *Adjectives.*

"Gods partial, changeful, passionate, unjust,
Whose attributes were rage, revenge, or lust."

3. *Pronouns.*

"Though you, he, and they, were to combine against me, yet would I not be afraid."

4. *Verbs.*

"To be, to do, and to suffer, are the lot of man."

5. *Adverbial Expressions.*

"I remember with gratitude, his love, and services."
"He did it, but undesignedly."

6. *Conjunctions.*

"Wherefore, deeming the time that is already gone bye sufficient, walk ye, henceforth, in all manner of godliness."

Besides these points, there are a few others with which it is necessary to be acquainted, in order to point a sentence with propriety; as, the interrogation point (?), when a question is asked; the point of admiration, or exclamation (!): the parenthesis ( ), when a clause is introduced into a sentence, which neither affects its construction, nor is absolutely necessary to complete its sense: the apostrophe ('), which is either the sign of the possessive case, or of certain letters being dropped: the hyphen (-), which signifies that the words or syllables between which it is placed, are to be considered as forming one word; and the accent (ʹ), which marks the syllable upon which the stress of the voice should principally fall, in preference to the other syllables. A few examples will serve to illustrate the use of all these points much better than any general rules:

"Wanderer of the trackless air,
Wherefore dost thou sigh and rave?"

"Vain fears! vain hopes! vain supplications!
Weak and unworthy lamentations!"

"Know then this truth, (enough for man to know,)
Virtue alone is happiness below."

"Let all the ends thou aim'st at, be thy country's,
Thy God's, and truth's."

These are the principal points belonging to sentences.

A collection of sentences may be divided into paragraphs, sections, chapters, and books.

A section is marked thus (§).

A paragraph thus (¶).

CHAPTER III.

HISTORY.

History is at once the most useful and the most agreeable exercise to which young persons of either sex can apply, in order to perfect themselves in the study and the use of languages; because it makes them familiar with facts, and events, and characters, at the same that it makes them familiar with words. It gratifies that love of adventures, which nature has, doubtless for the wisest of purposes, implanted in the youthful mind; and, by setting before them what actually has happened in the world, it assists in preparing them for understanding and bearing what may happen to themselves.

But it is to be regretted, that the desire of information which, if not exclusively intended for the purpose of acquiring historical knowledge, is at all events most usefully gratified by that acquisition, is but too frequently neglected, and allowed or even encouraged to waste itself on improper subjects: this is especially the case with young females. The habits of society are understood not to demand of them the same range and grasp of intellectual information which are demanded of the other sex; and the school discipline which they are made to undergo does not admit of their being so much at large, or following those bodily and gymnastic exercises which are not only allowed, but encouraged in boys; and thus reading becomes of necessity, as it were, an earlier, and a more frequent means of entertainment. Perhaps, there is in the female constitution a stronger predisposition to this mode of employing time: but whether this be the case or not, the fact is certain; and, therefore, there is not a more important branch of female tuition than that which goes to direct their judgment toward the kind of reading that should occupy their hours of relaxation.

It too frequently happens, however, that this desire, instead of producing those advantages which even with a moderate degree of care might be ensured to it, is converted, or perhaps allowed to convert, itself into a source of idleness and insignificance for life; for instead of authentic history and the adventures of real characters being held up as furnishing the most interesting entertainment, at the same time that they open the doors of general knowledge, they are but too often held up in the repulsive character of tasks, from which the pupil recoils at every opportunity; and thus the vacant hours which they would naturally occupy, are occupied by the frivolities of the circulating library. It is not meant to bring a censure against all, or even any, of these latter productions; there is no department of literature that has not its uses; and, probably, there is not to be found upon the shelves of the least carefully selected assemblage of duodecimos, a single volume from which, lessons both of wisdom and of morality may not be drawn; but still, even the best of these are in no way comparable to the authentic annals of mankind; while in the generality of them the characters and incidents are so perfectly out of nature, and the good fortune by which the heroes and heroines of them are at last made happy, are so entirely contrary to what actually takes place, and so totally wild and romantic, that instead of serving in any way as guides to young persons in the real path of life, they deserve rather to be characterized as so many *ignes fatui;* which, by their glimmer-ing, delude the inexperienced and the unwary into a wrong one.

Whoever has attended to the dispositions of young persons must have remarked, that there is in them a very strong tendency to believe every thing that they read. Now this tendency alone, without any other consideration, might teach those who have the care of them, how essential it is, not only that the first books which they read of themselves, and not as mere exercises prescribed to them, should contain nothing but truths. When the case is otherwise, it not only creates an inordinate desire of romance, but has a tendency to destroy, or at least to confuse, the legitimate principles of belief; for when, in after life, they find out that those exquisitely, generous characters, and delightfully opportune instances of good fortune which in early life they fondly believed, are completely fallacious, and have no counterpart whatever, there can be no doubt that, if this does not tend to make them altogether disbelieve the truths which they learned in early life, it will give them a decided disrelish, not only for these, but for information in general.

If the preference which many young ladies seem disposed to give to the silliest of imaginary tales, over the most interesting of authentic histories, be not occasioned by the indiscretion of parents and teachers, in representing the latter in the repulsive attitude of something towards which they must be schooled and driven, and giving to the former that imputed sweetness, which the wise man justly ascribes to stolen waters, not because of their own superior virtue, but from the mere fact that they are come at by the desire, and at the pleasure of the partaker, in the face of restraint and opposition, it is difficult to assign any other cause for it. The human mind, in its infantine stages, so far from preferring fiction to reality, has no conception that any thing exists but the latter; and to pretend, that, without some false and perverting education, human beings would prefer histories of man's invention to the real history of the world, is but saying, in other words, if man had had the making and the conducting of the world, it would have been far more interesting and delightful than it is—a saying as absurd as it is blasphemous.

The fact is, that if the mind were permitted to come unsophiscated and unrestrained to the study of real history, it is difficult to conceive a pleasure more exquisite than it would derive from thence. The events are so gigantic, compared with the puny occurrences of a romance, and the vistas of years, through which the student is enabled to look, are so long and so magnificent, compared with the brief span of a single life, that it must require no ordinary neglect or perversion to make the smaller be preferred to the greater. And there is an additional charm: when one takes up a romance, however skilfully it may be managed, and however interesting may be its incidents, it is still a thing indifferent, in which the reader has no personal interest, or with which he can claim no relationship; but when one turns to the pages of real history, the case is altogether different:—if it be of the present time, the persons with whom we are actually acquainted, however humble, bear some part in it; and though it be traced backward to the very beginning of the record, our ancestors, whether mentioned or not, as among the actors, must in some way or other have been upon the stage, and connected with the scene. Real history, therefore, besides the grand quality of truth, has the additional recommendations of sublimity, extent, and personal interest.

It may be said, that to make historians of school girls would be a hopeless attempt—that it would be needless to demand from young ladies a knowledge of that, of which the longest and most studious life of man is barely sufficient to investigate some limited portion. And it is not meant to be argued, that young ladies should either become professed historians, or take any credit to themselves for whatever historical knowledge they may acquire; all that is contended for is, that if due attention—even a very moderate degree of attention, were bestowed on this portion of female education, ladies would not only be a good deal more intelligent, but a good deal less dependent upon frivolous amusements, than they are under the opposite system. No person, whether of the one sex or of the other, is expected to become, while at school, an adept either in history or in any thing else. That is not the meaning of education: its proper object is so to arouse the activity of the mind, and so to store it with the first and most general and simple principles of knowledge, as that any department which necessity or disposition may require, may, with certainty, be accomplished in after life. Nothing could be more pernicious, or more subversive of substantial and complete information, than to impress upon pupils that they could leave school perfectly informed in any one science, or perfectly skilful in any one art. This would be to lay an embargo on all subsequent improvement; and to substitute pedantry and self-sufficiency for that modesty and desire to be informed, which are the most amiable, because the most valuable characteristics of young persons of either sex; but although this species of confidence be highly pernicious, there is another species which is equally salutary: and that is, a feeling that there is no department of useful information, upon the successful study of which they are not prepared to enter, and which they may not, with certainty, acquire, by devoting to it the requisite portion of time and attention.

The general elements of history should in this way be taught, along with the elements of other subjects; and as the details of history happen to be more interesting, and more easily understood, than the details of almost any other science, history, as has been said, offers itself as a relaxation from study—as an amusement for play hours, highly desirable both for the good which it does, and the evil which it prevents.

The best way of teaching history, as a part of the general system of female education, obviously is, not to fritter away the time, and confine the attention to the laborious and minute details of any single nation or period, but to give a general, clear, and comprehensive sketch of the whole; to fix the great eras and events of that in the mind, and to point out the way in which the one leads to the other. In doing this successfully, it is difficult to determine at what precise stage of the course it should come in; because, though in many respects history be a simpler science than geography; inasmuch as it requires no reference to those mathematical and physical principles without which the other cannot be properly underderstood, yet there is no better artificial memory for assisting the pupil in history than well constructed maps, upon which the scenes of the different events may be pointed out. This, however, must be left to the discretion of the teacher; and, perhaps, the best way might be first to communicate the simpler and more general parts of each separately, and then to go over them a second time in conjunction.

With regard to the means of ascertaining whether the history has been read with due advantage, the best undoubtedly is a regular examination, or putting of questions upon the different portions of it, as they are read. If the teacher had always sufficient capacity and leisure, those questions should invariably be framed extempore; and instead of arranging the pupils in a class, and making them each answer a question each in succession, it is much better only to examine two or three, to examine them fully, and to take particular care that it shall not be previously known which are to be examined. If that be carefully concealed, they will all have the same inducement to prepare themselves for the examination; the teacher will be enabled to take the subject in a new order; the pupils actually examined may have the questions so framed, as exactly to suit their capacity; and if any of the rest be inattentive to what is going on, stopping the one examined, and instantly calling up the inattentive one, will effectually cure that. In those extempore examinations, the teacher should not only take especial care to avoid putting questions that may be answered by *yes* or by *no*, but to avoid using the literal words of the book which has been read, or receiving those words as an answer; because if either the one or the other of these is done, there must always be a danger that the mental advantage may be destroyed, by a conversion of the whole into a mere exercise of the memory.

Where the teacher is not sufficiently skilful, or has not sufficient leisure, prepared questions may be used. To prepare these questions, however, demands more skill than it does to write the narratives to which they apply. In them the language of the narrative should be carefully avoided; when they are printed in the same book with the narrative, they should never be such as that the mere literal words of that narrative shall be sufficient answers to them; and wherever they are printed, they should never be accompanied by answers. They should be numerous too, and so much varied in difficulty, as that some of them may be adapted to pupils of every capacity. With these precautions, the catechistic mode of teaching, if preceded by sufficient information, may be rendered very valuable; and its value applies to every branch of knowledge as well as to history.

After a general sketch of history has been read and understood, if there be leisure for it, the pupil may proceed to the more detailed histories of particular nations and ages, taking them in any order; and afterwards they may be compared—put together as it were—to observe their relations to each other, and their general union as a system.

History is valuable in three respects: on account of the events which it details, of the causes and consequences of those events, and of the characters which are connected with them. The questions for exercise on history should be so framed as to bear upon all these three, not only because they are all useful, but because of a number of young ladies, some will have greater capacity and liking for one of them, and some for another.

The causes and consequences being the most difficult, and those of which it is least easy to discover the practical application, may be most sparingly introduced; but the characters should be well attended to, not only on account of the life and interest which they give to the history itself, but because of the value of biography as a separate, or an accompanying study. No doubt, the illustrious personages which figure there are objects of emulation rather than of imitation; but still, this is a branch of reading which forms one of the most delightful accompaniments of history—those more remarkable persons who have brought about general changes, may be said to enliven the general sketch, and they who who have been conspicuous in any particular country, to enliven the more detailed history of that country.

SKETCH OF GENERAL HISTORY.

I. *From the Creation of the World to the foundation of Rome,* 3251 *Years.*

The events which this period of history presents, though they are highly important in themselves, are neither so numerous, nor, with the exception of those recorded in the Scriptures, related with such minute and accurate details, as those of succeeding times. Our sketch of the history of this period will therefore consist of little more than a simple narration of the most interesting facts and events.

The creation of the world, and of every thing which it contains, was the work of six days; the seventh was hallowed by the Almighty, and set apart as a day of rest. The original parents of the human race were Adam and Eve, who were created in purity and innocence, and placed by the Almighty in the garden of Paradise, with permission to eat of the fruit of every tree which it produced, except that of the knowledge of good and evil. Instead, however, of honouring the command of their Maker (which was given to try their faith and obedience), by abstaining from this forbidden fruit, they deluded themselves with the notion either that there was no necessity for the prohibition, or that the Almighty would not punish them so severely as he had threatened, for disregarding it. They accordingly partook of the forbidden fruit; fell from the state of innocence in which they had been created, and were expelled for ever, with a curse upon all their descendants, from the garden of Paradise.

The evil fruits of their disobedience were soon evident. One of their sons, Cain, who, like his brother Abel, was employed in tilling the ground, and in keeping flocks of sheep, being offended and jealous, on account of his brother's offering being preferred to his own, laid violent hands upon him, and slew him. Cain was in consequence driven forth "from the face of men," and a mark put on his forehead to distinguish him from all others.

Among the immediate descendants of Adam, (who lived to a great age) are to be found the first traces of those arts and inventions which have been since brought to so great perfection. Cain built a city or a village: Jabal followed a pastoral life; Jubal invented the harp and the organ; and Tubal Cain found the means of applying brass and iron to the common purposes of life.

As population increased, wickedness also spread; and, with the exception of the posterity of Seth, who continued for a while faithful and obedient, the whole human race became so vicious and depraved, that the Almighty determined to sweep it from the face of the earth. He accordingly caused it to rain so heavily for forty days, that the earth was completely inundated, and all its inhabitants overwhelmed in the deluge, with the exception of Noah and his family, who, being forewarned of God, had built himself an ark, which floated on the surface of the waters, and preserved himself, his family, and two of every species of animals, from destruction.

[B. C. 2348.] This general overthrow of the human race took place about 1656 years from the creation of the world, and is proved, beyond the possibility of doubt, not only by the record of the sacred Scriptures, and the general traditions existing among all nations, but by the appearances of the earth, and the discoveries which have been made, and are still making, of the remains of plants and animals in its bowels, which are now nowhere found alive; and which could not indeed exist owing to the nature of the climate under which they have been brought to light.

The family of Noah, consisting of eight persons, soon increased and spread abroad; making settlements and establishing colonies in different quarters. Their numbers at last increased to such a degree, that they vainly imagined themselves capable of building a tower which should reach unto the heavens. In consequence of this wicked attempt God rendered their language unintelligible to each other, and dispersed them over the face of the earth to prevent them from renewing it. The three sons of Noah, it has been supposed, took possession of those parts of the earth which were then known. Shem settling in Asia, Ham in Africa, and Japheth in Europe. Whatever truth there may be in this supposition, it is certain that Ham was worshipped as a God by the Egyptians under the name of Jupiter Hammon, and Japheth in Europe under the name of Japetus.

As the earth became more thickly peopled, progress in the arts of life became more rapid; cities and towns were built, and some sort of government established in each. Nimrod, who delighted in hunting and killing the wild beasts which then overspread the earth in great numbers, took upon him the authority of a king, and laid the foundation of Babylon. Nineveh, Damascus, Thebes, Memphis, Sidon, and Phin, all of which became so famous in future periods, were soon after founded. The corruption and depravity of the human race also increased; and displayed itself, not only in an abandonment of the worship of the true God, for that of a multitude of false gods, but also in the most disgusting rites and inhuman sacrifices. God, however, did not, as formerly, destroy the human race for their enormities; but selected Abraham to preserve the worship which was due to him, and extend the knowledge of him as the Creator and Preserver of the world; promising to him that his posterity should be multiplied "as the stars of heaven, and as the sand that is by the sea-shore innumerable." This venerable servant of God, as well as his descendants, Isaac and Jacob, led a pastoral life; and were remarkable as well for the simplicity of their manners, as for their unshaken faith in the Almighty, and their exemplary obedience to his commands.

Jacob was the father of the twelve patriarchs or heads of tribes, who removed from Canaan into Egypt at the persuasion of their brother Joseph, whom they had sold as a slave; and multiplied to such an extent, that the inhabitants became jealous of them, and oppressed them in the most cruel manner. "They were at this time called Israelites, from the name Israel," which God had given unto Jacob; and were delivered from the bondage in which they had been held by the Egyptians by means of Moses, of whom God had made choice for that purpose. In their journey towards Canaan, which, on account of their rebellion and wickedness, they were not permitted to reach, God delivered to them, by the hands of Moses, a code of moral and ceremonial law for their guidance and direction; the former of which has been the groundwork of legislation in every civilized country. Joshua, who succeeded Moses, finally brought their descendants into the land of Canaan, which was then inhabited by tribes grossly superstitious and idolatrous. These tribes they partly conquered and extirpated; but several of them remained, became intermixed with them, and drew them aside from the true worship of God.

After the death of Joshua, the Israelitish people was governed by a succession of judges; but they soon became disgusted with this form of government, and transferred the supreme authority into the hands of a king. The first who reigned over them in that capacity was Saul, a man of violent temper and unhappy disposition. Saul was succeeded by David, a prince equally distinguished by his personal talents and personal misfortunes. His son Solomon, so famed for his wisdom, ascended the throne of Israel on the death of his father, and immortalized his reign by building the temple of Jerusalem. During the government of his successor and son, ten of the tribes withdrew themselves from his allegiance and put themselves under the authority of Jeroboam, who dwelt in Samaria. These ten were called the kingdom of Israel, and the remaining two the kingdom of Judah.

1004.] While these things were taking place among the tribes of Israel, the descendants of those who had set out to establish colonies in the different quarters of the globe, had been making progress in numbers and in civilization. The Egyptians and Chaldeans became celebrated for their improvements and discoveries in the arts and sciences. Astronomy was cultivated with ardour and success by the latter; while the former were rendering themselves conspicuous by the wisdom of their laws, and the astonishing edifices which they erected. Nineveh and Babylon were consolidated into one empire called the Assyrian or Babylonian, under the authority of Ninus, who so extended its limits and dominion, that for many centuries afterwards there was no power in Asia fit to cope with it.

Along with these improvements, trade and commerce began to flourish. The Arabs, and afterwards the Jews, traded by sea with the inhabitants of the Indies; the

Phœnicians extended their navigation to the remotest corners of the then known world, and sent out colonies to the coasts of the Mediterranean, to Africa, and even to Spain. Carthage, afterwards so celebrated for its extensive commerce, and its long contest with Rome for the supremacy of the world, was founded by them, and attained, in a comparatively short period, considerable splendour and importance.

About this time, also, flourished Zoroaster, who composed a celebrated code of laws for the Bactrians, a Persian tribe, and instructed the magi, or priests, in astronomy and the worship of the sun.

Of the different races who inhabited the various countries of Europe, little is known beyond their mere names. Gaul, Brittany, part of Spain, and the south of Italy, were inhabited by the Celts; the immense and almost imperviable forests of Germany, by different tribes of the Teutones. In the north of Europe, the inhabitants were comparatively few, and extremely barbarous. The arts and sciences of Egypt were, however, transplanted into Greece, by the colonists of that country, and were brought in the course of time to a degree of perfection, which even now has not been surpassed. Cecrops founded twelve cities in Attica, while Cadmus led a colony of Phœnicians into Bœotia, and laid the foundation of Thebes. The religion of these tribes or colonies was a fabulous polytheism, which, though somewhat modified by circumstances, was undoubtedly, for the most part, of Egyptian origin. Various jealousies and animosities afterwards arose between these tribes; but in every war, which threatened the liberty and independence of Greece, they generally joined together, and made common cause against the enemy.

1183.] About this time, also, the city of Troy, rendered so famous by the two great poets of antiquity, Homer and Virgil, was, after a siege of ten years, reduced to ashes by the Greeks. The cause of this war, as related by the poets, was the carrying away by Paris, the son of Priam, then king of Troy, of the wife of one of the kings of Greece. The remains of this celebrated city, and the positions of the Grecian camp, are to be traced even in the present day.

The war of Troy brought into action all the military talent of Greece, and gave birth to heroes whose names will be known and celebrated, while the language of Greece, and the Iliad of Homer remain. The principal of them were Achilles, Agamemnon, Menelaus, Hector, Ulysses, Diomedes, Ajax, Sarpedon, and Æneas.

The manners and customs of the Greeks appear at this period to have been but little removed from barbarism. Music, however, and poetry, hitherto unknown, except in the sacred effusions of David, the king of Israel, began to flourish, and under their influence, they rapidly improved. Orpheus, of the effects of whose music and poetry so many wonderful accounts are given, lived about this time, as also Musæus and Linus. Hesiod, whose works still remain, followed next, and soon after the immortal Homer, the prince and father of epic poetry.

As the new states of Greece increased in strength and opulence, they extended their intercourse with foreign nations, planted colonies in Asia Minor, Italy, and Sicily, and improved their laws and civil institutions. The Athenians being oppressed by a cruel and tyrannical king, exchanged the monarchical for the republican form of government; while the Lacedæmonians received a code of laws from Lycurgus, so different from those of all other states, and yet so completely adapted to the purposes which they were intended to accomplish, as to render them the most singular in their manners and customs, and at the same time the most formidable in war, of all the people of Greece.

A few of the Trojans escaped from the destruction of their city by the Greeks, and were conducted by Æneas into Italy, where, about three centuries after that event, one of his descendants laid the foundation of a city, which, in the course of a few hundred years, extended its conquests to the banks of the Rhine, and the borders of India—subduing tribe after tribe, and nation after nation, till there scarcely remained a power which could dispute its supremacy.

II. *From the foundation of Rome, to the birth of Christ.* 753 *years.*

The first part of this epoch is remarkable for two great events: the downfal of the Syrian monarchy, and the destruction of Jerusalem. The former was occasioned principally by the corrupt and effeminate manners of the reigning prince, and the unwarlike habits of his subjects, who, after the destruction of their capital, Nineveh, were carried away as captives to Babylon. Jerusalem, after being three times taken by Nebuchadnezzar, was at length finally destroyed, and its inhabitants led away captives to Babylon, at that time mistress of the world, where they and their descendants remained in slavery for a period of seventy years. Babylon was taken, in its turn, by Cyrus, a Persian by birth, who united under his authority the empires of Persia, Babylon, and Media; and with a magnanimity worthy of more enlightened times, not only gave orders for permitting the Jews to return to their native country, but also for rebuilding the temple of Jerusalem. This event took place exactly at the time predicted by the Jewish prophets.

In the meantime, the kings of Egypt and Lydia consolidated their authority, and extended the boundaries of their kingdoms. Greece was making rapid progress in the arts and sciences, and gave birth to seven sages, whose names and maxims are still celebrated. These seven were Solon, lawgiver at Athens, Phales, Chilo, Pittacus, Bias, Cleobulus, and Periander. Rome also began, under the government of her kings, to extend her boundaries, and to lay the foundation of her future greatness.

The kingdom of Persia had received such an accession of strength from the wise institutions of Cyrus, and had become so much more powerful than any other state which existed at this period, that her kings were puffed up with pride and ambition, and determined to enlarge her boundaries still farther. Their efforts, however, though seconded by the most numerous and powerful armies, were, fortunately for the liberties of Greece, and for the interests of philosophy and science, wholly unsuccessful. The first who attempted to destroy them was Darius, who sent an army, under his general Mardonius, of two hundred thousand men, to invade the country. A handful of Athenians, commanded by Miltiades, and resolved on victory or death, defeated this mighty host on the plains of Marathon, with immense slaughter, and acquired for themselves the admiration of the world, and the everlasting gratitude of their countrymen. The Persians were so irritated at this signal defeat, that they determined to make still greater efforts to revenge it. An immense army, amounting, it is said, to seventeen hundred thousand men, was accordingly fitted out by Xerxes, against the Greeks; and this, too, like the preceding, was so signally defeated by the Lacedæmonians and Athenians, that few of the combatants remained to carry home the intelligence. Leonidas and Pausanias, kings of the Lacedæmonians, and Themistocles and Aristides, surnamed the Just, were the commanders of the Grecian forces—men, who will be remembered for patriotism and devoted heroism, as long as the straits of Thermopylæ, and the names of Mycalé, of Salamis, and of Platæa shall continue to be known.

Cambyses, the son of Cyrus, was more successful in his attack upon Egypt, which he finally subdued. His name is otherwise known in history, on account of his having caused his brother to be murdered, for no other reason than that of a dream which had disturbed his slumbers.

The efforts which had been made by the kings of Persia, to overturn the liberties of Greece, had united its various states in the bands of amity and friendship; but no sooner had the common danger been removed, than dissensions and animosities arose among them, and finally rendered them a prey to the artful and ambitious king of Macedon. That wily monarch saw the advantages which he would derive from the jealousy which they entertained of each other, and used his utmost endeavours to foment and increase it, by every artifice of bribery and intrigue. The powerful eloquence of Demosthenes roused the Athenians, occasionally, to a sense of their danger, and induced them to make a few efforts in favour of those states which Philip had attacked; but these only served to delay, for a few years, the downfal of Grecian independence, which finally expired in the battle of Coronea.

Previous to this fatal defeat, which established the authority of Philip over the whole of the Grecian states, literature, philosophy, science, and art, had attained to a degree of perfection unknown at that time in any other quarter of the world, and even now unrivalled in some departments. The art of war, as then practised, had been almost perfected by Epaminondas; the drama had been cultivated with the greatest success by Eschylus and Sophocles; history was clothed in all the graces of style, and all the beauties of philosophy, by Herodotus, Thucydides, and Xenophon; painting and sculpture had attained an excellence which no future period has been able to match; while eloquence, in the persons of Pericles, Demosthenes, and Æschines, gained a perfection which has excited the wonder, and bidden defiance to the genius of modern times! But, in the ruins of Grecian independence and liberty were also buried the genius and talents which had shone with such splendour in the days of her freedom. Though a few men of a philosophical turn of mind appeared subsequently to this period, there was not one among them, with the exception of Aristotle, who lived about this time, who could aspire to the most distant comparison with those who had flourished in the times of Grecian liberty, and enlightened and illustrated them by the splendour of their genius and talents. The names of Plato and Socrates are known to every reader of history; those of subsequent times, to the learned and the curious only.

Sicily was at this period divided between the Carthaginians, who were rapidly growing into consequence, and the different states of Greece. It was sometimes governed by kings, and sometimes by magistrates elected by the citizens; while Rome, as yet but little known beyond the boundaries of Italy, had been obliged to exchange the tyranny of her kings for the more popular and free government of consuls. The first Brutus rid her of one tyrant; and a second, in the course of not many ages, felt himself called upon to free her from a second.

At the other extremity of the globe, morality and jurisprudence were cultivated with considerable success, by Confucius; who, at this early period, imparted to his countrymen, the Chinese, almost all the philosophy which they yet possess.

[A. C. 331.] On the death of Philip, king of Macedon, Alexander, his son, surnamed the Great, succeeded to the throne. The same ambition which had goaded on the father to overturn the independence of Greece, impelled the son to plan and to execute still more ambitious schemes. After extinguishing the few remaining sparks of liberty in Greece, and overrunning the whole of Asia Minor, he thrice attacked and finally overcame Darius Codomanus, the last king of Persia. But his ambition was still unsated, and his desire of conquest undiminished. He penetrated with his armies as far as India, and was only prevented, by a premature death, from extending his empire still farther. He died at Babylon, on his return from India, not without strong suspicion of having been poisoned. His education was superintended and directed by Aristotle, and he was the founder of what has been called the Macedonian empire.

The death of this great conqueror was the signal for the division of the empire which he had founded. His generals, too equal in power to be commanded by one another, and thirsting for dominion, shared it among one another; and, to secure their usurpation extinguished the last remnant of the family of Macedon. For a long period, nothing but dissension and devastation, and scenes of cruelty and bloodshed were to be witnessed.

Several states, sufficiently large in extent and in power to form empires, arose in the course of time out of these convulsions; and, instead of the Macedonian empire, history will henceforth speak of Macedon and Thrace, and Syria and Pergamus, Pontus, Parthia, and Bactriana.

The conquests of the Macedonian king, though founded in unjust aggression, and necessarily made, like all others, at a great expense of blood, and treasure, and misery, were not altogether without their use. The language, the literature, the arts, and the sciences of the Greeks were diffused, by means of them, through India and Egypt; geography was improved, the knowledge of nature and her productions considerably enlarged, and the habits and manner of thinking of the conflicting parties changed for the better.

In relating the growing greatness of the Babylonian empire, we had to record the captivity of the Jews, under Nebuchadnezzar; and their restoration, under Cyrus, to their native country and the free exercise of their religion. The captives, on that occasion, were the kingdom of Judah; the ten tribes, who formed the kingdom of Israel, having been, long before that time, either destroyed by Shalmaneser who besieged and took Samaria, or carried away as captives into Assyria, from which they never returned.

On their return from their Babylonian captivity, the Jews, deeply impressed with a sense of the divine punishment, which had befallen them on account of their disobedience, continued for some time in the strict exercise of their religion, and increased and prospered. They soon, however, forgot the hand which had rescued them from slavery, and returned with fresh delight to their wonted carelessness and wickedness. The Almighty, in consequence, again forsook them, and they became subject to the dominion of the Persians.

[A. C. 332.] A remarkable circumstance in the history of the Jews is recorded, in regard to the Macedonian king, Alexander the Great, whose exploits we have recorded. While employed in the siege of Tyre, which yielded to his arms after a long and obstinate resistance, he had requested a supply of provisions from the Jews, which they refused him. He proceeded therefore to Jerusalem, to chastise them for not complying with his wishes, and, on his entry, was met by the high priest, whom he recollected to have seen in a dream two years before. The venerable appearance of the high priest, dressed in the magnificent robes of his office, and accompanied by the priests of the temple,—along with the conviction that he had before witnessed that spectacle, struck him with awe and veneration. The prophecy in the book of Daniel, in which his conquests are foretold, was shown to him, which excited his wonder and admiration to such a degree, that instead of punishing the Jews, as he had intended, he not only paid the greatest respect and attention to the high priest, but offered sacrifice, according to his directions, in the temple, and determined to take the nation under his particular protection.

[A. C. 166 to 135.] His sudden death, and the division of empire among his generals, prevented the execution of his plans; and the Jews had to endure much hardship and oppression, both from the kings of Syria and Egypt. Their hopes of independence, which had been well nigh extinguished by the repeated attacks which had been made upon them, were at length revived under the Asmonean princes, or Maccabees, who bravely contended for their religion and liberties, and gained many signal victories over their enemies.

To return to the affairs of the western states.—Although Greece had been humbled and subdued by Philip and Alexander, and the flame of liberty had ceased to burn with its former brightness, a few traces of that spirit of independence and freedom which had produced so many illustrious heroes did still exist, and gave birth to a league, (called the Achæan,) in the Peloponnesus, which struck its enemies with terror, and inspired fresh hopes of the revival of liberty. The Achæans were, however, finally subdued by their powerful enemies, and obliged to bend their necks to the yoke of the conquerors. Rome, on the other hand, now become a power of great magnitude and importance, although sorely pressed by foreign aggression, and occasionally weakened by intestine feuds, succeeded at length in humbling or exterminating every opponent. All the little states and colonies which existed in Italy at the foundation of Rome, and for many years afterwards, fell one by one, under her arms and authority. Pyrrhus, the warlike and magnanimous king of Epirus, was compelled to relinquish his attempts to subdue her; and Carthage itself, the most powerful and inveterate enemy with which she ever had to contend, razed to the foundation. The severe habits of her citizens, their love of military glory, and above all, their attachment to their country, enabled them to rise superior to every surrounding nation, and to struggle for independence and victory, where despair would have paralysed others. A fierce rivalry had long existed between Carthage, a commercial power, and Rome, which was wholly military; and that rivalship had now, [264,] acquired such a ferocious and determined character, that nothing short of the destruction of the one or the other could put an end to it. The father of Hannibal, the Carthaginian general, had made him swear upon the altar, when a boy of only nine years old, eternal hatred to Rome; a vow which he kept, not in letter, but in spirit and in reality. Having been appointed to the command of an army destined for Spain, he passed over into Italy, and by his repeated victories, brought Rome to the very brink of ruin. Though opposed by the ablest and most experienced of the Roman generals, he still advanced towards Rome—gained at Cannæ the most signal victory of either ancient or modern times, and threatened, in the course of another campaign, to extinguish the last remnant of Roman power. His troops, however, during the time that they were in winter quarters at Capua, became luxurious in their habits, and careless in their discipline; so that when Scipio was appointed to the command of the Roman army, he found them much less formidable opponents than he had reason to expect from their former victories. This general, equally distinguished for his courage, his humanity, his moderation, and greatness of mind, drove the Carthaginians out of Spain, followed them into Africa, defeated them, (now forsaken by their allies,) with great slaughter on the plains of Zama, though commanded by Hannibal, and obliged them to accept such terms as he deemed necessary for the safety and welfare of the republic. The ruin of Carthage was almost complete, [146,] in a few years afterwards she was razed to the ground; and now, not even a vestige of her ruins, great as they must have been, can be traced on the soil, from which she sent forth such powerful armies, and such innumerable fleets. Hannibal, the most skilful general of ancient or modern times, though defeated at Zama through the cowardice of his troops, and the desertion of his allies, did not relinquish his hatred to the enemy of his country; but passing from place to place, endeavoured to stir up fresh opposition.

Rome having overturned the Achæan league, and rendered herself mistress of Greece and Africa, had not, at this period, a single rival from which she could apprehend the slightest danger.

From this period, (the ruin of Carthage,) to the birth of our Saviour, about 145 years, the history of the world is almost the history of a single nation. The great rival of Rome, Carthage, had not only been laid in ruins, but all that part of Africa which had belonged to her, had yielded to her arms. Spain had either been subjugated by force, or drawn into submission by conciliation. The Numidians and Moors, though commanded by one of the most warlike usurpers, and skilful generals of the age, were conquered by her; Gaul was in part subjected; and the last ray of freedom and independence extinguished in Greece.

Rome, in fine, though she afterwards extended her limits, may now be said to have attained that period of her greatness, which was more formidable to herself than to the rest of the world. From this time, every conquest which she made tended to weaken her resources, by dividing and separating her forces; while the relaxation of discipline, and the luxurious habits engendered by the plunder of so many conquered nations, rendered her armies less effective in their operations, and more eager for spoil than for victory. Her conquests in Asia Minor, however glorious in themselves, laid the foundation of that decline, which was accelerated by external conquest, and internal discord, and which, nothing short of the existence of Carthage, or some rival state equally formidable and equally dreaded, could possibly have arrested. The destruction of that enterprising people, was in fact, the most impolitic, as well as the most cruel measure ever adopted by the Roman government; and instead of laying the foundation of greater strength and splendour, was the first omen of departing glory, and decreasing power.

Civil dissension was, in fact, from this period till the time of the emperors, as striking a feature in the history of Rome, as her external conquests. Marius and Scylla, two rival chiefs, shed in their contests for supremacy, and the proscription which followed the success of the latter, more Roman blood than had ever flowed during a similar period of external war; and laid the foundation for that confusion of the interests of the republic, with the mere interests of chiefs, which finally caused its ruin.

In the east and in the west, Rome continued to extend her conquests: Pompey overthrew Mithridates, the king of Pontus (who had made a long and hitherto successful resistance to Roman encroachment) subdued the kingdom of Syria, and extended the authority of Rome to the banks of the Euphrates, where the Parthians only, a brave and warlike race, made any thing like a stand against his arms. Cæsar, on the other hand, though firmly opposed, succeeded in overcoming the Gauls, and not only displayed the Roman eagles on the banks of the Rhine, but attempted to penetrate into Britain, then almost unknown to the Roman people.

[A.C. 47.] The success which had accompanied the arms of these two chiefs, and the popularity which they enjoyed, both with their armies, and their countrymen generally, made them look upon one another as rivals for power as well as fame. A civil war was the consequence: their two armies met, and a dreadful battle ensued on the plains of Pharsalia. Cæsar was victorious at once over his rival, and the liberty of his country. At home there was no one, after the death of Pompey, who could oppose his authority; and abroad, Egypt, Asia, Mauritania, and Spain, yielded to it without any decided resistance. He caused himself to be appointed supreme ruler in the state, under the title of perpetual dictator; aimed at regal authority, and by the urbanity of his manners, and his readiness to forgive all those who had opposed his ambitious schemes, gained the hearts, and conciliated the affections of a people, whose love of liberty had almost expired, and whose patriotism was fast sinking in the contests of rival factions.

This period of Roman history, notwithstanding its luxury, its ambition, its rapacity, its corruption, and its avarice, was distinguished by some noble examples of undaunted heroism, and chivalrous devotion to the liberties of Rome. Cicero, second only to the immortal orator of Athens, whose genius he admired, and from whose eloquence he drew large draughts of inspiration, exerted all the powers of a highly cultivated and patriotic mind in behalf of his country; attacked with unsparing severity, but merited justice, the enemies of her liberty; denounced their ambitious and selfish schemes, and finally lost his life in her cause. His works, equally distinguished by their philosophy and eloquence, attest the vigour of his mind, and his unquenchable love of his country; and will continue to be read and admired, when the vile contests of his opponents for personal aggrandizement and supreme power have faded from the recollection of men. Nor must we forget Cato of Utica, that undaunted patriot, whose example deserves to be held up to the admiration of posterity. Though he was unable to make any successful resistance to the impending ruin of his country, yet such was the disinterestedness of his conduct, and the purity of his motives, that his very enemies respected him, and would have hailed his submission as the greatest victory which they could have gained. He fell by his own hand, rather than become the subject of an enslaved state.

[A. C. 44.] Cæsar, in effecting the ruin of the republic, paved the way for his own death. The spirit of liberty though well nigh extinct, still burned with ardour in the bosoms of a few leading men, who determined to avenge her cause in the blood of her destroyer. Cæsar fell amidst their daggers in the senate-house; but his death, instead of freeing his country from the despotism of an individual, only furnished the means of establishing and confirming it. Brutus and Cassius, who had acted the most conspicuous part in dispatching the usurper, were obliged to fly from Rome, and finally lost their lives in the anarchy and civil war which ensued; Anthony, a wicked and profligate character, was defeated by Augustus Cæsar, nephew of the dictator, in the battle of Actium; and the whole power and authority of the republic fell into the hands of this crafty and ambitious individual. Egypt, the cradle of art and science, soon swelled the extent of his authority; and the land of Judæa owned the control and government of his prefects.

A. C. 1.] The whole world was now in that state of universal peace, and under that supreme dominion of Rome, in which the prophets had predicted that Jesus Christ, the Saviour of mankind, would appear. He was born at Bethlehem, in Judæa, in a state of great poverty and humility; and after working the most astonishing miracles, in confirmation of his heavenly mission, and inculcating the most pure and sublime precepts which had ever been communicated to man, expired on the cross at Jerusalem, through the malignity and hatred of the Jewish priesthood.

We have now sketched the history of the world during a period of 4004 years; and it may not be altogether useless to review for a moment the results of the mighty changes which took place during this first age of the human race. We have seen four empires or monarchies arise, and all but the last, which has just sprung into existence, extinguished or swallowed up. The Assyrian empire, founded by Ninus, ended with Sardanapalus, and was destroyed by Cyrus. The Persian empire, begun by that wise and victorious prince, finally sunk under the arms of Alexander, notwithstanding the resistance made by its last sovereign, Darius Codomanus, who fell by the treachery of one of his generals. The Macedonian empire, commenced by Philip and established by Alexander the Great, expired during the reign of Perseus, under the victorious arms of the Romans. That of Rome, which was at first governed by consuls, is therefore the only one in existence at this period. It was founded by Augustus, and like the others which it swallowed up, was also destined in the course of time to expire under the attacks of barbarian hordes.

III. *From the Birth of Jesus Christ to the Adopting of Christianity as the Religion of the State by the Emperor Constantine, in the Year* 312.

The events recorded in the preceding part of the history of the world are stated to have happened so many years before the birth of Christ; those which are now to be related belong to the Christian era, and are dated from the birth of our Saviour.

At this period, the world presents the singular spectacle of universal peace, and of almost universal submission to the authority of an individual. Gaul, or, as it is now called, France, Italy, Spain, Portugal, Switzerland, Belgium, Greece, a great part of Asia, and of Africa, owned the dominion of Rome. Christianity, in the mean time, though opposed by the malignity both of the Jewish and heathen priesthood, and at first viewed by philosophers and learned men merely in the light of a new superstition, was making rapid progress in the hearts and affections of men, in every quarter of the globe. Its apostles, supported by divine aid, and exemplifying the doctrines which they taught, by unspotted purity of conduct and dignified submission to the established governments, overcame every opposition, and triumphed over every obstacle. Churches were built and congregations formed at Antioch, Damascus, Philippi, Corinth, Athens, Alexandria, Ephesus, Thessalonica, and even at Rome. Several of its disciples lost their lives in consequence of their adherence to its cause; and by the undaunted fortitude, which they displayed in the midst of every torture which malignity or cruelty could invent, convinced their persecutors of the sincerity of their belief, and of the divine nature of a religion which could enable its followers to suffer so nobly for its sake.

The temple of Jerusalem, whose destruction our Saviour had foretold, happened about forty years after his death. The most awful scenes of desolation, of carnage, and of misery accompanied its siege and capture. The city itself was reduced to ruins, the temple burned, and its subjects scattered abroad, without any hope or any probability of being again united into a kingdom.

From the time of Augustus to the destruction of the empire under Augustus, Rome and the countries subject to its authority was governed by a succession of emperors, or rather by a succession of armies, who elected or deposed them at pleasure. Some of these emperors were distinguished for their learning and the mildness and integrity of their government; but as the authority of the army became predominant, their attention to the interests of the state diminished. Adrian, Titus, Marcus Antoninus, Trajan, and Severus, have been distinguished for the purity and integrity of their conduct as sovereigns of the Roman empire. Trajan was possessed of great military talents, and succeeded in gaining a complete victory over the Dacians, who had invaded the Roman frontiers. He dictated terms of peace to them; but, being irritated by their defeat, they made a second and a more powerful attempt, and were a second time defeated. Dacia became in consequence a Roman province. Nor did his conquests stop here. The whole of Asia, as far as the confines of India, became subject to his authority, and had he survived for any length of time, would also have acknowledged the wisdom and justice of his goverment.

Under his successor Adrian, and the two emperors who followed him, Rome continued to support her character as mistress of the world; but the growing luxury and licentiousness of the times, and, above all, the contests, among the leaders of the army for the choice of an emperor, enfeebled her authority and gradually paved the way for her downfal.

One wall was built by Adrian in Britain, extending from Carlisle to Newcastle, to prevent the incursions of the Picts into England; and another, from the Forth to the Clyde, by Severus,—who landed in person in the year 208, and marched against the Caledonians, but without being able to subdue them.

About this time also the Parthian kingdom, which had so long withstood the armies of Rome, merged into that of Persia, and encouraged that power, by the additional strength which it imparted, to continue its enmity to the Romans, and to harass them on every accessible point. On the frontiers of the Rhine and the Danube also, various hordes of barbarians, tempted by the hope of plunder, attacked the outposts of the Roman armies, and threatened the safety of the republic.

Various persecutions were directed against the Christians under Domitian and other emperors; but their consequences were directly contrary to those which had been anticipated. Christianity continued to spread more and more, and not only withstood every effort which was used to oppose its progress, but seemed to increase in proportion to the attempts which were made to suppress it. The pure and unblemished lives of its disciples, attested its salutary influence as a rule of moral conduct; their submission to the powers that were, its spiritual and unoffending nature; and the blood of its martyrs shed so freely and willingly whenever force was employed to induce them to desert it, made an impression on the public mind, which neither calumny, contempt, or ridicule could eradicate.

IV. *From the time of Constantine the Great, in* 312, *to the Fall of the Roman Empire, in* 476.

Hitherto, in treating of the history of Rome, we have only had to relate the progress of its authority and the constant additions which were made to the extent of its boundaries by the different emperors, who were invested with the imperial purple; but this state of things was not destined to last; the security which resistless power had fostered, produced a great relaxation of discipline in the Roman legions; the absence of war gave rise to luxurious and indolent habits; and although the spirit of former days occasionally broke forth and conquered in the contests which we have now to relate, the hardy habits of the barbarians who assailed them, proved more than a match for their acquired skill and mature experience. These barbarians were inflamed by the love of blood which their religion tended to foster, and the love of plunder, which the wealth of the empire strongly contributed to confirm. Under the Emperor Constantine, the empire successfully withstood their incursions; but, as we shall soon see, no sooner had it been divided, and the seat of the government removed to another city, than all, and more than all, the calamities which the Romans had inflicted on others, fell with tenfold violence on themselves.

Constantine attributed his conversion to christianity to a miracle; the reality of which has been strongly affirmed by some, and as staunchly combated by others. According to his account of the matter, the figure of a resplendent cross appeared to him in the heavens a little after noon-day, bearing the inscription, "*In hoc signo vinces,*" "under this banner thou shalt be victorious." He accordingly adopted the cross for his standard, advanced against the tyrant Maxentius, who had revolted in Italy, defeated him with great slaughter, and entered Rome the next day, where he was received and hailed as a deliverer.

Constantine was the first Roman emperor who openly embraced christianity, and under him and his successors, who, (with the exception of Julian the apostate, who endeavoured unsuccessfully to rebuild the temple of Jerusalem, and revive the pagan worship,) were equally favourable to it, it made rapid progress. The support of the state proved, however, in the course of time, a source of greater evil than its enmity and persecutions had formerly done. Many embraced it from temporal and interested views, who either did not believe in its doctrines and were attached to the rites of paganism, or only adopted its form without imbibing its spirit. The primitive purity, disinterestedness, and devotion of its disciples disappeared, and were supplanted by the grossest superstitions, the greatest hankering after worldly distinctions, and disputes in regard to articles of belief were exceedingly trifling in themselves, and by no means necessary to constitute a sincere Christian. An ecclesiastical government was formed totally different from that of the church in preceding times; and more calculated to aggrandize individuals and give birth to a persecuting spirit, than to aid in establishing and propagating the religion of Jesus. Celibacy also became a favourite virtue, and gave rise to convents of monks of both sexes for the practice of austerities, and the suffering of mortifications, the very mention of which is sufficient to excite horror and disgust.

On the death of the Emperor Theodosius, his two sons divided the empire between them. Honorius obtained the western part; Arcadius the eastern. The former was almost entirely over-run by those hordes of barbarians, who, issuing from the forests beyond the Rhine and the Danube, had some years previously made incursions into the Roman territories: they were now more successful in their attacks. The Vandals seized upon Spain and part o Africa; the Visigoths on southern Gaul and Spain; the Burgundians on the eastern part of Gaul, and the Heruli on north of Italy. The mistress of the world was thus curtailed of her former proportions, made to disgorge the accumulated treasure of ages, and to repay with oceans of blood, the carnage and devastation which had accompanied her footsteps in former times. Her chieftains and emperors, once so brave and warlike, had now yielded to the soft and degrading influence of luxury, and possessed not even sufficient spirit to face an enemy, on whom, in the times of her real greatness and splendour, the meanest of the Roman citizens would have been ashamed to turn their backs.

To this dismemberment and demolition of the Roman empire, the removal of the seat of government to Ravenna on the western, and to Constantinople on the eastern side, powerfully contributed. While Rome was the fountain from which all commands issued, her very name acted as a magical spell, and inspired her enemies with terror and dismay; but no sooner did she cease to be the abode of the emperors, than the barbarians, as if released from the influence of some mighty spell, assumed a degree of bravery and fearlessness which they had never before exhibited, and assailed her on all sides with unheard of success.

In the midst of these things the city of Venice, afterwards so celebrated for its wealth and extensive commerce, took its rise. Its foundation has been generally attributed to some followers of the barbarian Attila—a man notorious above all others for the savage and cruel nature of his disposition, and of whom it is recorded, that he made it his boast to be called "the scourge of God."

V. *From the fall of the Roman Empire in the West, in* 476, *to its re-establishment under Charlemagne, in the Year* 800.

The success which had accompanied the incursions of the barbarians in the reign of Honorius and Arcadius, the territory of which they had made themselves masters, and the plunder which they had acquired, made them thirst for fresh conquest, and undertake other expeditions. Transalpine Gaul, which had yielded to the arms of Rome under Julius Cæsar, and had continued in her almost undisturbed possession till now, fell under the dominion of the Goths, the Burgundians, and the Franks. The latter people proclaimed Pharamond king; and the kingdom was still further enlarged by the conquest of the country which had been possessed by the Huns under the command of Attila.

In the year 493, Odoaces, who commanded the Heruli in Italy, was attacked by Theodoric, king of the Goths, and forced to retire within the walls of Ravenna, which he defended with the most obstinate bravery for a period of three years. Theodoric concluded a treaty with him, by the terms of which Ravenna was to be surrendered, and the personal safety of Odoaces guaranteed; but, with the most dishonourable treachery, he no sooner took possession of the city than he put Odoaces to death with his own hand.

We now turn to the history of Britain, which, until this period, had remained in possession of the Romans. Being obliged by the incursions which were made into the very centre of the empire by the northern barbarians, to recall the troops which had been stationed in Britain, that country was left undefended, to withstand the invasions of the Picts and Scots. Their united force proved too powerful for the English, who had been long accustomed to rely on their conquerors for support; and they accordingly applied to the Saxons, a powerful nation of Germany, for assistance. The Saxons came to their relief; but, instead of delivering them from the common enemy, and returning to their own country, they reduced them under their own subjection, and founded what has been called the Anglo-Saxon heptarchy. The seven kingdoms or counties of which it consisted, were each headed by a commander-in-chief; and the general affairs of the nation regulated at a meeting, in some measure resembling a parliament, and called a Wittenagemont.

Some resistance was made, but unsuccessfully, to this faithless aggression on the part of the Saxons, and the native inhabitants enjoyed but little quiet or personal freedom, till the contests of the different chiefs had terminated in the destruction of the heptarchy, and in the transference of the whole power and authority into the hands of Egbert, (at that time chief or king of Wessex,) who caused himself to be crowned at Winchester, by the title of king of England. The heptarchy lasted upwards of two hundred years.

In Italy, after the defeat and unjustifiable slaughter of Odoaces, Theodoric reigned supreme, sanctioned by the authority of the Emperor of Constantinople, who was unable to oppose any decided resistance to his power, and who therefore contented himself with receiving his submission as his vassal. Theodoric showed himself to be an able politician, as well as a skilful warrior, and employed his Gothic and Italian subjects without any other partiality to either, than their fitness for executing his purposes.

On the death of Theodoric, the Goths, disdaining to acknowledge themselves the vassals of the Emperor of Constantinople, rebelled against his authority. Justinian, a name celebrated in the annals of legislation as well as in those of war, was at this time emperor, and soon found means to convince the Goths, that the vigour of the Romans, though weakened, was not altogether exhausted. Belisarius, one of the greatest generals who have ever lived, in any age or country, defended the city of Rome for a whole year, with only five thousand men, against an innumerable army of barbarians, of whom he slew thirty thousand in one day, while Narses, the first exarch of Ravenna, defeated the Goths, as well as the Franks and Altemanni, who had invaded Italy in great numbers, and filled it with terror and dismay. Justinian was a man of no ordinary talents; and these talents were not only highly cultivated, but rendered more effective by a cool and steady perseverance. The code of Roman laws, which bears his name to this day, is sufficient to attest the wisdom of his reign, and the vast extent of his genius.

The period of which we are treating was, however, on the whole, rather a time of misery and distress, than of national prosperity and advancement. The barbarians, who now on every hand surrounded and assailed the Roman empire, kept it in a perpetual state of alarm, and gave rise to scenes of carnage, and desolation, and distress, at which the heart sickens, and the blood runs cold. Add to these, the dreadful pestilence which broke out in almost every quarter of the world—which depopulated whole towns, and in Constantinople alone, for a period of three months, carried off daily upwards of five thousand people, and you will altogether have a picture of general misery and suffering, unparalleled in the annals of ancient or modern times. The effects of all these calamities were visible for ages, in the thinness of the population, and in the ruined state of the countries in which they happened.

In the meantime, the nations which had possessed themselves of Gaul, Italy, and Spain, had been converted from Paganism to Christianity, and acquired some resemblance in manners and habits to people whom they had conquered. Their languages, merging gradually into those of the people among whom they had settled, formed at length what are now known as the Italian, the Spanish, and the French. The disturbances and devastations, however, which they caused, along with their own ignorance and barbarity, were extremely unfavourable to the cultivation of science and literature, and paved the way for that reign of darkness, by which the middle ages of modern history are distinguished. The monasteries were the principal depositaries of the knowledge which existed in the west, and even these were not altogether safe from the attacks of the barbarians.

In the east, the sixth and seventh centuries were distinguished by the fierce disputes of the Christians, about the worship of images, which ran so high, as not only to separate the Greek and Latin churches, but to occasion the revolt of Italy from the authority of Constantinople. About the same period, also, Mahomet, an Arabian by birth, assumed the title and pretensions of a prophet, and after some struggles, succeeded in converting to his religion the numerous tribes of Arabia. A faction was at one time excited against him, which obliged him to fly from Mecca to Medina, from which, after making many converts, he returned and re-took Mecca. The religion which he taught was, in one respect, similar to the Christian. It inculcated a belief and worship of one God; but instead of committing its doctrines to the exercise of reason, recommended their propagation by force. Mahomet pretended to work miracles in support of his divine mission, and appealed, as a proof of their reality, to the style and composition of the Koran. After all, however, which has been said on this subject, it must be allowed by every unprejudiced reader of that volume, that along with a few beautiful passages, it contains much that is equally destitute of meaning and polish; and that many of the stories recorded in it are so grossly absurd, and contrary to all reason, as to excite contempt and disgust, rather than admiration and wonder.

The Saracen princes who succeeded Mahomet, pursued the same plan of propagating their faith by the sword, and were victorious in almost every quarter where they carried their arms. They made themselves masters of Persia, and narrowed the limits of the eastern empire, by taking from it Syria, Palestine, Sicily, and Africa. From Africa, they passed over into Spain, where they overthrew the kingdom of the Goths, [712,] and by their successive victories, struck terror into the heart of the whole Christian world. Charles Martel alone made a successful resistance to their invasion, and obtained a decided victory over them.

The most severe check, however, which they received, was from his grandson, Charlemagne, the son of Pepin, who had received the title of king of the Franks, at the hands of the French bishops. Charlemagne annihilated the kingdom of the Lombards in Italy, made various successful attacks upon the Saracens in Spain, subdued the Saxons, and rendered himself master of the whole of Germany. His various achievements obtained for him the title of Emperor of the West, which was conferred upon him at Rome, by the hands of the bishop, in the year 800. Charlemagne cultivated with zeal the arts and sciences, favoured the revival of literature, and enacted many wise and politic laws, both civil and ecclesiastical. The most remarkable feature in his character is that love of economy, or rather of parsimony, and that attention to little and trifling things which he exhibited, in conjunction with the highest talents, during the whole course of his life; managing his household as he did his empire, and selling the produce of his garden and poultry yard. He died in 814.

In the meantime, a new power, which afterwards, on many occasions, proved more than a match for the crowned heads of different countries, was fast springing into existence in the person of the bishop of Rome. The prelates of this metropolis of the world, from the circumstance of their local situation, had often been referred to, as umpires, in the ecclesiastical disputes which not unfrequently arose without the pale of their see. From umpires, they began to assume, though gradually and mildly, the right of interfering in all ecclesiastical matters, both of a temporal and spiritual nature, in the western church; they took the title of pope for that of bishop, which had originally belonged to them, and from the rights conferred upon them by the French over the city of Rome, as well as the grant of a considerable extent of territory from the same source, became temporal princes of no inconsiderable importance in the political system of the period. The reception of the imperial crown by Charlemagne from the hands of the pope, tended to confirm a usurpation of authority which was still further extended by the abasement and submission of his successor, Louis the Pious.

The character and situation of the clergy had become altogether different, by this time, from what it had previously been. From the apostles of a religion, whose chief recommendation and characteristics were their simplicity, purity, temperance, and unambitious disposition, they had now become possessed of fiefs and lordships—began to mix with the nobility in all public councils, and, instead of being remarkable for the virtues exhibited by the primitive church, scarcely retained any other resemblance to it, than the mere name and dress of ecclesiastics.

VI. *From the time of the re-establishment of the Roman Empire in the West, under Charlemagne, to the end of the Fourteenth Century.*

The period comprised in this section, is the most remarkable, perhaps, of any in the history of the world, for the great events by which it was distinguished, the change which was operated on society by new institutions, the general ignorance which prevailed, and the enormous increase of power which the see of Rome received. Though longer, therefore, than some of the preceding periods, we have deemed it proper to treat it without any subdivision into shorter periods, in order to preserve, as much as possible, that unity of purpose and feature by which it is characterized.

The princes who succeeded to the throne of Charlemagne, were unable to preserve it in that splendour and authority in which he had left it. The custom introduced by Constantine, and followed up by Pepin, of dividing the empire between their sons, along with the practice of rendering hereditary the great offices in the state, and converting the fiefs into hereditary lordships and manors, tended greatly to diminish the strength of the empire, and to weaken the hands of royalty itself. The numerous princes and dukes who were created, and invested with large portions of territory, began to arrogate to themselves supreme authority in their dominions, and though they formally recognised the royal supremacy, did not hesitate to dispute it, whenever it suited their purposes or inclination. Aquitain, Burgundy, and Brittany had their dukes; Toulouse, Anjou, and Flanders, their earls, who were no less powerful, and who held the people in the most slavish subjection. Normandy, also, was erected into a dukedom, [912,] on condition that the inhabitants, who had for a long period rendered themselves notorious by their piracies and robberies, would desist from such disgraceful practices.

The descendants of the house of Charlemagne beyond the Rhine, soon became extinct; and the branch of it which remained in France being totally destitute of capacity and talent, Italy and the imperial crown were seized by a succession of German princes and nobles. A diet, or assembly of the bishops, princes, and representatives of its different states having been called, a king was elected, and invested with the title of emperor of Germany, and king of Italy. This circumstance presented too favourable an opportunity for the aggrandizement of the see of Rome, and the extension of its already enormous authority, to pass unheeded; and it was accordingly very warmly embraced by the pope, who henceforth assumed the right of conferring or withholding the imperial crown according as circumstances might dictate.

The latin, or western church, having become by this time almost wholly dependant on the see of Rome, another expedient was resorted to for confirming and extending the authority and influence of the church. Celibacy, which had been hitherto confined to the monks, was strictly enjoined upon the whole church, and tended, perhaps more than any other circumstance, by separating the interests of the clergy from those of the other classes of the community, to produce that state of intellectual darkness and degrading superstition, which characterized succeeding ages. The patriarchs of Constantinople, and the clergy of the Greek church, impelled more by jealousy and rivalship, than by regard for the welfare of the people, alone presented a barrier to the dominion of Rome, which increased with the darkness and bigotry of the times, and finally, set its foot upon the neck of every prince of Christendom. Some little resistance was indeed made to its pretensions by the Ottos and Henrys, emperors of Germany and kings of Italy; but the tortuous and persevering policy of Rome was more than a match for these barbarians, and in spite of all their endeavours to the contrary, succeeded in rendering itself the arbiter in all disputes, and the supreme dispensator and fountain of honours.

The race of Charlemagne yielded at length in France, as it had done in Germany, to another of greater vigour and talent. Hugh Capet, a duke of France, received the crown in 916, and by a steady perseverance in various measures calculated both for his own aggrandizement, and the welfare of the country, succeeded in restoring it to a degree of eminence, which it had never before attained. From this period in fact, it may be looked upon, as forming one of the most important and powerful of the continental states.

The German empire also received some addition to its territories, by the acquisition of Burgundy and Lombardy in 1032, while Denmark and Sweden, hitherto almost unknown, except by the piracies and incursions of their inhabitants, began to emerge from their obscurity, and to form a part of the Christian world.

Various changes also took place about the same period in other countries. The Hungarians, natives of Scythia, possessed themselves of that country which they still inhabit, embraced Christianity, and made some progress in civilization; while the Sclavonians in Bohemia, Lusatia, Poland, and Russia, which they had formerly seized, having been converted by the ministers of the Greek church to the religion of Jesus, began also to be considered as forming independent states. The government which prevailed among them was of a feudal nature, the heads of which received the title of dukes.

We have already mentioned, that the heptarchy in England, after lasting for upwards of two hundred years, was dissolved, and formed into a kingdom under Egbert. For a long period, the Saxons were dreadfully harassed by the Danes, a barbarous and savage race, who delighted in blood and cruelty, spared neither age nor sex, and plundered the inhabitants without mercy or regard. This wretched state of things continued till the time of Alfred, surnamed the great, a wise, virtuous, and enlightened prince, who succeeded in subduing them. He divided the kingdom into shires, hundreds, and tythings for the better administration of justice, enacted many salutary laws, and used his utmost endeavours to promote the cultivation of science and literature.

The deliverance of the Saxons was, however, of very short duration. The Danes under Canute, who succeeded to the throne, again invaded England, plundered and totally subdued the inhabitants, and remained in the possession of the country, till they were in their turn overcome in 1066 by William the Conqueror, duke of Normandy.

This period of the history of the world is particularly distinguished by the spread of ignorance, superstition, and bigotry; by a belief in absurd fables and ridiculous miracles, by the addition of many foolish ceremonies to the rites of the church, by pilgrimages to the sepulchre at Jerusalem, and the erection of chapels and of monasteries, which sprang up in every direction, and became scenes of the most scandalous intrigues, and the most senseless and cruel mortifications by which human nature was ever degraded. Some little allowance must be made in favour of the Greek church which, though rapidly declining, still possessed some men of talent and learning, and presented much fewer abuses.

In the east, the disciples of Mahomet reigned with uncontrolled sovereignty, and not unfrequently exercised the greatest cruelties upon those who had come to perform their devotions at the Holy Sepulchre of Jerusalem. The indignities suffered by the pious pilgrims, and the enormous ransoms demanded by the Mussulmen for their liberation, at length excited a strong spirit of indignation throughout the whole of Christendom. One of the popes conceived the idea of conquering the Holy Land, and rescuing the sepulchre from the dominion of the infidels. His scheme was realized by a hermit, who had just returned from a pilgrimage, and witnessed the indignities which his fellow Christians suffered at the hands of the Mahometans. Traversing Europe with his staff in his hand, and preaching at every great city, court, and council, the necessity of succouring the pilgrims, and of driving the infidels from the Holy Land, Peter the hermit excited such an enthusiasm in the cause, that the whole of Christendom was ready to take up arms against the unholy possessors. Almost any other project, indeed, might have succeeded at the time, if backed by the same proposals, and promoted by the same overpowering eloquence. The serfs were anxious to free themselves from slavery; the vassals to escape from the despotism of their masters; debtors and criminals to free themselves by indulgences; and all bent upon gaining Paradise, which was held out as the reward of their enterprise. An expedition or Crusade, as it was termed, accordingly set out, consisting of an immense undisciplined multitude, under Peter the Hermit, which carried desolation wherever it went, and of which a great part found its grave in Hungary. Jerusalem, however, was at length taken in 1099 by a remnant of the feudal army, and Geoffry of Bouillon, one of the chiefs, placed upon the throne.

This period, and more particularly the capture of Jerusalem, was distinguished by the creation of various orders of knighthood or chivalry, partly military, and partly religious. A grand master, under the superintendance of the pope, was chosen for the government of each; and innumerable donations of lands and money bestowed upon them by the credulous, the enthusiastic, and the superstitious.

The new kings of Jerusalem however, notwithstanding every aid which could be afforded them, found it extremely difficult to maintain their ground against an enemy, distinguished by a high degree of bravery, and enjoying many local advantages, which they did not possess. Nor is it to be wondered at that the Crusades ultimately failed: for, independently of the immense power of the Saracens, the crusaders had also to combat the Turks, a very warlike race, of Tartan origin, who had overrun Persia, Syria, and a large portion of Asia Minor, and finally embraced the religion of Mahomet. The emperors of Constantinople were also jealous of the kings of Jerusalem, and by no means favourable to the passage of such numerous and undisciplined armies through their territories. Add to these, that the chiefs of the different nations quarrelled frequently among themselves about the right of command; and that every supply of troops, and of other necessaries for supporting and defending themselves, had to be brought from a great distance, and at a very considerable expense, and it will rather be matter of wonder that they struggled so long with the Mussulman power, than that they ultimately failed in retaining possession of the Holy Land.

[1137.] A second Crusade was undertaken, at the instigation of St. Bernard, by Conrad III. of Germany and Louis VII. King of France; but without any other result than the commission of numerous acts of pillage and rapacity on their route. This was followed by a third under Frederic Barbarossa, [1189.] Philip Augustus of France, and Richard I. of England, which, though signalized by many acts of distinguished bravery, particularly on the part of Richard, and Saladin the Sultan, was productive of no happier consequences.

The Crusades, in fine, from whatever motives they were undertaken, were certainly not wise, and very far from being beneficial to the countries which sent them out. Europe was drained by them of a large mass of her population and wealth; and although those who joined in them no doubt brought themselves better acquainted with the manners, customs, and inventions of their enemies, the benefit which was derived in this way furnished but a poor compensation for the anarchy and confusion which prevailed in their absence.

In the meantime a new kingdom of no small consequence made its appearance in Europe. Roger, a Norman baron, erected into a kingdom, Apulia, Cabria, Sicily, Capua, Benevento; to which he added, in 1139, the duchy of Naples. It did not, however, last long; for the Emperor Henry VI. having married Constantia, it went over to the house of Suabia. England, which had possessed extensive territory in the time of Henry II., who united under his crown Normandy, Anjou, Poitou, Guienne, and Ireland, experienced very considerable disasters about the end of the twelfth century, and was deprived of Normandy in 1214 by Louis IX. Venice, Genoa, and Pisa, all enjoying a republican form of government, became, on the other hand, great maritime powers, and carried on a successful and lucrative commerce with the different nations of Europe and Asia. The Venetians obtained possession of the Morea, the island of Candia, and Dalmatia, after the conquest of Constantinople by themselves and the French, as their share of the spoil.

About the same time a Crusade of a more intolerant and cruel nature was undertaken at the instigation of the pope against a body of Christians, called the Albigenses, who professed similar opinions to those which were afterwards embraced by the Protestants. The Count of Thoulouse suffered an inquisition to be established against them, and took a vow to exterminate them, which he was not slack in fulfilling.

The court of Rome had by this time established her authority over every king and prince of christendom; and assumed and exercised the power of appointing or dethroning them whenever it suited her interests. Though unpossessed of any very great extent of territory to enforce compliance with her mandates, the ignorance and superstition of the times lent a degree of strength and terror to her arms which few were disposed to contest; and at this period she may be fairly set down as by far the first power in Europe. Some opposition was indeed made to her arrogant pretensions by the Emperors Frederic I. and II., as well as by Philip le Bel of France, which gave rise to two violent factions, called the Guelfs and the Ghibellines, who long desolated the fair fields of Italy by their ridiculous contests. The former defended the supreme authority of the pope; the latter that of the emperors. The spirit by which they were actuated found its way into the conclave; where, on the cardinals disagreeing about the election of a pope, two were chosen; one of whom kept his court at Rome, the other at Avignon. From this circumstance may be dated the decline of that authority which had hitherto continued to increase, and had exercised such baleful influence on the moral and political state of Europe.

In Asia the Tartars, under the command of Ghengiz Khan, one of the greatest scourges of the human race, established themselves, during this period, in Persia, and in that part of India known as the empire of the great Mogul; while other chiefs of the same country took possession of China. The history of their conquests is only a narrative of blood and slaughter; the difference to the people whom they conquered, only a change of tyrants; and therefore any farther mention of their proceedings may safely be omitted.

In Germany, in 1273, Rodolph of Hapsburg, having been chosen emperor, laid the foundation of the present house of Austria. The authority of the emperors, however, was not so great or extensive now as in former times, and began visibly to decline. Various towns in Italy succeeded one after another in asserting their independence, and freeing themselves from the imperial yoke; and their example was soon followed by many others in Germany. Bologna, Florence, and Lucca, were the foremost in the former; Hamburg, Frankfort, &c. in the latter. Switzerland also, which had been divided into a number of petty republics, appeared among the independent states of Europe in 1307, after having long suffered the most dreadful oppression from an Austrian governor, Jagellan, who was elected king of Poland.

The first half of the fourteenth century is principally distinguished by the contests between France and England, and those of the Spaniards against the Moors. The kings of England, though the period was distinguished by some of the most celebrated victories recorded in the annals of any nation, lost a considerable portion of the territory which they had possessed in France, which was torn by internal dissension. The Moors also lost ground in Spain, by the efforts of the kings of Castile, Leon, Arragon, and Portugal, to root them out.

In literature and science, the Jews and the Saracens held the first rank. The former established many schools, of distinguised celebrity, for the promotion of learning; and the latter, encouraged by the caliphs of Bagdat, made considerable progress in astronomy, geography, philosophy, and the natural sciences. The study of these sciences, to which we may add astrology and chemistry, found its way into Spain and Italy. The Justinian code and the canons of the church now become extremely numerous and complex, excited the attention of monks and lawyers; while the philosophy of Aristotle and the writings of St. Austin became the oracles of the schools. The useful formed no part of the learning or philosophy of the age, which was more distinguished by its subtilty and total inapplicability to any practical purpose, than by its depth or beneficial tendency. Various schools and universities were indeed founded; but the men who presided over them, and the scholars whom they produced, are now only remembered for the pertinacity and trifling nature of the disputes, in which they spent their time and their talents. No work was produced by either the one or the other, which would now bear a perusal; and perhaps the only benefit which mankind owe to them, rests entirely upon their having assisted in preserving the treasures of antiquity. Duns Scotus, Lombard, and St. Thomas Aquinas, were the most distinguished of the scholastic doctors.

Some useful inventions were, however, made towards the end of the fourteenth century; among which may be mentioned the mariner's compass, so absolutely necessary in long voyages, and gunpowder, since so destructively employed. The taste for music and poetry was also revived by the troubadours of Provence and the poets of Italy; chronicles of history, and romances of chivalry were written; farces, or sacred homilies began to be in vogue; and tournaments and bull-races were at their height. But still the closest and most impartial examination of the features of the time afforded but little indication of the revival of that literature, science, and philosophy, which, in less than a century and a half, broke forth with such splendour over the face of Europe, and exercised such beneficial influence on its political and moral condition.

Before closing this sketch of the history of the darkest and most barbarous period of the history of man, we must not omit to mention that the anxiety of the sovereigns of the different states to diminish the power of the barons, who were frequently too powerful rivals of their authority, had induced them to grant various privileges and immunities to the lower orders of society, with the view of attaching them to their interests, and forming a counterpoise to the influence of the nobles. Towns began to have their magistracies and peculiar privileges; and deputies from what was called the commons, or third order, to have their seats in the legislative assemblies.

In England, nothing of any peculiar importance occurred till the year 1400, when the subjects of Richard II. becoming discontented with his government, called in the duke of Lancaster, who deposed him, and seated his own line upon the throne.

VII. *From the Beginning of the Fifteenth Century to the Commencement of the Reformation in Germany—containing* 119 *Years.*

The fifteenth century is principally remarkable for the wars between the Turks and the Tartars, and the victories which the former obtained over the princes of Christendom. Tamerlane, khan of Tartary, conquered Persia and took Bajazet, the Turkish sultan, prisoner, in 1401. The Turks were also, on the western side, vigorously opposed by Scanderberg, prince of Epinus, and by Corvin, surnamed Hunniade, whose son became king of

Hungary. These defeats were not, however, sufficient to repress Turkish ambition; for, in a few years afterwards [1444] their sultan, Amurath, attacked Ladislaus, king of Hungary, and slew him, while Constantinople, [1433] the metropolis of the eastern empire, fell by the prowess of his son, Mahomet II.

The affairs of the church in the west were again reinstated in their former condition. The schism caused by the election of two popes, which we have already mentioned, was terminated by a council, assembled [1415] for that purpose at Constance, which deposed the two reigning popes and elected another in their stead.

That council was also rendered famous by an act of a much less commendable character—the condemnation of John Huss and Jerome of Prague, for having charged the Roman church with various gross abuses. The severity of the church made them be looked upon as martyrs in the cause, and gave birth to a number of followers, whom it was extremely difficult to subdue.

[A. D. 1431.] In a few years after this event, another council of the church was convened at Basle, by pope Eugenius IV.; but finding it more refractory and unmanageable than he had expected, he changed the place of its sitting to Florence. Deputies from the Greek church were sent to it by the Greek emperor, in the hope that the schism between the two churches might be permanently terminated; but the union which took place not being generally relished, was of very short duration.

In the meantime, the council which had been assembled at Basle, not conceiving itself to have been lawfully dissolved, continued its sittings, declared its authority superior to that of the pope, and proceeded to elect one of its own. The choice fell upon Asmodeus VIII. of Savoy, who assumed the name of Felix V.; but being of a peaceful disposition, and anxious to restore the harmony of the church, he abdicated in favour of Nicholas V.

The pretensions of the kings of England to the crown of France, aided by Charles VI. were again renewed. Henry V. and Henry VI. got possession of one half of the kingdom, and of Paris itself, where they caused themselves to be crowned. The famous battle of Agincourt, one of the most memorable victories ever gained by the English nation, was fought by the former. These defeats were somewhat repaired by Charles VII. who was aided by the celebrated maid of Orleans, Joan of Arc. Louis XI. the whole aim of whose life was to render himself absolute and independent, obtained by the will of the last count of Anjou, Provence, Anjou, and Maine; and from the circumstance of its being a male fief, fell again into the possession of Burgundy.

Edward IV. was the first of the branch of York in England. His successor Edward V. and his brother, were murdered by order of their uncle, who took possession of the throne by the title of Richard III. who was slain in the battle of Bosworth, which put an end to that rivalship between the houses of York and Lancaster, by which the kingdom had been so long distracted.

In Italy various changes took place. Several noble families rose into notice, such as the Visconti, the Sforze, the Gonzagues, and the Medici;—names which frequently occur in the history of Italy, and all of which exercised considerable influence on its politics, its literature, and its science. The republic of Venice, though deprived of some of its possessions in the East by the Turks, embraced an opportunity of enlarging its possessions in Lombardy; while the crown of Sicily and Naples, of which we have already mentioned the union, was transferred to the princes of Arragon. This event took place in 1434. The most considerable movement of the period, however, was the invasion of Italy by Charles VIII. who lost the conquest almost as soon as he had made it, and the various attempts of his successors to unite the duchy of Milan to the crown of France, in which they at length succeeded. To these may also be added the famous league of Cambray, between the emperor Maximilian and the king of France, against the Venetians, which the latter succeeded in dissolving.

In Spain, the fifteenth century was marked by the union of the crowns of Castile and Arragon, in the persons of Ferdinand and Isabella, who, after a series of sanguinary conflicts, succeeded in [1492] taking Grenada, and expelling the Moors from a country which they had now ruled for many hundred years, and into which they had introduced no inconsiderable portion of learning, science, taste, and chivalrous feeling. The fate of the descendants of those brave warriors, who first planted the crescent in the soil of Spain, was truly deplorable, and conveys such an impression of the barbarity and cruelty of the Spaniards, as almost to make us regret that they should have succeeded in expelling them.

Austria received considerable additions to her strength by the marriage of the emperor Maximilian with the heiress of Burgundy, and of his son Philip with the Princess of Castile and Arragon. The consequences of these accessions will become visible when we treat of the reign of the emperor Charles.

A great change, and upon the whole a highly favourable change, was effected towards the end of this century, in the manners, habits, and modes of thinking of the different nations of Europe. The invention of the mariner's compass had emboldened seamen to desert the hitherto cautious course which they had pursued, and to undertake voyages, which no one, in former times, would have ventured to suggest. The Portuguese succeeded in doubling the Cape of Good Hope, and in discovering a maritime passage to the East Indies, where they formed large commercial establishments; while Christopher Columbus, with a few Spaniards, found out the islands of Cuba and St. Domingo, [1492.] The vast continent of America was next discovered, which derived its name from Americus Vespuccius, an Italian by birth, and at that time in the service of Spain. A new scene was thus opened for the enterprize of the speculating and the adventurous; and fleet after fleet was fitted out for the purpose of subduing this hitherto unknown region, and bringing home those various curiosities, and particularly those immense quantities of gold and silver in which it was said to abound. The old notions in regard to the extent and form of the earth, gave way to the demonstration of facts; the art of navigation received various improvements, and the operations of commerce became more extensive.

The invention of gunpowder, which we have already mentioned, introduced a considerable change into the mode of carrying on war. The weapons of attack and defence formerly in use, were found to answer very little purpose in a contest with an army furnished with fire arms, and were, consequently, laid aside: while the art of fortification, which had been rendered almost perfect, where swords, and spears, and arrows were the principal means of annoyance, became necessarily altered to suit the new state of things.

Every thing, in fact, portended a change in the state of society. The lower ranks of the community, hitherto oppressed by the feudal barons and great lords, began to emerge from that state of slavery and wretchedness in which they had formerly been held; while the nobility, deserting those castles and forts from which they were accustomed to sally forth for plunder and devastation, repaired to the court of their sovereign, and imbibed some refinement of manners, as well as liberality of sentiments. The study of the Greek classics was revived in Italy, under the fostering care of the Medici family, by those learned Greeks, who had been obliged to leave Constantinople, on its capture by the Turks in 1453; and who had repaired to that country as the only retreat from barbarity and ignorance. The discovery of the art of printing, however, in 1440, contributed still more powerfully to the same end, by furnishing at a comparatively trifling expense, and in the greatest abundance, the works of those celebrated men in Greece and Rome, which formerly could only be procured in manuscript, by the most wealthy and opulent. The Hebrew language, also, began to be studied; and the voice of the public, hitherto wholly unknown, was loudly raised against the corruptions and ignorance of the clergy, and the cruel and oppressive government of the court of Rome. The distinctive features of the period were ignorance, barbarism, and a general relaxation of morals; but these clouds were evidently shifting their place in the horizon, and were, in the course of no distant period, wholly dispelled by those master spirits of the subsequent age, who stripped the idol of the nations of her false pretensions, and laid her bare, in all her nakedness and deformity, for the inspection and almost unmingled disgust of mankind.

MODERN HISTORY.

VIII. *From the election of Charles V. as Emperor of Germany, in* 1519, *to the Execution of Charles I. of England, in* 1649.

We are now arrived at that period, when modern history may be properly said to begin; a period, of which the early and latter parts abound in events, the most interesting and important in the annals of the world. That revolution in the civil and spiritual condition of a great part of Europe, of which the corruption and immorality of the court of Rome was the main and primary cause, took place in the reign of Charles V., and was effected by the bold and intrepid conduct of a monk, of the order of St. Augustin. The name of this monk was Luther. He was a Saxon by birth, and a subject of the Elector Frederic, to whose countenance and support he was much indebted, both for the Reformation which he was the means of effecting, and for the preservation of his life on many occasions. He was naturally of a sanguine and ardent turn of mind; much devoted to studies connected with his profession; bold and courageous to excess; and disposed to favour neither friend nor foe who might differ with him in opinion. A visit which he had paid to Rome undeceived him as to the opinions which he had formerly held of the piety and sanctity of the Holy See, and laid the foundation of that opposition, which he so successfully made to its errors and profanations. His first burst of indignation against its iniquitous practices, was occasioned by a monk, of the name of Tetzel, who, under the sanction of the see of Rome, was selling indulgences, as well for sins already committed, as for those which might be committed in future. From inveighing against the sale of indulgences, he proceeded to attack the doctrines and worship of the church; and supported his remonstrances by so much reason and argument, as to attract the attention and favour not only of the multitude, but of the learned and noble in the land. Every means were adopted by the court of Rome to check the career of the reformer, and the progress of that spirit which he had lighted up in Europe—but in vain; the light of truth had been once let in, and continued to spread with the rapidity of lightning, notwithstanding every effort to obscure and extinguish it. Zwinglius at Zurich, Calvin at Geneva, and Knox in Scotland, preached with no less energy, and succeeded at length in overturning the temporal power of the pope of Rome, and introducing a more spiritual and simple doctrine, as well as a purer and less ceremonious form of worship; while in England the same ends were attained by the vices of the reigning monarch, Henry VIII. who, being refused a dispensation by the court of Rome for divorcing his wife and marrying another, withdrew from his allegiance to it, and became as bitter an enemy to popery, as he had originally been to protestantism. The reformation prevailed also in Sweden, Denmark, the Low Countries, and part of France.

Two different powers were thus created in Europe, the protestant and the catholic, which, for a long period, exercised considerable influence on the political movements of the reigning monarchs. The spirit of reason and of civil liberty, every where necessarily accompanying the adoption of protestanism, made it be viewed with alarm and dismay, by those princes who wished to exercise a despotic authority, and gave rise, in France and England, to cruelties and massacres, at which humanity shudders, and the blood runs cold. The names of Catherine of Medici and Charles IX. of France are justly immortal in the annals of infamy, for the massacre of Protestants [1167] on St. Bartholomew's day; whilst those of Mary of England and her husband, Philip of Spain, are little less so for their bigotry and intolerance, and the cool and deliberate cruelties which they commanded to be practised upon their protestant subjects.

To oppose the progress of protestantism and prop the fading glory of the court of Rome, a new religious sect under the name of Jesuits, and organized by Ignatius Loyala, a Spanish soldier, who had retired from service, made its appearance in the course of this period. The privileges and immunities conferred upon it, its complete discipline and organization, and above all its zeal, learning, and devotion to the interests of the see of Rome, rendered it a powerful auxiliary to the church; and for a period of nearly three hundred years gave to it an influence and authority, both in civil, ecclesiastical, and political affairs, which no other body of men has ever possessed; and which, for the welfare of society, it is sincerely hoped that no other will ever attain.

In consequence of the discovery of the art of printing, and the consequent circulation of the writings of antiquity, as well as the greater liberty enjoyed by the people of promulgating their opinions and discoveries;—the period of which we are treating was highly distinguished by its progress in literature, in art, and in science. The human mind, as if it had been silently acquiring strength during those centuries of darkness in which it had slept in ignorance and barbarism, burst forth with a splendour and energy unknown in preceding times, and began to exercise that influence on the tastes, dispositions, pursuits, and institutions of society, which the hurtful contests of kings and barons, the jealousies of states, the romance of chivalry, and the more foolish crusades of the church for regaining the dominion of the Holy Land, had once possessed. The barbarous Latin of the schools was exchanged, as a medium of written communication, for the language spoken by the community; and the more barbarous logical disputes in which they had abounded, and of which the philosophy of Aristotle was the foundation, for lectures on science and literature. In Italy, Dante, Ariosto, and Petrarch immortalized themselves by the brilliancy of their poetical talents; Macchiavelli by his political dissertations; and Palo Sarpi and Davila by their skill in the composition of history. France produced her great dramatic poet, Corneille; England her Spencer, Shakespeare, Raleigh, and Bacon. The reformation, in fine, brought along with it wherever it was adopted, a spirit of inquiry, investigation, and love of liberty, which was then productive of the most beneficial consequences, and the effects of which are still visible in every country to which it has extended.

We must now return from tracing the progress of the human mind in literature and liberty, to the less pleasing task of recording the political contests of the period. The Knights of St. John of Jerusalem, who had long maintained possession of the island of Rhodes, were at length driven from it by their mortal enemies the Turks, and obliged to settle in Malta; while the latter extended their empire over the fertile plains watered by the Nile. In Germany the ambitious schemes of Charles V. were vigorously opposed, on the one hand, by the electors of Saxony and other protestant princes, and on the other by Francis I. of France, the most amiable and generous monarch of his time, and his successor Henry II. Philip II. in whose favour Charles at length abdicated, and retired within the walls of a convent after a life of activity, intrigue, and war almost unequalled in history, seized for a time upon Portugal, and threatened England with an invasion; but was ultimately unsuccessful in all his enterprizes, and left Spain at his death considerably curtailed of her authority, weakened in her resources, deprived of her wealth, and diminished in her population. More than one hundred thousand Jews were expelled by his bigotry and intolerance from Spain; great numbers of his subjects, allured by the hopes of immense wealth, repaired to the New World in search of fortunes; while the Low Countries, disgusted by his arrogant proceedings and endless endeavours to deprive them of the produce of their industry, [1572] revolted from his allegiance and formed themselves into a republic, under the name of the United Provinces, which acquired consistency and strength, and at length rivalled in commerce and in war the most powerful states.

France during almost the whole of this period was torn by intestine division. A catholic league was formed to exclude from the throne the lawful heir, Henry of Bourbon, King of Navarre, which gave rise to the most dreadful scenes of carnage and devastation, which did not terminate until that prince, by a true or pretended conversion to the Roman catholic faith, had silenced all opposition to his claims. The schemes which he entertained of humbling the power of the house of Austria were cut short by the hand of an assassin in 1610; but they were carried into effect during the succeeding reign by the manœuvres of Cardinal Richelieu, who entered into league with Gustavus of Sweden, who advanced into the heart of Germany, and fell gloriously in the battle of Leipsic.

In Portugal, the house of Braganza ascended the throne; in Africa, the kingdom of Fez and Morocco was founded by a Mahometan fanatic; in Italy, Parma and Placentia were erected into duchies in favour of the house of Farnese; while Ferdinand, brother of Charles V. was placed on the throne of Hungary and Bohemia.

England, however, during this period underwent the most important revolutions. Though disgraced by the cruelties, and weakened by the impolitic measures of Henry VIII. and his daughter Mary, who used every endeavour, in conjunction with her husband Philip, to re-establish popery; she attained a degree of prosperity during the long and prosperous reign of Elizabeth, to which she had hitherto been a stranger, and laid the foundation of that maritime and commercial power for which she has long stood unrivalled by the other nations of Europe. Personally, she was a woman of strong mind, but unamiable disposition; strongly inclined to increase the authority of her crown at the expense of her subjects, and seldom scrupulous about the adoption of any measure, whether right or wrong, which she conceived necessary for the accomplishment of her purposes. Her reign was disgraced by the condemnation of Mary, Queen of Scotland, whose son James I. succeeded to the throne at her death. The ridiculous pedantry, love of arbitrary power, and pusillanimous conduct of this prince deprived him of all influence in the councils of foreign nations, and of all respect on the part of his subjects, who remonstrated loudly against the system of favouritism and senseless expenditure which disgraced his court. His successor Charles I. found the people and the parliament agitated by a totally different spirit from that which had characterized the reign of Elizabeth. Various religious sects had arisen in the kingdom, whose opinions in regard to civil and religious liberty were diametrically opposite to those doctrines about the divine right of kings, which James had been so zealous in promulgating, and to which his successor was as firmly attached. Disputes arose between Charles and his subjects on various points both of external and internal policy; which, as neither party was inclined to yield, soon broke out into open war, and terminated only in his death on the scaffold in 1649.

IX. *From the Execution of Charles I. of England in* 1649, *to the death of Louis XIV.*

Notwithstanding the excesses and devastation caused by the civil wars in France in the preceding century, that kingdom, under the management of Cardinals Richelieu and Mazarine, again attained considerable influence among the states of Europe. The reign of Louis the XIV. has been as justly celebrated for its splendour as it deserves the execration of every friend of humanity for the cruelties and devastations by which it was marked. The ambition of that monarch was insatiable, his pride domineering, his bigotry cruel and intolerant, and his morality of a very dangerous and questionable character. The progress which the arts, sciences, and literature made during his reign, and which they probably would have made whoever had been at the head of the government, has thrown a halo of glory around his name which has passed as a sufficient apology with many for the cruelties and incessant wars which marked both its commencement and termination. His generals spread alarm and consternation through the Low Countries, which they ravaged and destroyed with fire and sword; while his minions at home, by his revocation of the edict of Nantes, which had allowed liberty of conscience to the protestants, either exterminated by fire and sword, or expelled from the kingdom more than one hundred thousand of his most industrious subjects. He next entered into a war with the house of Austria on the death of Charles II. in 1700, about the succession to the crown of Spain, in which almost all Europe took part, and which reduced his kingdom to the last stage of misery and wretchedness. He succeeded, however, in placing his grandson Philip V. on the throne of Spain and the Indies; whilst the archduke of Austria received the Two Sicilies, the Milanese, and the Low Countries. For this success he was indebted to a change in the politics and councils of England, which disgracefully seceded from its alliance with the other states, whose armies were miserably commanded, and unable to cope with those of Louis. He died in 1715, and obtained the title of Great; which, if war, devastation, and unlimited expenditure and luxury, both at home and abroad, have any thing great in them, he amply merited.

His reign brought into the field many great generals, such as Condé, Turenne, Boufflers, Vauban, Vendome, &c.; some distinguished writers and preachers, such as Racine, Moliere, Bossuet, and Fenelon; and many eminent in painting, sculpture, and architecture.

Sweden, towards the end of this period again appeared, under the reign of Charles XII. a first-rate power among the states of Europe. This prince at a very early age, displayed the greatest military talents, chastised the Danes; dethroned the king of Poland, and marched against the Czar of Muscovy. With only eight thousand men, he gained the battle of Nerva, against an hundred thousand Russians. His rival, however, Peter the Great, who was endowed with greater prudence and perseverance, instead of being disheartened by the losses which he had sustained, submitted to be instructed by his misfortunes, and finally, defeated him at the famous battle of Pultowa. After various endeavours to regain the ground which he had lost, and after defending Stralsund in Pomerania against the kings of Denmark and Prussia, he at last fell, at the siege of Frederickshall in 1718, by a treacherous hand. His skill as a military man was great, his rashness and imprudence almost without precedent. He was naturally generous, proud, and obstinate; and by his foolish wars reduced his country to a state of poverty and exhaustion from which it did not readily recover.

His rival on the other hand, Peter the Great, though decidedly a barbarian in manners and habits, was remarkable for his prudence, his perseverance, and his enlightened zeal for the best interests of the country over which he reigned. He was skilled in many of the common arts of life, some of which he worked in foreign countries, for the purpose of introducing them into his own. He enacted many wise laws, founded many excellent institutions, built the city of St. Petersburg, formed a considerable navy; and did more for the civilization of his barbarous subjects, than was ever before or since done by any crowned head.

England, after the death of Charles I. was completely under the authority of Cromwell, who assumed the title of Protector. The country prospered exceedingly during his administration, and was held in greater respect and terror by foreign nations than during any preceding period. He was succeeded by Charles II. in 1660, a luxurious, dissipated, and selfish monarch, who greatly lowered the character of the country by his impolitic measures, and degraded himself by receiving bribes from the king of France. At his death, his brother, James II. succeeded to the throne, and to the hatred of the nation. Both had long been suspected of attachment to the Catholic religion, and of encouraging Jesuits, and other emissaries of the church of Rome; and the suspicion was converted into certainty by the imprudent and tyrannical conduct of James. A general terror prevailed in the nation of a return to the bloody times of Philip and Mary; the consequence of which was, that the Prince of Orange, who had married Mary, the eldest daughter of James, was invited by a powerful party to land in England, and effect a Revolution. James, on the occurrence of this event, was deserted by almost all his former adherents, and after an ineffectual struggle in Ireland, where he was defeated at the famous battle of the Boyne, retired to the court of France, where he retained the empty title of a king, and acquired that of a saint. William governed with much prudence and moderation; and the character of the country was once more respected abroad, her army and navy were victorious in every contest, and her commerce began to flourish. William having died in consequence of a fall from his horse, in riding from Kensington to Hampton Court, Anne, the next daughter of James, was raised to the throne in 1701. Owing to the intrigues of Louis XIV. to reinstate her father in his kingdom, and the ambitious designs of that monarch in other respects, war was almost immediately declared against France, in which Holland and Germany joined. The Duke of Marlborough, the greatest general and diplomatist whom England has ever produced, was appointed generalissimo of the allied army, and gained such signal victories over that of the King of France, as effectually to humble his power and ambition. He was powerfully seconded by Eugene, Prince of Savoy, no less distinguished for his military skill, who cordially joined with him in all his plans. The victories of Blenheim, Ramillies, Malplaquet, and Oudenarde, are monuments to their memory, which time will not readily efface. The war was terminated by the treaty of Utrecht, which secured to England Newfoundland, Nova Scotia, New Britain, and Gibraltar, which had been taken in the course of the war, along with the demolition of the fortifications of Dunkirk, and the liberation of those Protestants in France, who had been immured in dungeons on account of their religious opinions; Holland obtained the barrier for which she had so long sighed; the Duke of Savoy's territories were encreased at the expence of France; and the emperor acquired an undisputed title to the kingdom of Naples, the duchy of Milan, and the Spanish Netherlands. Philip was acknowledged King of Spain, and renounced all right to the crown of France.

[1714.] In a short time afterwards Anne died, after a reign of about fourteen years, distinguished by its naval and military triumphs, its progress in arts, sciences, literature, and commerce; the great number of men of eminent talents who lived under it, and the union of England with Scotland—a measure which was strongly opposed by the Scots at the time it was effected, but which has proved equally beneficial to both countries.

This period of our history, of which we have now traced the most remarkable events, produced more eminent men than any which had preceded it; in proof of which it is only necessary to mention the names of Butler, Milton, Sir W. Temple, Locke, Boyle, Addison, Atterbury, Clarke, Swift, and Sir Isaac Newton. The principles of religious and civil liberty, which the Stuarts had endeavoured to undermine, were settled by the Revolution of 1688, on a firm and permanent basis.

X. *From the Death of Louis XIV. in* 1715, *to that of Louis XVI. in* 1793.

George I. elector of Hanover, succeeded to the crown on the death of Queen Anne, which he wore for thirteen years with credit to himself, and with benefit to the country. His reign, which terminated in 1727, was undistinguished by any event of importance, if we except the attempt on the part of the Jacobites to raise a rebellion in favour of the Pretender; and the scheme of the South-sea Company, which ended in the ruin of many respectable families. The country, however, made on the whole, considerable progress in national wealth, and in repairing those losses which a desructive, though glorious war, had entailed on the nation.

George II. was a prince of warlike habits, and of considerable military genius. His reign was rendered illustrious by a constellation of victories in every quarter of the world, which raised high the naval and military character of the nation, and afforded greater scope for its trade and commerce. At home, the Jacobite party was extinguished by the battle of Culloden; in Germany, the battles of Dettingen, Minden, and Fontenoy, have rendered it memorable; in America, the French were completely beaten, and deprived of their possessions; and in India, Lord Clive gained victories over the natives and the French, unknown for their splendour and consequences, since the days of Cortes in South America. The peaceful ministry of Sir Robert Walpole was followed by one of a more energetic and glorious character—that of the Earl of Chatham, (father of William Pitt,) a name dear to every lover of the liberties and prosperity of England.

George III. succeeded to the throne in 1760. His reign is the longest, the most glorious, and the most fertile in great events of any upon record in any age or nation. Soon after his accession, the colonies in America becoming disaffected on account of the imposition of a tax on stamps, revolted from their allegiance, and after a tedious war, unsuccessfully conducted, and badly managed on the part of Britain, became an independent state under the name of the United States of America. The great instrument of their liberation, in effecting which they were assisted by the French, was General Washington, a man of distinguished firmness, moderation, prudence, and humanity. The termination of this war, the course of which had been marked by the most violent political disputes, was followed by considerable gloom and stagnation in trade, general discontent with the measures of government, and a strong desire of change, which continued until the revolution in France; and the year which ensued attracted the attention of all parties, and united them in the furtherance of one common object.

Prussia during this period acquired a higher rank by means of Frederick the Great among the states of Europe, than she had hitherto held. That prince displayed talents of the highest order in the art of war; and though his arms frequently experienced the most decided reverses, and his resources appeared to be almost at an end, he always rose from them with redoubled energy, and struck terror into his enemies by the rapidity of his movements, and the boldness of his enterprizes. He was a man of eccentric habits, delighted in the conversation and esteem of literary men, and was himself addicted to literary pursuits. Like all ambitious kings, he raised the character of his kingdom at the expense of the blood and wealth of his subjects.

Austria, under the archduchess Maria Theresa, was threatened by the united arms of France, Prussia, and Bavaria, with complete ruin, but succeeded at length in checking her enemies. The only sacrifice which she was obliged to make was that of Silesia to the king of Prussia, the duchies of Parma and Placentia to the infant of

Spain, and the promise of a small portion of the Milanese to the king of Sardinia.

Russia in the meantime was rapidly advancing in improvement and civilization; and, towards the close of the period of which we are treating, gained some additional territory, and many celebrated but bloody victories over the Turks. Her sovereign, along with Prussia and Austria, joined in the partition and dismemberment of Poland—a transaction the most infamous and unprincipled which ever disgraced the annals of any age or country.

This period of the history of France is much less brilliant, except for the many celebrated men of science, philosophy, and literature, which it produced, than the preceding, and ended in scenes of anarchy, and confusion, and bloodshed. The long and almost incessant wars of Louis XIV. had completely drained her resources, and left her in a state of apathy and exhaustion, from which she only recovered under the peaceful administration of Cardinal Fleury. Louis XV. being a minor on his accession to the throne, the duke of Orleans was appointed regent, and though profligate and careless in the extreme, contributed considerably to the improvement of the finances of the state, by keeping aloof from every warlike enterprize. Louis XV. partook of the same indolent, profuse, profligate, and peaceful disposition; but allowed himself to be hurried into several unsuccessful wars, through the intrigues of his mistresses and ministers, the former of whom completely governed him. The crown of France was stripped, during his reign, of several of its possessions abroad; its armies became only famous for their retreats, and its navy sustained some signal disasters. The nation, however, was upon the whole not in a worse condition at his death, in 1774, than on his succession to the throne. It had enjoyed considerable intervals of peace, which in some measure made up for the lavish expenditure of the court.

Louis XVI. was a prince of a more amiable disposition than any Bourbon who had preceded him, and much more zealous for the public welfare; but was not, unfortunately, distinguished by that firmness, prudence, and comprehensive understanding which was necessary to deal with times so troublous, and spirits so daring as those which he found on his accession to the throne. He cordially joined in the reform of many prevailing abuses, re-established the parliaments, restored the French navy to some degree of splendour, and, if he had not been too much controlled by his queen, Marie Antoinette, a proud and haughty daughter of Austria, would have undoubtedly made such concessions to the spirit of the age as would have preserved his own life, and kept his family on the throne. The persons by whom he was surrounded prevented him from yielding, till concession became useless. His subjects, long oppressed by the tyranny of the government, of the clergy, and of the nobles, unaccustomed to take any part in political affairs, and consequently incapable of deliberating upon them, were led away by fanatical agitators and politicians. Some of these were no doubt zealous friends of liberty and justice; but their voice was still and small compared with that of the many whose objects were private vengeance and power, and who cared not through what scenes of blood, and misery, and horror, they might have to pass in order to accomplish them. The consequence of this state of the population of France was, that, as soon as the states general had been convoked, the fire, which had been smouldering unseen, broke out into flames, and ceased not to burn till the best and noblest blood in France had been shed, drop after drop, on the altars of fanaticism and anarchy.

To enter into the particulars of the horrors which characterized this period, to enumerate those celebrated and virtuous characters who fell victims to its ferocity, or to indicate the various movements which led to the death of Louis XVI. and the ruin of his family, would be subject enough to occupy volumes. The events are, besides, fresh in the recollection of every one; and we shall therefore close this sketch of the period by a retrospect of the causes which led to it, and the progress of society in literature, science, and philosophy.

The latter part of the eighteenth century was undoubtedly marked by a spirit of inquiry and philosophical investigation, totally unknown in any former period, and fostered by the intercourse which took place between the literary characters of different countries after the peace of Utrecht. Voltaire and other celebrated characters repaired to England, for the purpose of studying its laws, its manners, and its institutions, and returned to their own country fraught with an admiration of the genius of the people, and of the excellence of their political constitution, which they were not slow in communicating to their countrymen. The spark once kindled soon spread into a flame, which was still farther fanned by the intercourse which took place between the Americans and the French during the war of independence;—an intercourse intended to ruin the prosperity and commerce of England, but which, like many other schemes of the same kind, rebounded with tenfold violence on the heads of the aggressors. Add to this panting after a liberty which they but little understood, and a form of government for which they showed themselves unripe; a complete loosening, by means of the deistical and atheistical writings of the period, of all those ties which bind society together—a sense of religion and moral obligation :—add also the vices of the clergy, the tyranny of the nobles, the public sale of the offices of justice, the embarrassed state of the finances of the kingdom, and the existence of a great number of political agitators, panting for power, and in possession of the minds of a people, easily worked up the most brutal excesses, and you will see no reason to wonder that the first years of the French revolution were marked by such sanguinary scenes.

The progrees of literature, science, and philosophy was never greater or more glorious than during the period now under consideration. England had to boast of Bolingbroke, Hume, Robertson, Smith, Johnson, Sterne, and Goldsmith, in prose; of Glover, Cowley, Cowper, Shenstone, Gay, Akenside, &c. in poetry; and of Priestley, &c. in philosophy. France rose also in the scale of intellect, and independently of Voltaire, Rousseau, D'Alembert, Buffon, Lavoisier, Bailly, and others, whose names are known to every one, produced many others, whose influence on the literature and modes of thinking of their times was by no means inconsiderable. Germany also gave birth to many celebrated men, and Italy exhibits a few names, which would do honour to any age or nation.

XI. *From the Death of Louis XVI. in* 1794, *to the present time.*

The convocation of the States-General, which took place previously to the period of which we are now treating, was the signal for the formation of various clubs or associations, whose aim was the overthrow of the government, and the delegation of the supreme authority to the

Duke of Orleans. The most powerful and influential of these were the Jacobins. Petitions, addresses, and denunciations were prepared at their meetings, and spread the flame of anarchy not only over the whole of the kingdom, but through other countries. A new constitution was formed in 1791, which yielded to another in 1792, and this, again, to a national convention, to determine the fate of Louis. Robespierre, Danton, and Marat now succeeded to the supreme authority, in the councils of the nation ; the whole country was covered with guillotines ; and the streets of every town ran red with the blood of those, whose sole crimes were their innocence, and their horror of the scenes which were daily acting. Robespierre and his accomplices at length fell under the machinations of each other ; and another constitution was framed in 1795. Some tranquillity was now restored to that unfortunate country ; her inhabitants began, once more, to taste the sweets of security, and might, possibly, have at length succeeded in establishing a government on liberal principles, had not an ambitious and highly successful officer usurped the supreme authority, at the head of a band of soldiers, and destroyed the only remaining hopes of the friends of liberty.

No sooner had the French Revolution broke out, than the different states of Europe declared war against the new republic, and commenced hostilities against it, which ended, with the sole exception of England, in disgrace and disaster. The French armies, except in Egypt, where they were opposed by the English, were every where victorious. The Prussians were defeated, and obliged to accept a peace at the hands of the conquerors ; and the Austrians shared the same fate.

The Dutch, worked upon by the emissaries of the republic, became inflamed with the same spirit, and obliged the stadtholder to seek an asylum in England. Instead, however, of deriving any advantage from this step, they only exchanged one yoke for another.

We have now to direct our attention to the progress of an individual, who, from an officer of engineers, rose, in the course of a few years, not only to the supreme authority in France, but, also, to the dominion of kings and emperors.

In 1796, Napoleon Bonaparte gained the battle of Montenotti over the Austrians, which was followed by a series of brilliant successes, to which there was no intermission, till he landed in Egypt in 1798. Here he was opposed by Sir Sidney Smith, who defended St. John d'Acre against him for sixty days, and at length obliged him to retire. Seeing no prospect of a successful termination of the war in Egypt he set sail for France—overthrew, on his arrival, the existing government, and had himself appointed to the chief command, under the title of consul. This, however, he soon exchanged for that of emperor; and extending his ambitious designs in proportion as he felt his power to increase, entered into one scheme after another for the subjugation of Europe, till every country rose in arms against him, and reduced him to such extremity, as to consent to an abdication of the throne, on condition of receiving the island of Elba as a sovereignty. There, however, he did not long remain. Returning to France in the spring of 1815, he marched, with a handful of men, to Paris without firing a shot; collected an army, and again appeared in the field against the combined armies of the Allied Powers of Europe. The battle of Waterloo, so glorious to the British nation, put an end once more to his ambitious schemes; he set sail from France, to seek the protection of England, his most powerful and bitter enemy, and was with the consent of the allied powers, transmitted to St. Helena, where he died in 1821.

We have already mentioned, that the Prussians and Austrians were defeated by the armies of the republic. They shared the same fate under the government of Bonaparte, and only regained their former position and independence after the overthrow of his army in Russia. Holland became a province of France; but was restored to her former condition in 1815, at the general pacification; the Netherlands being added to her former dominions, and the Prince of Orange assuming the title of king, instead of stadtholder.

Russia successfully opposed the armies of France in Italy, in 1798; and afterwards those commanded by the emperor in person. Having refused to agree to certain measures dictated by Napoleon, she was invaded with an immense army in 1812, commanded by the emperor in person, which, after fighting several bloody and doubtful battles, at length perished among the snows and frost of Russia, and thereby left that ambitious usurper without the means of continuing his conquests. At the peace in 1814, she acquired considerable additions, in the annexation of a great part of Poland, to her former immense territory.

England alone, during this long and protracted war, which, by her wealth, she was the principal means of bringing to a successful termination, covered herself with glory. Her fleets, under the command of Duncan, Howe, Nelson, and others, bore away the palm of victory wherever they appeared. The battles of the Nile, Trafalgar, and Copenhagen, are monuments to the memory of Nelson, which time only can efface. Nor were her armies less successful. In Egypt, the battle of Alexandria attests their undaunted firmness; in Spain, those of

Corunna, (where the gallant Moore lost his life,) Vimeira, Barrossa, Talavera, Salamanca, Vittoria; and the Pyrenees; in France, those of St. Jean de Luz, and Bayonne; and in Flanders, Waterloo.

A general peace was concluded in 1814, which was broken in the spring of 1815, by the return of Bonaparte from Elba. The battle of Waterloo again put an end to the war, and restored Europe to a state of peace and tranquillity.

The situation of the various states that had been engaged in the war, was considerably different from what it had been in 1792. Some acquired, and others lost territory—all were dreadfully exhausted and enfeebled. Sweden had been aggrandized, by the addition of Norway, to her former possessions, and had attained to considerable importance, under Bernadotte, among the states of Europe. Denmark was indemnified for the loss of Norway, by the acquisition of a part of Holstein. The Netherlands were united to Holland, under the Prince of Orange, who was created king. Austria again extended her iron dominion over the fair fields of Italy; while Russia became possessed of the greater part of Poland, and also of all Sweden, east of the Gulf of Bothnia. Prussia also came in for a share of that unfortunate and devoted country, as well as for a great part of the dominions of the Elector of Saxony, who had been created king, of which he was despoiled by the allied powers on account of his forced adherence to the fortunes of the French emperor.

In regard to colonial possessions, the Dutch, French, and Danish governments were placed nearly in the same situation in which they stood previous to the war. England alone magnanimously refused to share in the spoils which she had been the principal means of placing within the reach of the nations of the continent, and contented herself with the glory of having delivered them from the tyranny of France—a line of conduct no less politic than it was just and magnanimous.

The restored kings, forgetting the real cause of their previous humiliation, had entered into a league, which they styled, "The Holy Alliance," and which, as they pretended, was for the preservation of the catholic church, but which was, in reality, a combination against learning and liberty. The students at the German universities had, during the war and the subsequent partitions, spoken with great freedom of the conduct of Austria and Prussia; and one of their number, who had assassinated Kotzebue, a writer of some note, but at that time supposed to be a spy in the service of Russia, was regarded as a martyr in the cause of freedom. This occasioned a dislike of learning and learned men on that part of the continent; and as the causes of the dislike spread into other countries, the dislike itself followed, and produced severe, but by no means efficient restrictions on the liberty of the press.

The great and remarkable power which England had shown, when the most powerful of the other nations were bending to the yoke of France, together with the intelligence, wealth, and happiness of her people, had excited a desire for a representative form of government, on the part of some of the states. Spain set up a constitution of this kind, and so did Portugal and Naples; and an attempt was made in Lombardy to throw off the Austrian yoke. It did not seem, however, that the people of those countries were ripe for those matters; and thus, by their own want of skill and means, as well as by the direct influence of the allied powers, their attempts at liberty only ended in a more degrading tyranny than before; while those rulers, who might have been supposed to have learned prudence, if not wisdom, in their years of adversity, returned to all the indolence of their former state, and the mummeries of their former superstition.

But freedom which, having merely awakened, had been first changed for military despotism, and then for the old systems on the continent of Europe found a place throughout the whole extent of central and southern America. There, with the exception of Brazil, to which a prince of the house of Braganza had gone, the colonies of Spain and Portugal, (chiefly, indeed, those of Spain,) had formed themselves into independent states, and had been recognised as among the sovereign and independent powers. Greece, without a master spirit, to conduct matters on either side, had been engaged in a contest with the Turks; but excepting that struggle, the close of the year 1825 found Europe at peace, and setting a proud example to the world, not only of the advantages of a liberal internal government, but of unprecedentedly liberal conduct in all her commercial relations.

CHAPTER III.

ARITHMETIC.

ARITHMETIC is a branch of general education to which justice is seldom done in the female schools. It is apt to be regarded not only as a mere art which has no connexion with, and therefore does not assist in, the other branches of female education, but as an art which is in itself low and vulgar, and of use only in those mere details of house-keeping, which many, from mistaken notions, delegate to menials. Now the want of a knowledge of arithmetic is not only a great disadvantage to ladies, who have occasion to manage or superintend domestic economy; it is also a great impediment in the way of acquiring many parts, indeed almost every part of knowledge.

Number is not the mere instrument of a single art, it is one of those general elements, of which the understanding of all things is made up; and she, who without some knowledge of the principles and some expertness in the management of numbers, would attempt eminence in any other scientific subject, in geography for example, would not fail to find herself much mistaken.

That arithmetic should be improperly taught, should be considered as a merely practical one, of which very little is necessary, is not to be wondered at in the practice of ladies' schools; for in many instances it is not better applied or appreciated in those that are devoted to the education of the other sex. It is considered quite enough if, after repeated trials, the young gentleman is capable of applying to "the working of a sum" as it is called, certain rules which he commits to memory, but of the meaning and reason of which he knows nothing; and hence one has only to visit the senate or the courts of law, and mark the blunders which honourable and learned gentlemen often commit, when they have occasion to treat of the simplest matters of calculation, in order to be convinced that no education can be perfect which does not comprise something more of arithmetic than the mere performing of two or three operations by rote.

It is not argued that all males, far less all females, should be either professedly skilled in the theory of arithmetic, or perfectly dexterous in the practice of it. But there is a portion of arithmetical knowledge which belongs, not to the education of an accountant but to a liberal education generally; and with this it behoves both sexes to be acquainted. Indeed, what was stated with regard to history in the introductory paragraph to the chapter upon that subject, may be stated generally of all subjects: a well educated lady should leave her school or her governess with her mind so prepared, that it shall not only not be rude to talk in her presence upon any branch of knowledge, but that she may with confidence be able to enter upon the study of any one, if she shall be so necessitated or so disposed.

In acquiring this knowledge of arithmetic, there are several things that demand separate and careful attention. First, the nature of numbers and their several kinds; secondly, the means of expressing them in writing; thirdly, the means of reading them when they are so written; and fourthly, the changes of which numbers are susceptible, and the means of performing those changes.

Number is one of those subjects of which it is not possible to give a strict and true definition. Taking it in its most general sense, it is any thing which gives us a satisfactory answer to the question, *how many?* *One*, or *unity* as it is sometimes called, is the smallest and simplest of all natural numbers; every other natural number consists of more or fewer ones; it is said to be great according as there are many, and small according as these are few; the difference of two natural numbers cannot be less than one; and one is the least part that can be added to a natural number or taken away from it. There are indeed other numbers which are considered as, in some cases, being less than one; but before these numbers can be imagined to exist, some *one*, or *whole*, must be supposed to be divided into parts, which parts are, in the language of arithmetic, called *fractions;* and as any thing that admits of being divided into parts, may be imagined to be divided into as many as one pleases; a fraction may be ever so small in comparison with the one or whole, of which it is considered to be a part: thus a lump of sugar which was once a whole, may be crushed into pieces or crumbled into powder; and thus a quantity of water may either be poured into different vessels or evaporated into steam.

Numbers, without any regard to how few or how many they are, may be considered in two points of view. First, they may he considered as *abstract* or general; and secondly, they may be considered as *concrete* or particular.

When the name of a number is used without relation to any kind of beings or things, it is abstract; but when the name of any being or thing is added to it, it is concrete; thus *three* is an abstract or general number, because it may mean three of any thing; but *three books* is a concrete or particular number, because it can be applied only to one particular kind of things,—namely books.

In abstract numbers *one* is always equal to *one*, because, not having any precise value independently of being itself and not another number, it cannot be greater or less in any one instance than in any other; but in concrete numbers; the value of *one* not only varies with that of the thing named after the number; but with the particular value of that thing compared with others of the same class: thus *one* house is not only different in value from *one* window, but one house upon this side the way may be more or less valuable than one house upon the other side of the way.

From this it is quite evident that we can always tell, when hearing them named, which of two abstract numbers is the greater, which the less, or whether they be equal. They are equal when they contain the same number of times one; and that which contains more ones is greater than that which contains fewer. Thus *one* becomes as it were the *measure* of all numbers of this kind; that is, it determines how great they are, and which is the greater compared with others.

Numbers, considered in this abstract manner, are among the most simple of all subjects about which one can think or reason; for they have only one quality, when considered in themselves, namely, "how many" (that is how many times one) "they express;" and they have only another quality, when compared with other numbers of the same kind, namely, how many more or how many fewer they are than those.

These may seem to be matters so simple, and so perfectly self-evident, that it is not necessary to give any explanation of them; but it is for the want of calling the attention of young people to those very simple parts of education, that makes them find any part of it difficult. When they are once understood, all parts of knowledge are about equally simple, and the steps toward any one of them would be just as simple too, if the preparatory ones were properly understood.

Particular numbers, that is, numbers when used in conjunction with the names of particular things, have two values: they have one that depends upon the number of times *one*, which is expressed by the name of the number, and another that depends upon the value of that *one*, which is expressed by the name of the thing. The first of these is called the *number*, and the second the *denomination*, and the whole that is made up of the number and denomination is called a *quantity*. Thus, when we say *five ladies*, or *five books*, the word five expresses the *number* in each, while *ladies* expresses the *denomination* of the one, and *books* the denomination of the other.

So that two particular numbers, as one might call them, may be alike or different in more respects than one: they may be equal in number, but not in denomination; and in those cases, that of which the denomination has the greater value, will, upon the whole, be the more valuable of the two: thus *six pounds* and *six shillings* are two quantities, which are exactly equal in number; but in as much as the denomination *pounds* is greater than the denomination *shillings*, the quantity of which it is, the denomination, is the greater of the two. In like manner, if the denomination were the same in both, but the number different, it is perfectly evident that that which had the greater number would have the greater value upon the whole. If both numbers and denominations were equal, the perfect equality of the quantities would follow as a matter of course; and if the superiority of the denomination in the one just made up for the superiority of the number in the other, the equality would be equally evident. Thus, if there are equal numbers of pounds in any two sums of money, these sums are equal; and two sums of money would also be equal if there were just twenty times as many shillings in one as there were pounds in the other.

In consequence of this confusion or combination of circumstances, upon which those values depend, they are considerably more difficult to be understood, and therefore not so fit a medium through which to explain the first sketch of arithmetic, as those abstract or simple numbers, of which the comparative value depends solely upon their being few or many.

SKETCH OF PRACTICAL ARITHMETIC.

PART I. ARITHMETIC OF SIMPLE NUMBERS.

1. *Nature, Notation, and Numeration.*

The nature of simple numbers has been partially explained already; Notation is the name given to the method of writing or expressing numbers by peculiar characters, different from the common alphabet of language; and Numeration is the name given to the reading of them, after they are so written.

Taking *one* as the smallest of the natural numbers, they proceed in a regular series, each being one greater than that which precedes it; and as one can conceive no end to this series, it would be utterly impossible to have a different name for each number, or a different character for expressing it. This naturally leads to the adopting of some method of arrangement, by means of which a limited number of names and of characters denoting those names, shall serve for as many numbers as it is easy to imagine. There is another reason for some contrivance of this kind; when a number is very large, it is not easy, or even possible, to tell what it is. Tumble a basket of common pins promiscuously upon a table, and you shall not be able even to make a mere guess at how many there are; but arrange them in rows in paper, let there be (say) ten pins in each row, ten rows in each paper, ten papers in each bundle, and ten bundles in each heap, and then the whole number could be told without any very great difficulty.

A similar contrivance is made use of for understanding and expressing numbers. Ten *ones* or *units* make a *ten*, ten tens make a *hundred*, ten hundreds make a *thousand*, and so on,—every *one* of the next greater parcel, or class, or rank, or whatever you may choose to call it, being exactly equal to *ten* of that which immediately precedes it. In this way only *nine* simple and original names, each of them expressing the whole of the numbers of which they are the names, are required, together with either separate or compounded names for classes.

These simple names are, *one*, *two*, *three*, *four*, *five*, *six*, *seven*, *eight*, and *nine;* and they are used as well for the *whole names* of the numbers to which they are simply and originally applied, as for *parts* of the names of the other classes. Thus, when the name *two* denotes individuals, it is used alone; but when it means *hundreds* or *thousands*, or any larger class, the name of that class is added to it.

The names of the classes, as far as ever they are needed for practical purposes, and indeed a good deal farther, are these: *units*, *tens*, *hundreds*, *thousands*, *tens of thousands*, *hundreds of thousands*, *millions*, *tens of millions*, *hundreds of millions*, *thousands of millions*, *ten thousands of millions*, *hundred thousands of millions*, *billions*, and so on,—the word *billions* being continued till it has appeared in six classes; after which comes the word *trillions* for as many more; the word *quadrillions* for as many after that; then the word *quintillions,* and so forth. The *ten,* the *hundred,* the *thousand,* and the *million,* are, however, the only original names, after the first nine, which are used in all the ranks; for *billions* is only a short way of saying *millions* twice, trillions of saying *millions* three times, and so on.

If these names are written out, it will be found that a new name is introduced after every six; and that, excepting in that new name, which belongs to all the six, the rest of them are the same: thus,

First,	Units, millions, billions, &c.
Second,	Tens of, &c.
Third,	Hundreds of, &c.
Fourth,	Thousands of, &c.
Fifth,	Ten thousands of, &c.
Sixth,	Hundred thousands of, &c.

In further examining these it will be found that the first three of each six have *units, millions, &c. tens* and *hundreds;* and that the second three have, besides the name common to the six, *thousands, ten thousands, hundred thousands.* Thus the expresssing and reading of numbers is farther simplified by this arrangement of the classes into sixes, and the subdivision of these sixes into threes.

From this method of naming numbers, it is obvious that by whatever characters the names are represented, no more characters are required than there are original words; the number of which is altogether only *thirteen!* and even four of these, *ten, hundred, thousand,* and *million,* as they happen to be the names of classes, are dispensed with by the introduction of a character which points out the class and not the number.

The characters are these:

For *one* 1, *two* 2, *three* 3, *four* 4, *five* 5, *six* 6, *seven* 7, *eight* 8, and *nine* 9. The character which denotes the place to which any of them happens to belong being written 0, and called *cipher*, *nothing*, or *'ought;* any one of the nine characters, or *figures* as they are called, stands always for the same number, but that number may belong to any class; thus 3 stands for *three ones;* 30 for *three tens*; 300 for *three hundreds*, and so on; every 0 that is put after it making it stand for the next in rank by ten; put *before*, 0 does not alter any thing.

The lowest rank or class always is put on the right hand, so that the highest ones are first named in reading.

When a number consists of several ranks these are put in their proper places; and if any place would be blank it is supplied by 0. This is merely a short method of writing, for in reading the classes are named as if they were written separately. Thus, if the number were *three thousand and seventy-five* it would be written 3075, but it would be read as if it were 3000, 70, and 5.

Each of the nine characters used for the expressing of numbers has thus two values; one which depends upon its form, and which never changes; and one which depends upon the place, and which alters with every change of that place; being made ten times greater by every place that it is removed from the right hand.

When in two numbers two figures are equally distant from the right hand, 1 in the one of them is always equal to 1 in the other; and two numbers are equal in every respect when the same figures occupy the same places.

The reading and the writing of numbers are easily learned; the pupil has only to write a row of different figures, interposing a 0 here and there, then write *units* over the right hand one, *tens* over the second, and the other names in their order, as they have been explained; and then beginning at the left hand pronounce the name of each figure with the words written over it; and the whole will be the name of the number. If this be done very carefully a very few times, the numbers may be read without writing the names of the places; and then the business of notation and numeration is completed.

The nature of numbers, and the method of reading and writing them being understood, the pupil may proceed to combine them together and to perform what are called the "common rules," or common operations of practical arithmetic.

In comparing two numbers, that which consists of the greater number of figures is always the greater; and if they have the same number of figures, the greater is that which hath the greater figure on the left hand.

There are only two ways of changing a number,—making it greater and making it less; but each of these may be done in two ways, and for two different purposes; thus the object may be to make a number greater by taking along with it or adding to it several numbers all different, or by adding to it a certain number of numbers each of them equal to itself. These two are the same in principle; but they are performed in different ways; and the one is called *Addition*, and the other *Multiplication*.

In like manner, a number may be diminished by taking away from it any number or numbers, that are not altogether greater than itself, and this is called *Subtraction;* or the object may be to find how much any part (say the third part) of the number would be, and this is called *Division*.

Addition, Multiplication, Subtraction, and *Division* are the *four rules* of arithmetic. The method of performing them is easily explained; but nothing except careful exercise will enable any one to elicit either with ease or with accuracy, and without these the practice of arithmetic is of no use.

2. *Addition.*

The object of addition is to find one number that shall be exactly equal to several numbers; or to express by one number that which is found in two or more.

It was mentioned that numbers are equal when they contain the same number of times *one;* and consequently one number will be equal to the whole of several numbers, when it contains as many times *one* as them all; this number, when it has been found, is called the *sum* of all those numbers to which it is equal.

The object of addition being understood, the next thing is, how to accomplish it; and in order to understand this, it is necessary to reflect, that before things can, strictly speaking, be called *one* number they must be all of the same kind, thus: a book, a chair, and a table, cannot properly be called *three,* because they are not three of any one kind of things. In like manner *one unit, one ten,* and *one hundred,* cannot be called *three,* or in any way represented by the character 3; but as any two or more numbers of chairs, tables, books, or other things of the same kind may be expressed by one number, so may any two or more numbers of units of tens, or of any one rank or class of numbers, according as they have been explained in the preceding section.

It was already mentioned that one number is made up of, or in other words is the sum of, all the units, tens, hundreds, &c. of which it consists; and in like manner the sum of several numbers must be the same as the sum of all their units, all their tens, all their hundreds, &c. Or simply, the numbers in all the corresponding ranks or places, must be collected into as many sums as there are of these, and then if those sums be all written after each other in proper order, the sum of the numbers will be obtained.

As the number in any one place can never exceed 9, more than 9 will never have to be added at one step of the operation; and if the sum of any rank exceed nine, that is, amount to two figures, the left hand one of three will belong to the next rank toward the left, and must be taken in with it. Hence the following

Rule for addition. Arrange the numbers so that the corresponding places from the right be under each other; count up how many the numbers in each rank make, and, writing the units of it below the rank, take in the tens with the next rank toward the left. The operation must be begun with the units, and the whole of the left hand sum must be written down.

A single example will sufficiently illustrate this; let it be required to find the sum of 8275, 1946, 92807, and 7258.

Arrange thus:

$$\begin{array}{rl} 8275 & \\ 1946 & \\ 92807 & \\ 7258 & \\ \hline 110286 & \text{Sum.} \\ \hline \end{array}$$

The lowest figure in the units rank is 8, to which, if 7 be added, it makes 15, then 15 and 6 make 21, and 21 and 5 make 26; that is, 2 tens and 6 units. The 6 units are written below as the units of the sum, and the 2 tens are taken along with, or as it is called "carried to" the tens. The tens are summed in the same manner: the 2 that were carried and 5, make 7, 7 and 4 make 11, 11 and 7 make 18—8 to be written down, and 1 to be carried to the hundreds. In the hundreds, (1 carried,) and 2 make 3, 3 and 8 make 11, 11 and 9 make 20, 20 and 2 make 22—2 to be written down, and 2 to be carried to the thousands. In the thousands, (2 carried,) and 7 make 9, 9 and 2 make 11, 11 and 1 make 12, 12 and 8 make 20—0 to be written down, and 2 to be carried. Lastly, in the ten thousands, (2 carried,) and 9 make 11, which is written down. Thus the sum of the numbers is 110286; and in the same manner the sum of any other numbers however many, or however large, might be found.

The process is a very simple one; for, in adding each number, one has only to count forward as many from the last sum as there are 1s in that number.

3. *Multiplication.*

The object of multiplication is to find the number that results from repeating one number as often as is expressed by another. The number that is to be repeated, is called the multiplicand; and the number which shows how often it is to be repeated, is called the multiplier: the multiplicand is said to be multiplied by the multiplier; the number produced is called the product, and the other two numbers are called the factors of that product. Thus multiplication may be more briefly defined as being the method of finding the product of two given factors.

Multiplication might be performed upon precisely the same principles as addition—the only difference in the form being that, instead of the given numbers being written down, and added, the one of them would have to be written as often as the other expressed, and these repetitions added. Then, if the product of 1824, and 28 were required, 1824 might be written 28 times all under each other, and then added together, as in the preceding section. If, however, the number of times happened to be very great, the process would be exceedingly tedious, and therefore, means of abridging it have been devised; and, it is the application of those means which is, practically speaking, termed Multiplication.

The first thing to be done in order to perform this operation is, to commit to memory all the products of the numbers under 10, by all the numbers under 10; and the pupil may learn this by rote from a printed "table of multiplication;" or, which is better, as it takes less time and is more certain to be accurately remembered, find the products by addition, and make them into a table.

When, by either of those methods the pupil has acquired a perfect and ready knowledge of the table, it is to be applied upon these principles:

Since the units, tens, &c. of a number make up the whole of that number, it is obvious that multiplying these separately, or multiplying by them separately, and collecting the results, will be the same in effect as multiplying by the whole; or that to multiply the whole of one number by the whole of another, we have only to multiply all the figures of the one by all the figures of the other: that is, "multiply the whole of the one factor by each figure of the other in succession, and add the products."

The right hand figures of these products must not, however, be placed under each other as in addition; because, they are not, like those in addition, all units.

If the figure by which any number is multiplied be units, 3 for instance—the product of each figure of the number so multiplied will belong to the same class with that figure itself; that is, the products of the units, tens, and hundreds, &c. when multiplied by units, will be respectively, units, tens, and hundreds; but if they be multiplied by tens, each of them will be ten times greater than when multiplied by units—that is, the product of the units will be tens, that of the tens hundreds, and so on. In like manner, the product of the units of the multiplicand, when multiplied by any one figure of the multiplier, will always belong to the same class with that figure. For instance, if 729 were to be multiplied by 256, the product by the units' figure (6,) would be all units; that by the tens' figure (5,) would be all tens; and that by the hundreds' figure (2,) all hundreds. Hence the following

Rule for Multiplication.—Place the multiplier under the multiplicand, multiply all the figures of the former by all those of the latter, setting the right hand figure of each line of the product immediately under that part of the multiplier from which it arises, and add the products thus obtained.

In illustration of this, let it be required to multiply 729 by 256.

Arrange thus:

$$\left.\begin{array}{lr}\text{Multiplicand.} & 729\\ \text{Multiplier.} & 256\end{array}\right\}\text{ Factors.}$$

$$\begin{array}{rl}\hline 4374 & \\ 3645 & \\ 1458 & \\ \hline 186624 & \text{Product.}\\ \hline\end{array}$$

First, multiplying 729 by 6, we have—6 times 9, 54; write down 4, and carry 5; 6 times 2, 12, and 5, 17; write down 7, carry 1. 6 times 7, 42, and 1, 43; which write down. Secondly, multiply 729 by 5: 5 times 9, 45; write 5, (under 5, or in the tens' place, because 5 is tens;) carry 4: 5 times 2, 10, and 4, 14; write down 4, carry 1: 5 times 7, 35, and 1, 36; which write down. Thirdly, multiply 729 by 2: 2 times 9, 18; write 8 (under 2, or in the hundreds' place, because 2 is hundreds;) carry 1: 2 times 2, 4, and 1, 5; write down 5: 2 times 7, 14, which write down. Lastly, add these three lines, the product is 186624; and it is the true product, because all the figures of the one factor have been multiplied by all the figures of the other. In the same manner, the product of any other factors, however great, might be found; or if there were three or more factors, the "continual product" as it is called, might be found by multiplying the first by the second; then multiplying their product by the third, and so on.

From the way in which the multiplier is employed, it is obvious that, considered in regard to the product, it is not precisely the same as an ordinary number, inasmuch as it represents not a number of *ones*, but a *number of times*—namely, the times that the multiplicand would have to be repeated, if the operation were performed as in addition. The multiplier forms no part of the product or result, it only shows how the multiplicand is to be treated, in order to obtain the product.

The most general and obvious use of multiplication consists in finding the price, weight, or value of any number of things, when the price, weight, or value of one of them, and also the number of them, are known. Those who are adepts in arithmetic, devise means of shortening it, and also employ other and easier methods which in practice tend to the same results; but the explanation of these would not be consistent with a sketch so brief as this must necessarily be, neither do they form part of those general principles of arithmetic which ought to be introduced into every liberal education, whether for the one sex or for the other; and whether there be any probability that the pupil shall have occasion for the actual practice of arithmetic or not.

4. *Subtraction.*

The object of subtraction is to find by how much the greater of two numbers exceeds the less, or how much of the greater would remain if a part equal to the less were taken away.

Subtraction is the opposite or converse of addition; and just as the sum of two numbers, is the sum of the units, tens, hundreds, &c. of which those numbers consist; the difference of two numbers, is the difference of their units, tens, hundreds, &c.; and if the less number be placed under the greater, and the number by which every rank in the latter exceeds the corresponding rank in the former, be written below, the numbers so written will, taken together, form the difference of the two numbers.

In this however, there is a difficulty, though a slight one; for as the greater of two numbers is not necessarily that which has all its figures greater than the corresponding figures of the other, but that which has the greatest number of figures, or the greatest left hand figure, when the numbers are equal, and which may thus have any number or even all of its figures less than the corresponding figures of the smaller number. It may happen, that no one figure of the less can be taken away at once from the corresponding figure of the greater: thus, 1000 is greater than any number that consists of only three figures

—greater than 875, for instance; and yet its units, its tens, and its hundreds are all respectively less; and thus it is impossible without some sort of contrivance to find the difference of two such numbers.

The contrivance resorted to depends upon this principle: Equal numbers have no difference, and, therefore, if equal numbers be added to unequal numbers, one to each, the difference of the unequal numbers will not thereby be altered. For instance, 4 and 7 are unequal, the difference being three, and if you add equal numbers to them (say ten to each) and call the one 14 and the other 17, the difference will still be three. By the nature of numbers, as explained, 10 in any place is the same number as 1 in the place immediately to the left; and, therefore, if 10 be put, or supposed to be put, to any figure of one number, and if, at the same time, 1 be put to that place of another number which is one farther toward left than that to which ten was put in the other, the difference of the two numbers will not be altered. Thus, in the two numbers 1000 and 875, if ten be put to each of the three 0s in the first, and 1 to the 7, the 8, and to the next place to the left of 8, in the last, the difference will not be altered, while the figures of the former will be all respectively greater than the corresponding figures of the latter, and thus the latter can be taken from the former, and the difference known. In comparing the units figures, the difference will be that between 5 and 10, or 5; in comparing the tens, it will be the difference between 8 (7 and 1) and 10, that is 2; in comparing the hundreds, it will be the difference between 9 (8 and 1) and 10, that is 1; and in comparing the thousands, it will be the difference between 1 and 1, that is 0; as 0 is useful only when it alters the place of other figures, and as it cannot do this when upon the left hand, it may be omitted, and the difference altogether is 125. From this may be inferred the

Rule for Subtraction.—Write the less number under the greater, in such a manner as that the units stand under the units and all the corresponding figures under each other; take each figure of the under number from the corresponding one of the upper, and mark the difference below. When the figure in the under (or less) number exceeds that in the upper (or greater), put ten to the upper figure; but for every 10 that is put to a figure of the upper number, put 1 to the next figure toward the left in the under one.

The best way of acquiring facility in addition and subtraction is to perform them on the same sum, thus: take any number of lines of figures, arrange them and find their sum; then from this sum subtract all the numbers one by one, and if nothing remain over or be wanting, the whole will be right.

5. *Division.*

The object of division is to find how often one number is contained in, or may be subtracted from another; or to find what some proposed part of a given number will amount to.

The number from which the other is to be subtracted, or of which the part is to be found, is called the *dividend;* the number which is to be subtracted from the dividend, or which expresses the number of parts of the dividend, one of which is to be found, is called the *divisor*; the number which expresses the times that the divisor can be subtracted from the dividend, in the part which is to be found is called the *quotient*; and if the divisor cannot be subtracted an exact number of times from the whole dividend, that which is left over is called the *remainder*.

Division is the opposite or converse of multiplication; and as multiplication might be performed by writing down the number to be multiplied, as often as it is to be multiplied, and then adding; so division might be performed by subtracting the dividend from the divisor repeatedly, till either 0 remained, or till the number remaining became less than the divisor; and then the number of subtractions which had been made would be the quotient.

But this method of performing division by subtraction simply, would be even more tedious than that of performing multiplication by addition; and therefore, methods of shortening and thereby simplifying the process have been devised.

The general principle upon which these are performed is this: if the quotient is to consist of several figures, (which can always be known by comparing the divisor and dividend,) each of these figures is found separately; first the left hand one, then the next, and so on to the units.

In the application of this principle there are two things to be determined: first, how many figures there must be in the quotient; and, secondly, what those figures are to be.

1. To find the number of figures. Take the least number of figures upon the left hand of the dividend that will contain the divisor, once or oftener, but not more than nine times; and there will be one figure of the quotient for these, and another for every remaining figure of the dividend. Thus, let 256 be the divisor, and 186624 the dividend; it is required to know how many figures shall be in the quotient. Comparing 256 with 186624, one finds that the least number of figures upon the left

hand of the latter, that will contain the former, is 1866, and that there remain two figures, 2 and 4; therefore the quotient must contain three figures. In the same manner, the number of figures in any other quotient might be determined, whether the divisor and dividend were great or small.

2. To find what the figures must be. This cannot be determined all at once, like the former; but each figure may be found in succession, beginning with the left hand one; and the method of finding them is this: judge, as nearly as you can, how many times the divisor will be contained in that part of the left of the dividend that is to afford the first figure of the quotient; and when you have decided upon what you think is the proper figure, multiply the divisor by it, and compare the product with the part of the dividend. If the product be larger than the part of the dividend, then the figure which you have chosen is too great, and you must choose a smaller one, and, effacing the former product, perform the multiplication anew; but if, when the product is subtracted from the part of the dividend, the remainder be equal to the divisor, or larger than it, then the figure is too small, and you must choose a larger one; and, in either case, the trial must be repeated till the product be less than the part of the dividend, and the remainder, after subtraction, less than the divisor. When the first figure of the quotient has been found in this manner, you are to annex another figure of the dividend to the remainder; and the sum will furnish another dividend, out of which you must find the second figure, in the same manner. All the other figures are found in the same way, only when, in order to make any of the successive remainders, such that the divisor can be obtained from it, you have to

annex more than one figure of the dividend, 0 must be put in the quotient every time that you add two figures, 00 when you add three figures, and so on.

Let the example already assumed be again referred to: it has been already determined, that if the dividend be 186624, and the divisor 256, the quotient shall consist of three figures; let it now be required to determine what those figures shall be: for this purpose, compare 256, (the divisor,) with 1866, (the least portion of the dividend that will contain it,) and upon trial, it will be found, that the one can be obtained seven times from the other. Then multiply 256 by 7, the product is 1792, which is less than 1866; subtract it, and there remains 74, which being less than 256, shows that 7 is the proper figure. To find the second figure: to the remainder, 74, annex the next figure of the dividend, 2, and the sum 742 is the dividend, out of which the second figure is to be obtained. Comparing them, you find that the divisor can be obtained twice out of this number; multiplying the divisor by 2, you have 512; subtracting this from 742, you have 230, which is less than 256; therefore 2 is the second figure of the quotient. Again, annexing 4, (the remaining figure of the dividend,) to this remainder, you have 2304 for the dividend, out of which to obtain the third figure of the quotient. Comparing the divisor with this, it soon appears that the third figure must be 9, and multiplying the divisor by 9 produces 2304, which is exactly equal to the number from which it has to be subtracted; therefore the quotient is 729, and there is no remainder. If the numbers had been so arranged, as that the operation could have been performed with the greatest ease, and contained in the smallest space, it would have stood thus:

Div. Divid. Quot.
256) 186624 (729
1792
742
512
2304
2304
0

From merely exhibiting this operation, it is evident that every figure of the quotient will be of the same class, that is, occupy the same place from the right, as the last figure of that part of the dividend from which it arises. The same might also be inferred from the general properties of numbers. Thus, if a number be taken altogether, the whole of it is units, for the tens are tens of units, the hundreds, hundreds of units, and so on; if it be taken only from the tens figure, then that and the whole to the left of it is tens; and, generally speaking, every portion of a number may be considered as a number of that place or denomination that is occupied by its right hand figure. For instance, in the above dividend 186624, the 1866 is hundreds, and if written without the other figures, it would have to be 186600; in like manner, the 18662 is tens, and when alone would be written 186620. Now it is perfectly evident, that when any thing is divided, the quotient or part must always be of the same kind with the thing that is divided,—if you divide hundreds, the quotient must be hundreds; if you divide tens, it must be tens; and generally, if you divide any rank or place of a number, the quotient must always be of the same rank or place. From these observations we may derive the following

RULE FOR DIVISION. Write the divisor on the left of the dividend, and leave a space for the quotient upon the right. Assume as many figures on the left of the dividend as shall contain the divisor once or oftener, but not more than nine times. Find by trial how often the divisor is contained in the figures thus assumed; and write the figure expressing the times in the quotient. Multiply the divisor by this figure, and write the product below that part of the dividend which was assumed. Subtract the product from the number over it, and annex the next figure of the dividend to the remainder. Repeat this operation, till the whole dividend has been added to successive remainders, figure after figure, and the last remainder is less than the divisor.

The principal difficulty which beginners find in performing division, consists in not being able to think of the proper figures for the quotient, without a great number of trials. Practice, however, soon enables one to do this, and that practice may be facilitated by this consideration: if the part of the dividend contain the same number of figures as the divisor, consider how often the first figure of the one may, making allowance for what has to be carried in multiplying, be got out of the first figure of the other; and if the part of the dividend contains a figure more than the divisor, (and it can never contain exceeding one figure more,) consider how often the first figure of the divisor, (making allowance, as in the other case,) may be got out of the first and second figures of the dividend.

Multiplication and division mutually prove each other. If the product be divided by one of the factors, the quotient should be the other, and there should be no remainder; and if the divisor and quotient be multiplied, and the remainder, (when there is any,) added to the product, the sum should be exactly equal to the dividend. Hence not only one of the most useful exercises for the pupil, but one which spares entirely the labour of the teacher, any further than just to take care that there is no fraud in the matter, and that, in the case of ladies, is, of course, not to be supposed. The exercise is this: let the pupil take two large numbers, multiply them together, and divide the product by either of them; and continue at the same kind of operation, till it can be performed with sufficient accuracy, and the pupil feel confident that it must be right. This practice facilitates, more than any other, the two most valuable acquirements in the practice of arithmetic—accuracy and rapidity; and as the multiplication and division contain also addition and subtraction, it is an exercise in all the four rules at the same time. If, indeed, the object be, as it ought to be, to render the progress of the pupil as certain and as rapid as possible, the best way is to hurry over the other rules, till this point has been arrived at, but not to advance one step further, or point out one of the applications, until the requisite degree of dexterity and certainty has been attained.

In order to give the pupil facility in the performing of division, the best preliminary exercise is to take all numbers under 100, and ask how often each of the nine smallest numbers is contained in each of them, and how many are over. Thus: how many 7s are in 50? Answer, 7 and 1 over; How many 8s are in 36? Answer, 4 and 4 over. One hour's examination in this way, giving the pupil time to think of the answer, is really of more value, than a week spent in poring over the book or the slate. Perhaps, indeed, one of the chief reasons why arithmetic is considered so dry and unprofitable a study, is, that in the usual method of teaching it, it is rendered too much a matter of solitary plodding, and not mixed with sufficient intercourse and communication with the teacher.

6. *Fractions.*

As any thing, however small, may still be supposed to be divided into any number of parts; so any number, however small, may be supposed to be divided by any other number, however large. Thus there is no impossibility in supposing three loaves of bread to be divided among eight poor people, so that all may have equal shares; or leaving out this idea of the loaves of bread, and the poor people, and considering the numbers simply or abstractedly, there is no absurdity in supposing the number 3 to be divided into 8 parts, so that all may be equal; but as, in the one case, the share of the bread could not be expressed by loaves, or by one whole loaf, because there are not so many loaves as persons, so in the other case, the part of the number 3 could not be expressed in whole 1s, or in one whole 1, because there are not so many 1s as parts.

The bread might be actually shared, by cutting each loaf into eight equal parts or slices. Of these there would be twenty-four altogether, and the share of every poor person would be three of those slices, or one eighth part of each of the three loaves. In like manner, in the case of the number 3, each of the three 1s of which it consists might be supposed to be divided into eight equal parts, and the eighth part of the whole, that is, the quotient arising from dividing 3 by 8 would be expressed by three of those parts.

Numbers which are supposed to be produced in this way, are called *Fractions*, or parts; and as one of them is less than the number 1, and as the number 1 is the smallest number that can be expressed in the common way of expressing numbers, fractions require a different method of notation. Still, however, they are numbers; and when the method of writing them, and also their nature, are understood, the operations of adding, subtracting, multiplying, and dividing, may be performed with them on the same principles as with other numbers.

In common language, a fraction means that which arises from the breaking or dividing of a whole—it is a part—something that is less than a whole; and in the language of arithmetic, it is, properly speaking, a part of the number 1—something that is less than the number 1; and we derive our notion of it from the idea of a smaller number being divided by a greater.

A fraction is expressed by two numbers, one of which is usually written above a small line, and the other below the same.

The number above the line answers to the dividend in division, and is called the *numerator* of the fraction.

The number below the line answers to the divisor in division, and is called the *denominator* of the fraction.

The two together are called *the terms* of the fraction.

The value which the fraction expresses, or the number that it stands for, is the quotient that would arise from dividing its upper number, or numerator, by its under number, or denominator, if that division could be performed; and this value does not depend upon the absolute greatness of either or both of the two numbers, but upon the greatness of the numerator compared with that of the denominator. Thus, whatever were the greatness of the denominator, it is evident that if the numerator were just the same, the quotient, that is, the value of the fraction would be exactly 1, because every number is got just once in another number that is exactly equal to it. In like manner, if the numerator were exactly equal to half the denominator, it is equally clear that the quotient or value of the fraction would be just half of the number 1, because any number could be got just half a time in another number half as great as itself. And generally, if the numerator were any exact part of the denominator, the value of the fraction would be the same part of the number 1.

In this way, if one suppose the number 1 to be divided into as many parts as is expressed by the denominator, the fraction will contain as many of those parts as is expressed by the numerator. Thus, in the two numbers before alluded to, 3, divided by 8, or as it is written fractionally $\frac{3}{8}$, (pronounced three eighths,) the number 1 is supposed to be divided into eight parts, and the fraction $\frac{3}{8}$ expresses three of these.

Thus, the number that a fraction expresses has two values—one depending on the denominator, and another depending on the numerator. The former of these may be called its denomination, and the latter its number.

As the number 1 is always of the same value when considered simply as a number, it follows, that the greater the denominator of any fraction is, the smaller will be its denomination; but because the numerator merely expresses the number of parts of 1 that the fraction contains, without any reference to their denomination or individual value; it follows, that the greater the numerator is, the greater will be the value of the fraction.

Because, the value of a fraction is thus twofold, depending partly upon the numerator, and partly upon the denominator; and because it increases with increase of the numerator, but diminishes with increase of the denominator, it follows, that the changes of the value of a fraction, by addition, by subtraction, by multiplication, or by division, may each be performed in two different ways, or that any two opposite ones may be so performed at the same time, as that the value of the fraction may remain unchanged.

To add to a fraction, one may either add to its numerator, or subtract from its denominator.

To subtract from a fraction, one may either subtract from its numerator, or add to its denominator.

To multiply a fraction, one may either multiply its numerator, or divide its denominator.

To divide a fraction, one may either divide its numerator, or multiply its denominator.

As, however, the fraction expresses not a whole number, but a part, the number added to the numerator does not increase the value by as many times the number 1, as would be the case in adding one whole number to other whole numbers; it merely adds to it a number of those parts of 1 of which it consists; and the greatness or value of these parts, as has been shown, depends not upon the numerator, but upon the denominator. Thus, if it were proposed to add 2 to the numerator, of the fraction $\frac{3}{8}$, then the sum would not be 2 greater than $\frac{3}{8}$, it would only be $\frac{2}{8}$ greater—that is, it would be $\frac{5}{8}$.

So also, when one adds to the value of a fraction, by subtracting from the denominator, one does not add to the value of the fraction as many times 1 as the number which is subtracted; one merely adds to the value of each of the parts of which the numerator consists, the same part of itself, that the number subtracted is of the remainder of the denominator. Thus, if the number 2 be subtracted from the denominator of the fraction $\frac{3}{8}$, the result $\frac{3}{6}$ is not 2 greater than the original fraction; each of the three parts of which the numerator consists, is only increased by the same part of itself, that 2, the number substracted, is of 6, the remainder of the denominator; or, since 2 is one third part of 6, each of the three parts is increased by one third of itself. But, as the increasing of all the parts is the same thing as increasing the whole, the resulting fraction $\frac{3}{6}$ is just of the same value as if there had been added to the numerator of the original one third of itself; that is, as if it had been made $\frac{4}{8}$.

Diminishing a fraction, by subtracting from its numerator, or adding to its denominator, depends upon the same principles, and is performed in the same manner. Thus, if one subtract any part of the numerator, one subtracts the same part of the value; and if one add any part of the denominator to itself, one subtracts the same part of the value.

Generally, any change which is made upon the numerator of a fraction, leaves the natural denomination of the parts of which it consists unaltered, but changes the whole value of the fraction in the *same* manner, and to the same extent that the numerator is changed; and any change made upon the denominator, leaves the number of the parts unchanged, but changes their value in the *opposite* manner, and to the same extent as the change that is made on the denominator.

Hence also, when the change made upon the numerator and denominator is exactly the same, the value of the fraction is not altered, because, whatever change is produced by altering the one, is just reversed by altering the other. Thus, in the fraction $\frac{5}{8}$, if one were to multiply both terms by 2, the double would be halved, and half the double of any thing is just that thing itself. So also, if in the same fraction we were to divide the numerator by 2, the value would be halved, but if we at the same time divided the denominator by 2, the half would be doubled, and double the half of any thing is exactly equal to that thing itself.

Hence, generally, if both numerator and denominator of a fraction be multiplied by the same number, or decided by the same number, the whole value of the fraction will remain unchanged.

In consequence of this property of fractions, one is enabled to change a fraction from any one denomination to any other; and thus fractions which cannot be compared in their original form, so as that one may be able to tell which is the greater, or added, so as that one may be able to tell what is the sum, may be compared, or added with the same one as other numbers.

For instance, if one wished to know whether $\frac{7}{9}$ (seven ninths,) or $\frac{9}{12}$ (nine twelfths,) were the greater, one could not easily tell, because though the 9 be more in number than the 7, the nine ones of which it is made up are all less in value. As little could one add them together into one sum, for though the 7 and 9 added together would make 16, yet it could not be written 16, because it is not 16 ninths, or 16 twelfths; but 7 of the one, and 9 of the other; and before one could tell which were the greater, or what were the sum, one would have so to alter them that 1 in the numerator of the one of them should be exactly equal to one in the numerator of the other.

Now, it is quite evident, that if we could find two numbers, the one of which being multiplied by 9, and the other by 12, would give the same product, this product would do for the demominator of both; and if the numerator of each were multiplied by the same number as the denominator, the values would not be altered. But numbers of this kind are easily found; for 12, multiplied by 9, is just the same as 9 multiplied by 12. Hence, to give two different fractions the same denominator without altering the value, multiply both numerator and denominator of each by the denominator of the other. If these multiplications were performed with $\frac{7}{9}$ and $\frac{9}{12}$, $\frac{7}{9}$ would become $\frac{84}{108}$ and $\frac{9}{12}$ would become $\frac{81}{108}$,—two fractions of the same denomination, and therefore admitting of being either compared or added together. Comparing them we find, that $\frac{7}{9}$ is greater than $\frac{9}{12}$, and that the difference is $\frac{3}{108}$; and also that the sum of $\frac{7}{9}$ and $\frac{9}{12}$ is $\frac{185}{108}$, or $1\frac{77}{108}$. Had there been more than two fractions, and had both terms of each been multiplied by all the others, it is plain that the result would have been the same, and that the sum of them all, or the difference between any two of them, would also have been easily found. Hence we have this practical

RULE.—To change fractions of different denominations to the same denomination: multiply both numerator and denominator of each fraction by the denominators of all the other fractions. Thus to change $\frac{3}{7}$, $\frac{5}{8}$, $\frac{6}{10}$, to the same denomination, multiply both terms of $\frac{3}{7}$ by 8 and 10, both terms of $\frac{5}{8}$ by 7 and 10, and both terms of $\frac{6}{10}$, by 7 and 8.

Addition.—The general principle in every kind of addition is, that only numbers of the same kind or denomination can be shortened into one sum; hence,

1. To add a fraction to a number annex it to the right, thus: the sum of 12 and $\frac{5}{7}$, would be $12\frac{5}{7}$. Expressions of this kind are called *mixed numbers;* they cannot be expressed simply as whole numbers, unless the numerator of the fraction can be divided by the denominator without leaving any remainder; but they may always be expressed simply as fractions, and the method of doing this is, to multiply the number by the denominator of the fraction, add the numerator to the product, and make the sum numerator. Thus $12\frac{5}{7}$ could not be expressed by

a whole number, because 5 cannot be divided by 7; but if 12 be multiplied by 7, and 5 added, the result $\frac{89}{7}$ will express the same value as $12\frac{5}{7}$.

2. To add fractions, change them to the same denomination, and add the numerators.

Subtraction.—This being the converse of addition, will require the same preparation; and thus the rule for subtracting one fraction from another will be this: change to the same denomination, as in addition, then subtract the less numerator from the greater, and place the difference over the common denominator. Thus if the difference between $\frac{3}{8}$ and $\frac{9}{11}$ were required, the fractions changed to the same denomination would be $\frac{33}{88}$ and $\frac{72}{88}$, and the difference would be $\frac{39}{88}$.

The cases that most usually occur in practice, are the addition and subtraction of small fractions, (that is, fractions of which the terms are small) connected with whole numbers, and these may be added or subtracted separately; taking care, in addition, to take in with the whole numbers, any 1s that may be obtained from the sum of the fractions; and, in subtraction, when the fraction belonging to the smaller number exceeds that belonging to the larger, 1 must be added to the smaller fraction, and to compensate it, 1 must be carried to the units of the smaller number. In adding 1 to the fraction, add the denominator to the numerator, because a fraction having its numerator equal to its denominator is just equal to 1: thus, if it were required to subtract $12\frac{3}{4}$ from $21\frac{1}{2}$ one would soon perceive that $\frac{1}{2}$ is equal to $\frac{2}{4}$, and that $\frac{3}{4}$ cannot be subtracted from it. Hence add 1 or $\frac{4}{4}$ to the $\frac{2}{4}$ the sum will be $\frac{6}{4}$, and if $\frac{3}{4}$ be taken from this, the remainder will be $\frac{3}{4}$, and 1 will have to be carried to 2, the units of the smaller whole number. The difference of the whole numbers will thus be 8; to which annex the difference of the fractions, and the total difference between $12\frac{3}{4}$ and $21\frac{1}{2}$ will be $8\frac{3}{4}$.

Multiplication.—It has been shown, that to multiply a fraction we may either multiply its numerator or divide its denominator; and therefore it remains only to be shown how we are to multiply by a fraction. Now a fraction is nothing else than the numerator divided by the denominator; and hence the product by a fraction, will be the product by the numerator, divided by the denominator, therefore,

To multiply by a fraction; multiply by the numerator, and divide the product by the denominator, thus: to multiply 12 by $\frac{3}{4}$, multiply 12 by 3 and divide the product by 4. In this way the product will be 36 divided by 4, that is 9.

Taking this in conjunction with the method of multiplying a fraction, it follows that,

To multiply two or more fractions together, multiply the numerators for numerator of the product, and the denominators for denominator.

Division.—As division is the opposite of multiplication it follows that,

To divide by a fraction, multiply by the denominator and divide the product by the numerator, thus: to divide 9 by $\frac{3}{4}$, multiply 9 by 4, and divide the product by three; that is, the quotient will be 12.

Fractions may appear in much more complicated forms than those that have been noticed; but the management of these belongs rather to the business of a calculator than to general education; and the few principles that have been stated are quite sufficient, if carefully studied and explained, for giving, especially to ladies, all the information upon this subject which is necessary in order to prevent them from feeling difficulty when they meet with fractions in the study of other subjects which fashion, sole arbitress in those matters, places more fully and legitimately within the acknowledged pale of female studies.

7. *Decimals.*

Though the way of expressing fractions and performing the operations of arithmetic with them, as explained in the preceding section, be that which accords strictly with the way in which fractions are naturally produced, yet it is attended with considerable trouble, in consequence of there being as many denominations of fractions, as there can be different numbers used for denominators. In order to avoid this trouble, an artificial form of fractions has been invented, in which, as in whole numbers, the same figures of the numerators are always of the same denomination, and can be added or subtracted without any change. Fractions in this form are called *Decimals.*

They are so called because the denominator always consists of as many tens, *(decems,)* multiplied together, as there are figures in the numerator; and this not only prevents the trouble of changing the fractions, but also prevents the necessity of writing the denominations. A decimal, when it stands alone, is distinguished from a whole number by having a point (.) on the left of it. Thus, 5. is a whole number, and means *five*; but .5 is a decimal, and means *five tenths,* or *one half.* When a number consists partly of whole numbers and partly of decimals, the distinction is made by putting the point (.) between the one and the other: thus, 5.5 means five and five tenths, or five and one half.

In order to change any fraction to a decimal, one has only to find some number which, multiplied by the denominator, would produce 1 with 0s annexed; and the product of this number by the numerator will be the decimal; or, which is the same thing, one has only to put as many 0s as may be necessary after the numerator, and divide this by the denominator, and then the quotient will be the decimal. This division will in some cases never end, as some numbers (3 for instance) will not divide 1 with 0s without remainder.

If in the course of this division, any figures of the quotient are obtained without using any of the 0s, these figures will be whole numbers; and if more than one 0 be required in order to obtain the first figure of the quotient, an 0 must be put at the beginning of the quotient for every one more than one that is used in the dividend.

Thus the 0 has very different effects on whole numbers and in decimals: when put on the *left* hand of a whole number it has no effect, because it does not alter the place, and consequently not the value, of any of the figures; but when it is put on the *right* hand of a whole number, it makes the units tens, the tens hundreds, and the whole number ten times greater by every 0 so added. But in decimals, on the other hand, 0 put on the *right* has no effect, while every 0 that is put on the left divides the value by ten.

Addition and subtraction. In addition and subtraction of decimals, care must be taken that the points which mark the beginning of the decimals be arranged under each other, and that only those figures which are equally distinct from those points, whether on the right hand or on the left, be added or subtracted; and this being attended to, the operations are performed precisely in the same manner as with whole numbers.

Multiplication and division. These operations are also performed with decimals precisely in the same manner as with whole numbers, the only difficulty being to determine how much of the result ought to be considered as decimals, and how much as whole numbers; that is, in what place of the product or the quotient the point (.) should be inserted.

In multiplication this is easy; for one has only to count the number of decimal places, that is, the number of figures after or to the right of the point, that are in the multiplicand and multiplier, and allow as many decimal places in the product as there in them both; and if the product, which may sometimes be the case, shall happen not to have as many figures, the deficiency must be made up by prefixing 0s to the left, and placing the point before these. Nor is it difficult to see the reason of this: the denominator of each factor will consist of 1 with as many 0s after it as there are decimal figures; and the denominator of the product must, from what was explained in the former section, consist of the product of the denominators of the factors; but the product of two numbers, each consisting of 1 with 0s will consist of 1 with as many 0s as there are in them both; wherefore, the product must contain as many decimal figures as there are in both factors.

In division there is a little more difficulty. The general principle is indeed abundantly simple: the dividend, being the product of the divisor and quotient, must contain as many places as them both. But as the quotient is not found till the division be performed, and as 0s have sometimes to be put at the beginning of it, the best way in practice is this: lift back the decimal point to the right hand of that term, (the dividend or divisor,) which has the greatest number of decimals, make the number of decimals in the other equal by adding 0s, and remove the point to the right of it; then all the quotient that is obtained without adding any more 0s to the dividend will be whole numbers, and all arising from more

0s added will be decimals. If one 0 have to be added before a single figure of the quotient can be had, the point must be put before that figure; and if more than one 0 have to be added, an 0 must be put immediately after the point, for all of them but the first one.

These sections contain an outline of the whole principles of arithmetic, as applied to numbers only; but when it is applied to find the prices, or values of things, which it must always be when it is useful in the business of life, some further explanations are necessary; and a few of the more simple and generally useful parts of this, will form the subject of a second part of this brief sketch.

It may be proper here, however, to mention the characters by which the arithmetical operations are represented, when they are not performed but merely indicated.

1. The addition of numbers is indicated by writing between them the character + *(plus.)*

2. Subtraction, by writing the number to be subtracted after the other one, and placing between them the character — *(minus.)*

3. Multiplication, by writing × between the numbers.

4. Division, by writing the divisor after the dividend, with ÷ between them, or by writing the dividend above a line and the divisor below, as a fraction.

5. When one number is said to be equal to another, it may be expressed by putting = between them.

6. Inequality may be expressed by >, the open end being turned toward the greater quantity. Thus:

$2+4$, is the sum of 2 and 4, $=6$;
$6\quad 5$, is the difference of 6 and 5, $=1$;
3×2, the product of 3 and 2, $=6$; and
$6\div 3$, the quotient of 6 and 3, $=2$.

PART II. ARITHMETIC OF QUANTITIES.

The arithmetic of quantities, or practical arithmetic, is nothing more than the application of the principles which have been already explained, to those qualities, circumstances, or relations of things, which determine their value in the commerce of the world.

These qualities, circumstances, and relations, upon which the values of things depend, are very numerous, but the principal, if not the whole of them, as used for arithmetical purposes, may be brought under the several kinds of weight, measure, time, and money.

Weight determines the quantity of matter that is in any thing. All weights are of the same kind; but they may be of different denominations, and originally depend upon different standards. Thus a *ton* in England is precisely of the same kind with a *kilogramme* in France, or a *pood* in Russia; but they are not measured by the same standard; and a ton and pound in England, are measured by the same standard, but are not of the same denomination. The same name, and the same number of weight, is, however, always the same, considered as weight without any reference to the nature of the thing weighed. Thus a pound of lead and a pound of gold, or an ounce of paving-stone and an ounce of diamond, are exactly the same, as weights; and if the relation between them be known, a quantity expressed in any denomination of weight, can always be expressed in any other denomination.

Measure may differ not merely in denomination, but absolutely in kind, according to the sense in which it is used. There are three distinct kinds of measures, which cannot be compared with each other, although they may be expressed by the same name and number. These are: First, *simple extension,* or the distance from one point or place to another,—as when we say, the garden is 100 yards long, the walk is five feet broad, or the basin is six inches deep. Secondly, *surface,* when we consider the extension two ways, as when we say, the garden contains half an acre, the pane of glass measures half a yard, or the sheet of paper contains twenty inches. Measure of this kind is totally different from the former, and cannot in any way be compared with it, or changed into it; for the greatest extent of mere length would not make a single inch of surface. Thirdly, *solidity,* or *capacity,* which requires length, and breadth, and thickness, as when we say, the pedestal of the statue contains a yard of stone, the bottle holds a quart of water. This third kind of measure is different from both of the other two, and cannot be converted into them, or they into it; neither can they be compared, so as to say which is the greater, and which the less.

Time is a quantity, not only different from all these, but much less easy to understand. One can see the length to which a road or a line extends, the surface which a garden or a carpet occupies, or one may judge of the bulk of any thing solid, or the quantity that any vessel will hold; but time cannot be brought under the cognizance of the senses; we judge of it only by what happens, and estimate its parts only by the motion of whatever we suppose moves along at an equal rate—the motion of the sun, the running of sand or water through an aperture in a vessel, the revolution of the hand of a well regulated watch or clock, or something of a similar kind. We speak of time, but when we come to apply numbers to it, and attempt to say how long or how short it is, the thing that we really estimate is not time but motion.

If we had no contrivance except those quantities themselves, we should never be able to know any thing about the comparative greatness and value of those which were of different kinds, although we might be able to do that with those of the same kind. Thus, if the thing to be determined were the length of a rod or piece of silk, we could measure it with a yard measure; if it were the quantity of square yards in a carpet, we could measure the length and breadth, and from these get at the magnitude; also, if it were the quantity of wine in a cask, we could find it out by trying how often it would fill a quart (or any other) measure; or if it were the time from sunrise to sunset, or that which we would require to walk or ride from one place to another, we could easily find it out by a watch or clock; but if we were asked how much of any of these quantities were equal to so much of another, we would be unable to give any satisfactory answer. We could not tell how many yards of silk would be equal to so many quarts of wine, or how many miles of road were exactly of equal length with so many hours of a day. Such quantities are wholly different in kind, and however well we were acquainted with the greatness and value of any one of them, that would not in any way aid us in forming a judgment of another.

This utter impossibility of comparing quantities that are of different kinds, renders it necessary to introduce another quantity, which shall not belong to any of these kinds, but which may, when necessary, be the representation of them all; this quantity is that which we call *money*, whether it be composed of a substance which has real value in itself, like silver or gold, or whether its value depend upon the faith or confidence that people have in each other, as is the case with a bank-note.

Money, like the other quantities, may be of different denominations, and these denominations, as in the other cases, may either be formed upon the same standard, or upon different standards; but whether the denominations or the standards be the same, or different, we are always able, at least by a little labour and attention, to compare any quantity, (or, as it is usually called in the case of money,) any *sum* of money with any other sum; and as the common consent of mankind, at any particular place and time, settles the sum of money that all other quantities are worth, money furnishes us with a general medium of comparison, at once easy and convenient.

The denominations of the several quantities that have been now mentioned, are to be found in the usual collections of arithmetical tables, or in the common text books that contain rules and examples in arithmetic. In these may also be found the mechanical directions for changing quantities from one denomination to another, without altering its value; and therefore there is no need for introducing them into this general sketch.

Whatever may be the kind, denomination, or number of any quantity, it always has two values, the one arising from its denomination, and the other from its number. While both of these remain the same, the value of the quantity remains unaltered; if one of them be changed, and not the other, the value is changed the same way and to the same extent as the one that is changed; if both be changed in the same way, that is, both made greater or both made less, then the change of the whole quantity is greater or less by the product of the increases of the two. Thus the quantity *five half* crowns, depends for its value on the number, (5,) and the name (half crown.)

If the number be doubled (made ten) the value will be doubled; and if the thing meant by the name be doubled (made whole crowns) the value will again be doubled; and thus, by doubling both, the whole value will be increased four times, whereas if only one of them had been doubled, the value would have been only doubled. In like manner, the quantity, 8 pounds, will be halved, if the 8 be divided by 2, and again halved, if the pounds be reduced to half pounds; and thus by performing both changes the value will be diminished to one fourth of what it was originally.

If the one value be increased and the other diminished, then the whole value may be increased or diminished, or left unaltered, according as the increase is greater than the decrease, less than it, or equal to it.

After the denominations of quantities are known, and their nature, and the means of changing them from one denomination to another are understood, the application of arithmetic to them becomes an easy matter. In

Addition and subtraction the sums and differences of the quantities cannot be found in any way, if they are not of the same kind; and though they be of the same kind, they cannot be added as numbers unless they are also of the same denomination. Thus, for instance, we cannot in any way collect pounds *weight* and pounds of money into one sum, neither can we collect pounds and ounces in weight, or pounds and shillings in money, into one number. Hence the rule usually given for the addition and subtraction of quantities is as follows:

Arrange them under each other, so that the same denominations, and also the same places in each denomination, be under each other; add or subtract each denomination separately; in carrying in addition, or borrowing in subtraction, from one denomination to the other, always carry to or borrow from the higher denomination as many of the lower as shall make 1 of the higher; and the sum or difference will consist of the same denominations as the particular numbers.

A single exercise, either in addition or in subtraction, will better show how the operation is to be done than any directions, however minute; but considerable practice alone can be expected to produce expertness; and as this is the part of arithmetic for which most people have the greatest occasion, it is the one to which the greatest attention should be paid.

The use of addition consists chiefly in finding the whole of any number of parcels or sums, of which the particulars are given; and that of subtraction in finding the difference between any two; and as there is no one who has not occasion to examine bills, in order to see whether they be accurately added up, or to compare sums that have been expended with that which was originally on hand, in order to ascertain whether that which still remains be correct, this part of practical arithmetic may be looked upon as an indispensable part of education.

Multiplication. In the multiplication of quantities there may be either of these two objects in view: First, a quantity may be given, and it may be required to know how much a certain number of times that quantity would amount to; or, secondly, the price or value of some denomination of a given quantity may be given, and it may be required to know the price or value of the whole of the quantity.

In both cases the multiplicand, or quantity to be multiplied, must be of the same kind and in the same denomination with the product; and the multiplier must be regarded as a number.

When the multiplier is of one denomination and the multiplicand the value or price of one of that denomination, the operation may be performed by multiplying all the denominations of the multiplicand in their order, beginning with the lowest, and carrying from the one to the other as many of the lower as make one of the next higher. Then the product will appear in the same denominations as the multiplicand. Thus, if it were desired to be known what 24 yards of cloth, or 24 any thing else, would amount to at two pounds five shillings and sixpence half penny a yard, one would multiply the half pence, the pence, the farthings, and the pounds, each by twenty-four, beginning with the farthings, and the result would be the sum desired.

But if the quantity answering to the multiplier were in several denominations, the operation would be better performed by changing both factors to the lowest denomination that were in each of them, multiplying them together as whole numbers, dividing the product by as many of the denomination to which the multiplier had been changed, as made one of that denomination of which the value were represented by the multiplicand; and this would give the quantity desired in the denomination to which the multiplicand had been changed, which could then be changed to any denomination of the same kind. Thus, if it were required to find how much 4 hundred weight, 3 quarters, 14 pounds, and 4 ounces of tea would amount to, at 47 pounds 2 shillings and 8 pence each hundred weight; the simplest though perhaps not the shortest way of doing it would be to change the price to pence, which would be 11313 pence, and the quantity to ounces, which would be 8644 ounces,—multiply them together, which would produce 97780928,—to divide this 1792, the ounces in one hundred weight, and the quotient, 54565¼, would be the whole price in pence; and, lastly, this changed to pounds would give 227*l.* 7*s.* 1¼*d.* the price required.

All prices of goods, wages of labour, and other matters, which are reckoned by one and counted for a number, may be found by multiplication of quantities.

Division. In the division of quantities there may be three objects in view, as there may be two in the multiplication. First, the object may be to find how often one quantity is contained in another, and the dividend may be a quantity, the divisor a number, and the quotient a quantity, of the same kind, and in the same denomination with the dividend. Thus it might be asked, what were the 12th part of 129*l.* 17*s.* 8*d.*; and the quotient would be pounds, shillings, and pence.

Secondly, it might be desired to be known how often one quantity were contained in another quantity of the same kind; and in this case the divisor and dividend would require to be in the same denomination, and the quotient would be a simple number and not a quantity.

Thirdly, the price or value of 1 of some denomination might be given, and it might be required to find how much of that denomination would amount to a given sum or quantity. In this case the divisor and dividend would be quantities of the same kind with each other, and the quotient would be a quantity of a different kind.

The general principles upon which the performance of all these varieties depend are these: first, that when the divisor and dividend are of different kinds, the quotient is always of the same kind and denomination with the dividend; and, secondly, that when the divisor and dividend are of the same kind, the quotient must be of a different kind; and in order that the operation may be right, the divisor and the dividend must be of the same denomination.

When the divisor and dividend are of different kinds and the divisor of one denomination, the highest denomination of the divisor must be divided first, then the remainder changed to the next lower, and the operation continued to the lowest; and the quotient will consist of as many denominations as there are in the dividend. When the divisor is in different denominations, the best way is to multiply both it and the dividend by any number or numbers that will clear them away; and then perform the division as in the case of a divisor of one denomination.

When the divisor and dividend are both of the same kind, the best way is to change them both to the lowest denomination that appears in either, then to divide as if they were simple numbers, and the quotient will be of that denomination, the value of one of which is expressed by the divisor; and if lower denominations be wanted, these may be obtained from the remainder.

These are the principal operations in the arithmetic of quantities, and from them the others may be easily understood.

CHAPTER IV

GEOMETRY.

Though geometry, at least to any useful extent, does not usually form a part of the education of females, yet it is highly valuable to them not only for the mental exercise which it affords, and the utter impossibility of understanding natural philosophy, astronomy, or geography without it, but because of its great use in making them understand the nature and application of forms, and of the assistance which it is calculated to afford in those little elegant arts and arrangements which come so largely and so properly under the management of females.

It is not meant to be said that every lady ought to be a Donna Agnesi, or that she should even pass through the common school routine of the science; but still a definition of the leading terms, and some knowledge of the simple principles are absolutely necessary both to prevent a lady from hearing and from using words of which she does not know the meaning.

As arithmetic teaches the knowledge of whatever can be expressed by numbers or counted, so geometry teaches the knowledge of whatever is extended, and can be expressed by form or shape—whatever can be measured by mere extension, by surface, or by solidity.

The subjects to which geometry applies are all comprehended under the general name of *magnitudes;* but those magnitudes may be of different kinds, and those of the same kind may vary in size and in form. The principal kinds of geometrical magnitudes are, *bodies* or *solids*, *surfaces*, *lines*, *angles*, and *points*,—all of which may vary in size except the last, and they are invariable, being the mere marks of position.

Solids or *bodies* being the only geometrical magnitudes which exist in nature so as to be seen by the eye, are those of which a clear notion may most easily be formed; and from them the other kinds of magnitudes may be explained. Any solid—this book, for instance, fills or occupies some portion of space, and before it can thus occupy space it must have three dimensions, or be extended in three different dimensions; it must have length, and breadth, and thickness.

Again, before we can have any distinct notion of it we must imagine, that it and the space which it occupies are separated from the rest of space; and the separations—the places where the sides, ends, &c. of the book meet the rest of space, or where the space which it occupies is separated from the rest of space, are surfaces; they are no part of the book; they have no thickness, for if they had they would be solids; but they are of necessity extended in two directions or have two dimensions, they have length and breadth.

These surfaces again must have boundaries by which they may be known from each other; and those boundaries can have no breadth, otherwise they would themselves be surfaces; they have, therefore, extension only one way, or only one dimension—namely, length. They are lines.

But the lines must have boundaries or terminations, by which their extension may be marked, and which may show where the one ends and the other begins; and these cannot have even length, otherwise they would not be the boundaries or terminations of lines, they would be lines themselves. These terminations of lines therefore have position or place, but they have no magnitude or extension—they are *points*.

Referring to the book; it, or the space which it occupies is a *solid*, any side of it is a *surface*, any edge of a side a *line*, and any corner of an edge, a *point*.

Thus the geometrical magnitudes are;

1. *Points*, which have no dimensions, or extension;

2. *Lines*, which have one dimension, or are extended in length;

3. *Surfaces*, which have two dimensions, or are extended in length and breadth, and

4. *Solids* or *bodies* which have three dimensions, or are extended in length, breadth, and thickness.

Besides these there are,

5. *Angles*, which are not lines or surfaces, but the relations or positions which lines and surfaces, under certain circumstances have to each other.

Angles are either *plane* or *solid*. Where two edges of the book meet at one of the corners they form a *plane angle*; and when three surfaces meet at the corner of the book, they form a *solid angle*. A plane angle is formed by two lines, and two lines only; but a solid angle may be formed by any number of surfaces not less than three.

The explanation of the nature and properties of lines, angles, surfaces, and solids, with the method of comparing lines with lines, angles with angles, surfaces with surfaces, and solids with solids, forms the theory of geometry, and the method of applying those principles to useful purposes forms the practice of geometry.

Lines may be considered either as they are in themselves, or as they are compared with other lines.

Considered in themselves, lines are either *straight* or *crooked*. Straight lines are also called *right lines*, and crooked lines are called *curves*.

Straight lines are all of the same kind; and their properties are, that if two of them touch each other in two points, they will touch each other throughout their whole length, that two of them, which are not in fact a continuation of the same one, cannot have a part of any length common to both, that they cannot cross one another in more than one point, and that fewer than three cannot enclose a surface.

Crooked lines or *curves* are of an indefinite variety of kinds, and only one of them (the circle hereafter to be explained) falls within the limits of common or elementary geometry.

Straight lines, as compared with other straight lines, may be equal to them or greater or less; and this equality or inequality may be found out in three ways. First, if the edge of one book, for instance, be applied to the edge of another book, one can at once see whether they be of the same length, or the one be longer than the other. In all cases this, where it can be obtained, is the most simple and satisfactory proof. In the language of geometry it is called proof by *supraposition.* Secondly, if one wishes to find out whether the pane of glass in the window be of the same length or not of the same length as the pannel of the door, one cannot easily apply them to each other, but one may take a ruler and apply it first to the one and then to the other; and if they be both as long as the same part of the ruler they are of the same length, otherwise they are not. This is called proof by *analogy* and depends upon the self-evident proposition that "things, which are each equal to the same, are equal to one another." The third method of proving the equality or inequality of lines is resorted to in those cases where neither of these two will apply. It is called proof by *hypothesis,* and depends upon this principle, that, as any one thing of a kind, must be equal to any other of the same kind, or greater or less if it can be shown not to be either of two, it must be the third one.

These methods of proof apply not merely to lines but to surfaces, angles, and solids under certain circumstances.

Surfaces have their boundaries either straight lines or curves, and they are in themselves either plane or curved. If all the boundaries be straight lines, the surface has as many corners as there are lines. If a straight line be made to touch a plane surface on any two points, it will touch it through the whole length between them; and if two plane surfaces touch one another in three points, they will touch one another throughout.

Plane surfaces are called figures, and they are of many kinds, depending upon the number and relative length of their boundaries. When a figure is supposed to be set up on its edge, the edge or side upon which it stands is called the *base* of the figure, and the distance of the highest point from the base, is called the *altitude* or height; and a line drawn representing the height is called the *perpendicular*. In common language a perpendicular is any thing which does not lean to any side.

A *plane angle,* or rectilineal angle, is the opening or inclination towards each other of two straight lines which meet at a point. Thus, when a book is partially opened, the edges of the leaves form an angle having its point at the binding. Straight lines which would not meet and form an angle either way, are called *parallel.*

The point of an angle is called the vertex, and the lines whose inclination forms the angle are called its sides.

A plane angle may vary in magnitude; but that variation does not depend upon the length of the sides of the angle. Thus, as the book is further opened, the angle formed by the edges of the leaves increases, and it diminishes as the book is further closed; but the edges of the leaves remain of the same length all the time.

If one straight line be made to touch a point in another which is not the end of the other, two angles will be formed upon the same side of the line that is touched; and if one straight line be drawn across another, four angles will be formed, two on each side of every one of the lines. If the two angles in the former case be equal, or the four in the latter case, each of them is called a right angle. In common language, an angle is the same as a corner, and a right angle is the same as a square corner. A line which makes a right angle with another, is said to be perpendicular to it.

The four angles about a point are thus equal to four right angles, for the whole of any thing remains the same whether it be divided into equal or unequal parts; and all the angles about a point are also, taken together, equal to four right angles, because the whole of a thing is the same whether it be divided into few parts, or into many. So also, all the angles upon one side of a straight line, which meet at any point in it are equal to two right angles.

All right angles are equal.

An angle which is less than a right angle is called acute, or sharp; and an angle which is greater than a right angle is called obtuse or blunt.

A *circle* is the simplest of plane surfaces. It is bounded by one curve, which is called the circumference; and this circumference is every where equally distinct from the centre.

The name circle is used to denote both the bounding curve, and the surface or space which it bounds; and in like manner the names which are applied to other surfaces, mean either the boundary or the surface.

If a line be drawn through the centre of a circle to touch the circumference both ways, the centre will be in the middle of the line, and the line will divide both the circumference and the space within it into two equal parts.

One of these parts, whether of the boundary or the space, is called a semicircle, (or half circle,) and the line which divides them is called a diameter.

All diameters of the same circle are equal.

Half the diameter, or which is the same, a line drawn from the centre to the circumference, is called the radius of the circle. Two radii, which form an angle at the centre, together with the portion of the circumference between their other extremities, form a sector.

All radii of the same circle are equal.

If a straight line, which does not pass through the centre of a circle, touch the circumference both ways, it divides the circle into two unequal parts, of which the greatest is that in which the centre is.

Lines which are drawn thus are called chords; the portions into which they divide the circumference, or the space within it, are called segments; the portions of the circumference are also called arches, or arcs.

Every line which divides a circle into two unequal segments, is shorter than the diameter.

If two diameters cross each other, so as to make the four angles equal, (and consequently, each of them a right angle,) each of the four portions both of the space and the circumference, is called a quadrant.

In the same circle, a semicircle is exactly equal to two quadrants.

All circles which have equal radii are equal; because, if their centres were applied to each other, their circum ferences would coincide; and things which coincide, that is, fill the same space, are equal.

Of plane figures bounded by straight lines, that which has three sides, and consequently three angles, is called a *triangle;* that which has four sides, is called a *quadrangle* or quadrilateral; and that which has more than four sides is called a *polygon,* a multilateral. All the boundaries of a rectilineal figure are called the perimeter.

Triangles are of three kinds, according to the length of their sides as compared with each other. If the three sides be equal, the triangle is *equilateral;* if two be equal, it is *isosceles;* and if they be all unequal, it is *scalene.* An equilateral triangle has all its angles equal; an isosceles one has two equal angles opposite the equal sides; and a scalene triangle has all its angles unequal. In the same triangle, the greater angle is opposite to the greater side, and the less to the less; any two sides are together greater than the third; the three angles, (whatever be the lengths of the sides,) are always together equal to two right angles; and if one angle be a right angle, the triangle is called right angled, and the other two angles are together equal to a right angle. If such angle taken by itself be less than a right angle, the remaining two together are greater, and the triangle is called acute angled; and if one angle be greater than a right angle, the other two together are less, and the triangle is called obtuse angled.

When triangles are compared together, they may be either equal in every respect, equal in surface, equal in perimeter, or equal in their angles only.

Triangles are proved to be equal in every respect:

1. When two sides, and the angle included between them in the one, are equal to the corresponding sides of the other.

2. When the three sides are respectively equal.

3. When two angles and a side of the one, are equal to two angles and a side corresponding in the other.

Triangles are equal in surface when they have equal bases or sides, and when on applying those sides to a straight line, the other sides touch a line which is parallel to it.

They are also equal in surface, if the products arising from the length of a side, and a perpendicular drawn from the opposite angle to that side, expressed in the same kind of measure, are equal. They are equi-angular, when the three sides of the one are respectively the same parts of the three sides of the other, and when equi-angular, they are similar.

Quadrilateral figures are either *squares*, *rectangles*, or *rhombuses*, or *rhomboids*, or *trapeziums*.

A square has all its sides equal, and all its angles right angles.

A rhombus has all its sides equal, and its opposite angles equal, but the one pair of them greater than right angles, and the other less.

A rectangle has all its angles right angles, and its opposite sides equal, but two of them longer than the other two.

A rhomboid has its opposite sides equal, but two angles greater than the other two. A rhomboid has also two sides greater.

The opposite sides of each of these figures are parallel, and a diameter or diagonal—that is, a line joining the opposite corners, divides them into two triangles, which are equal in every respect.

These four kinds of quadrilaterals are also called parallelograms. When they have an angle of the one equal to an angle of the other, and the sides containing the equal angles equal, they are equal in every respect; when they are on equal bases, and between the same parallels, or when the sides are about an equal angle, taken in the same measures, and multiplied together, produce equal products, they are equal in surface; and when they have an angle of the one equal to an angle of the other, and the sides which contain the equal angle in the one, respectively, the same parts of the sides which contain the equal angles in the other, they are similar.

Trapeziums have all their sides and angles unequal, and a line joining the opposite angles, does not necessarily divide them into two equal parts.

Figures having more than four sides are called polygons. If all their sides be equal, they are called regular polygons, and have their angles also equal; but if the sides be not equal, they are called irregular, and their angles are not equal.

A circle may always be drawn so as to touch all the sides of a regular polygon internally, or all the angles externally.

All the internal angles of any polygon, whether regular or irregular, are together equal to twice as many right angles wanting four, as the figure has sides.

All regular figures having the same number of sides, are similar; and each may, by lines drawn to the centre, be divided into as many equal and similar triangles as the polygon has sides; also, when two regular polygons, having the same number of sides, have a side of the one equal to a side of the other, they are equal in every respect.

Regular polygons are named from the number of their angles, which is the same as that of their order.

A trigon, is an equilateral triangle.

A tetragon, is a square.

A pentagon, is a five-sided figure.

A hexagon, is a six-sided figure.

A heptagon, is a seven-sided figure.

An octagon, has eight sides, &c.

The area, or quantity of space in any figure, is found from the sides, or dimensions, taken in some measure of length; and when these are multiplied together in the way required for the particular kind of figure, they express the surface in squares of the same measure.

The reason of this can be shown mechanically by taking a leaf of paper, the length of which is, (say) 8 inches, and the breadth 6 inches, drawing straight lines both ways, so as to divide it into inches; and counting the number of little squares that are thus formed. Each of these will be a square inch, and their number be found equal to the product of the inches in the length, multiplied by the inches in the breadth. Thus if, as in the case supposed, the length were 8 inches, and the breadth 6 inches, the number of square inches would be found to be 48, which is exactly the product of 8 and 6.

From this it follows, that to find the surface, or as it is called, the *area* of any square or rectangle, we have only to measure the length and breadth, and multiply them together. Thus, if a room be 18 feet long and 12 feet wide, the surface or area of the floor or the ceiling, will be 12 times 18, that is 216 square feet.

This principle is the foundation of all measuring, or finding the area of surfaces. A triangle is half a rectangle, having the same base and altitude, as may easily be shown by drawing a diagonal, that is, a line joining the opposite angles. Hence the area or surface of a triangle may always be found by multiplying the base and perpendicular, and taking half the product; or by multiplying the whole of either of them by half of the other one.

But by joining the opposite angles of any figure, it may always be divided into triangles, the least number of them being always two less than the number of sides—that is, a four-sided figure is dividable into two triangles, a five sided one into three, a six sided into four, and so on. The reason of this is very simple: the first triangle that is made by drawing a line, takes two sides of the given figure and one line; every intermediate one takes one side and two lines, and the last one takes two sides and one line. Hence also the number of lines necessary thus to divide any figure, is always one less than the number of triangles.

When a figure is thus divided into triangles, one has only to measure the lines and perpendiculars of these, and take half their products for the areas, the sum of which is the area of the whole figure.

It can be found, that the area of a circle is equal to that of a triangle whose base is the circumference, and perpendicular the radius. The radius and circumference are not, strictly speaking, quantities of the same kind—the one being a straight line, and the other a curve, and therefore the one cannot be expressed exactly in terms of the other—that is, if the radius be any number of feet, inches, or any other measure, the circumference will not be an exact number of that measure; but still, the one can be expressed with sufficient accuracy for ordinary purposes. Thus, if the radius be 7 of any measure, the circumference will be very nearly 22 of the same.

Hence, when the radius is known, if one multiply it by 44, and divide the product by 7, the quotient will be the circumference; and when the circumference is known, if one multiply it by 7, and divide the product by 44, the quotient will be the radius.

The surface contained within the same measure of boundary, is not always the same. One can easily see, that the more sides any figure has, and the more that it approaches to being regular, its surface will be the greater: thus, if one were required to put the greatest possible quantity of space within a boundary of a certain length, one would form it into a circle; and if it were stipulated that it should not be a circle, but a figure bounded by straight lines, then the most capacious would be the regular polygon of the proposed number of sides.

These paragraphs do not contain the whole or nearly the whole principles of elementary geometry, as applied to lines and surfaces, but they contain as much as is compatible with the size of this little work, and as much too as will enable ladies if carefully studied, to study the science, if they shall have occasion for it.

The account of solids will not require to occupy even so much space, because it is less necessary toward the proper understanding of the other sciences, and because a solid being a thing which has real existence, and can be examined, is much more easily understood than surfaces, lines, and angles, which do not exist separately.

Solids, as has been said, have three dimensions, length, breadth, and thickness, which are understood to be situated at right angles to each other; they are bounded by surfaces; those surfaces are bounded by lines; and the lines terminate in points at which when two or more surfaces, not in the same plane meet, they form solid angles.

Of all solids, the most simple and beautiful is the globe or sphere; and it is also the one, with the properties, at least the simpler properties, of which it is most useful to be acquainted, because of the constant reference that we must make to it in the practical study of geography and astronomy.

The globe or sphere is bounded by one uniform convex surface, that is, a surface which is every way the same, and all points of which are equally distant from the centre. If a globe be supposed to be cut into any two parts by a plane—or even cut, the boundaries of the flat sides will always be circles. If the cut pass through the centre, the circle which bounds it will be the greatest possible; its diameter and circumference will be the same as those of the globe; it will divide the globe into equal hemispheres, or half globes; and it is called a great circle of the globe.

Because all points of the surface of a globe are equally distant from the centre, it follows that all great circles of the same globe are equal to one another; likewise that the measure across the convex surface of a hemisphere, so taken as to divide that surface into two equal parts, is just half the circumference of the globe; and that the measure from the centre of the convex hemisphere to its circumference, is every where the same, and equal to a quarter, or *quadrant*, of the circumference of the globe.

If a globe be supposed to be divided into two parts by a plane—or even cut, which does not pass through the centre, the circle which bounds the level or plane sides of the two pieces will be less than the circumference of the globe; and it will always be the less the more unequal that the pieces are to each other.

The unequal parts into which a globe is thus divided are called segments; and the circle which bounds their flat sides is called a small circle of the globe. Though all great circles of the same globe be equal to each other, there is no limit to the variety of small circles, other than that all of them must be less than the circumference of the globe.

A straight line passing through the centre of a globe and terminated both ways by the circumference, is called a *diameter* or *axis* of the globe; and the extremities of it are called *poles*.

The poles of any diameter are at the same distance from each other, on which ever side that distance be measured; and the distance, measured in the shortest manner possible, is always half the circumference of the globe.

If a globe be divided by a plane passing through the centre and at right angles to any diameter, the circumference marked by that plane will divide the globe into two hemispheres, having a pole of the diameter in the centre of each. The circumference marked by this plane, or a circle drawn upon the surface of the globe in the same direction, forms the boundary of two hemispheres, which have a pole of the diameter in the centre of each.

The word hemisphere is applied equally to denote half of the solid globe, or the half its surface; and, in the language of geography and astronomy, it is the half surface that is usually called a hemisphere.

As a solid means either any body or the space which that body fills, so the surface of any solid may mean either the external surface of the body, or the internal surface of the space that surrounds it; and hence the surface of a globe may be considered either as convex or round, or concave or hollow. Thus, an orange, a ball, or any round body, presents to us the surface of a convex globe, more or less perfect, according to the perfect roundness of the orange or ball; and if we press the same into any soft substance—wax, for instance, so as to get a complete mould for it, that mould would be a concave globe.

When we think of a convex globe we always imagine that we are without it; but we cannot form so perfect a notion of a concave one without supposing that we are in it. Hence the best notion that we can have of a concave globe is obtained from examining the sky,—the position of which over us, when our view is not interrupted by objects upon the ground, or by clouds in one place and not in another, appears to be nearly a hemisphere, the surface of which is equally distant from us.

When the diameter or circumference of a globe is known, every thing relating to its magnitude may be found: we may find its surface, its solidity, the size of segments of it, or the area of any portion of its surface.

All globes that have equal diameters are equal, and all globes whatever are similar; so that when we have found out any property of any one globe, considered merely as a body, or the surface of a body, we can always be certain that the same property belongs to every other globe; for in whatever way the property found out happens to be connected with any part (the diameter) of the one globe, it will be connected precisely in the same manner with the diameter in the other.

Of other solids, those which have parallel sides, with the ends at right angles to them, and are of the same thickness throughout, are called prisms. If the sides and ends of a prism be all equal and similar, each of them will be a square, and the six-sided solid, which they form, is called a die, or *cube*. If the bases or ends of the prism be equal circles, at right angles to the length, it is called a *cylinder*.

If a solid, having any figure for its *base*, terminate in a point at the other extremity, each of its upright sides will be a triangle, and the solid will be a *pyramid*.

Prisms or pyramids are usually distinguished from each other by the figure of their bases. Thus, if they have three-sided bases, they are called triangular; if six-sided, they are called hexagonal; if eight-sided, octagonal, &c.

A pyramid, having a circular base, is called a *cone;* and if the vertex, or point in which the cone terminates, be every where equally distant from the circumference of the circular base, it is called a *right* cone.

If a portion be cut from the top of a cone or pyramid, the remainder is called a fructum.

The nature and properties of solids are the foundation of our understanding those measures, which are called measures of capacity,—those by which the value of solid substances, such as blocks of stone and beams of timber, and also liquids, such as wine or milk, are estimated. In computing these, we are guided partly by the shape and partly by the size of the particular quantity; and here, as in the case of the areas of figures, the one which is the most regular, and has at the same time the greatest number of sides, has the greatest solidity, as compared with its surface: thus a globe or sphere contains more solidity within the same surface than a body of any other form; a circle contains more within the same surface than a prism, whose length is twice its breadth, and that twice its thickness.

Sometimes we have to refer to the solidity, or matter of a solid, sometimes only to its surface, and sometimes to both. Thus, the walls of a house, in as far as they depend upon the stone-mason or bricklayer, are solids; but as they depend upon the plasterer, the painter, or the paper-hanger, they are surfaces.

Solidity is a quantity altogether different from surface, just as surface is altogether different for mere length; and though we may speak of a foot, an inch, a yard, or any other measure, as being a line, a surface, or a solid yet no two of them are convertible into each other, or indeed, can be compared, so that one shall be able to say which is the greater and which the less.

As our notion of the extent of a surface is obtained by imagining two lines of known lengths to lie across each other at right angles; so our notion of that of a solid is obtained by imagining a third one to cross these two, lying at right angles to them both, and as the surface is expressed in numbers by the product of its length and breadth, so the solid is expressed in numbers by the product of its length, its breadth, and its thickness. The reason of this is easily understood, by supposing a piece of wood, or any other solid matter to be divided into parts. Let the wood be, for instance, a rectangular prism, of which the length is four inches, the breadth three, and the thickness two, then the solidity or content of the whole shall be twenty-four cubic or solid inches, that is twenty-four cubes, each of them having all its six sides or faces exactly one square inch, and each of its edges one inch in length. For first, let it be cut in two in the direction of the length, and parallel to the top and bottom, it will be divided into two prisms, each of them four inches long, three broad, and one thick. Again, let each of these be cut into three equal parts, by planes, in the direction of the length, and parallel to the sides, and there will be obtained six prisms, each of them one inch broad, one inch thick, and four inches long. Lastly, let each of these be cut into four equal parts, in the direction of the breadth and parallel to the ends, and the result will be twenty-four cubes, each of them one inch every way. Now it is not because the length, breadth, and thickness have been as named at 4, 3, and 2, rather than any other numbers, or that they have been taken in inches rather than any other measures, that these are the results. Therefore we are warranted in drawing the general conclusion, that, if the length, breadth, and thickness of any rectangular prism be expressed by any three numbers of the same kind of measure, the solidity of the prism in inches of that measure, will be found by multiplying them together; and, bearing this simple and general principle in mind, one has only to compare solids of other shapes with rectangular prisms, in order to find their solidity.

To do this, however, one is obliged to have recourse to another, and a very generally useful part of geometry—that which is called proportion.

Proportion is universal in its application, at least among all substances, and qualities of substances, which can in any way be measured, weighed, or valued, so as to be expressible in numbers.

Proportion is thus, strictly speaking, a part of arithmetic rather than of geometry; because it applies to all quantities, whether geometrical or not, and does not apply to them unless where they are expressed in numbers; but as all simple numbers, the only ones in which the theory of arithmetic can be easily and simply explained, are quantities of the same kind, the consideration of them does not afford sufficient scope for illustrating the doctrine of proportion; and as that doctrine applies equally to all the practical parts of accurate knowledge, and is among the most difficult to be clearly understood of the elementary doctrines, it is better not to introduce it, until a sufficient variety of quantities have been defined, for affording examples whereby to explain it.

Some instances have already been given of quantities that are of the same kind, as well as of quantities that are not; but still it is necessary, in order to understand and apply proportion, to be able at once to know when quantities are to be considered of the same kind, and when they are not.

It must be borne in mind, that the word *quantity* is here used to denote any thing, or any quality or property of a thing, which can be great or small, or which can in any way be expressed by number.

Bearing this in mind, we have the following general and simple means of determining when quantities are of the same kind, and when they are not. It is this: "When by comparing two quantities together, or thinking of them in comparison, we can say either that they are equal, or that they are not equal, those quantities are of the same kind; or if the smaller, without any change of its nature, could be augmented so as to equal or to exceed the greater, they are also of the same kind; but when we cannot say that they are equal or not equal, or imagine that the smaller one could be so augmented as to exceed the greater, then they are not of the same kind."

Quantities which are not of the same kind, can have no proportion to each other.

The proportion of one quantity to another, is the relation which the value or bigness of the one has to the value or bigness of the other; and this relation may be of three kinds: that which is compared may be greater than that with which it is compared, or it may be equal to it, or it may be less than it.

When the quantity compared is greater than the other, the proportion is said to be one of majority; when equal, it is said to be one of equality; and when less, it is said to be one of minority.

When quantities are thus compared, the one with which the comparison is made, and which, as it were, forms the standard, is considered as a *whole*, or *one;* and that which is compared with it is considered as a *part* or *portion* of this whole or one; and it is for this reason that the method of comparing is called *proportion.*

The portion which any quantity is of another of the same kind, or which is the same thing, the relation which the magnitude or value of the one, has to the magnitude or value of the other, is called a *ratio;* and when the values of the two quantities are expressed in numbers, the numbers which express them are called the terms of the ratio. Thus if the numbers compared be two lumps of sugar, and if the one which is taken as the standard of comparison weigh four ounces, and the other one, three; then, as the thing compared contains three parts of the same value as those of which the standard contains four, the one is three-fourths of the other, the ratio of the one to the other is said to be the ratio of 3 to 4, and the numbers 3 and 4 are called the terms of the ratio.

Ratios are usually expressed by writing the quantity compared, and after it the one with which it is compared, and separating them by two points. Thus the ratio of 3 to 4 is written 3 : 4, and is, when alone, read " three to four," and when taken in conjunction with other ratios, " as three to four."

The numbers which in this way express the terms of a ratio, must always be in the same denomination—that is, that 1 in the one of them must be equal to 1 in the other, or that when they are the same, the proportion or ratio must be one of perfect equality.

The first term or number of the ratio, that is, the one which is compared with the other, is called the *antecedent,* and the last, or that with which the antecedent is compared, is called the *consequent.*

The *arithmetical measure* of the ratio, or that which determines its value, is the quotient that would arise from dividing the antecedent by the consequent; and this measure may be either a whole number or a fraction, or there are some cases of ratios in which it cannot be exactly expressed either way,—these are called *incommensurable* ratios. A straight line and a curve, though both measures of length are not, strictly speaking, of the same kind with each other, and therefore their ratios, as for instance the ratio of the character of a circle to the circumference, cannot, generally, be altogether expressed in numbers. The same happens also with the side of a square, and the diagonal or line drawn from the one corner to the opposite one.

According as the quotient which would arise from dividing the antecedent by the consequent is great or small, the ratio is said to be great or small. When that quotient is greater than 1, the ratio is one of majority; when it is just 1, the ratio is one of equality; and when it is less than 1, it is one of minority.

All ratios which have the same measure, that is, which produce the same quotient upon dividing the antecedents by the consequents, are equal to one another.

Hence the absolute greatness or smallness of the terms has nothing to do with the greatness or smallness of the ratio, but merely the greatness or smallness of the one compared with the greatness or smallness of the other.

If the antecedent and consequent be made to change places, the ratio is said to be inverted, and that which results is called the inverse or converse of the original one. The converse of a ratio of equality, is still one of equality; but other ratios inverted, are changed from majority to minority, and from minority to majority.

The product which arises from repeating a quantity any number of times, or, which is the same thing, from multiplying it by any number, is called a *multiple* of it; that which is repeated or multiplied, in order to obtain the product, is called a *part* of the multiple, and the number that expresses the number of times, is called the multiplier.

If two quantities be multiplied by the same number, the products are called *equimultiples* of the quantities; and the quantities are said to be *like parts* of the equimultiples.

Equimultiples and like parts have the same ratio as the quantities of which they are equimultiples and like parts; and the terms of all equal ratios are equimultiples of the smallest numbers in which that ratio can be expressed; thus, the terms of all ratios which express the proportion of 1 : 2, must be equimultiples of 1 and 2.

The equality of two ratios is expressed by writing the sign of equality (=) between them; thus, 3 : 4 = 6 : 8, means that the ratio of 3 to 4 is the same as the ratio of 6 to 8, or that whatever part 3 is of 4, 6 is the same part of 8.

In two equal ratios, if the antecedent of each be multiplied by the consequent of the other, the two products must be exactly equal. The terms of the equal ratios are equimultiples of the same ratio, and therefore, may be both expressed by the same; and thus multiplying the antecedent of each by the consequent of the other is, in effect, nothing more than multiplying each term of one ratio by the other term of the same; and as the products in these cases are produced from the very same numbers, they must of necessity be exactly the same.

Upon this property depends one of the most useful applications of proportion,—namely, when there are given the two terms of one ratio, and one term of another, to find the remaining term of that one, so that the ratios may be equal; thus, for instance, if there be given two quantities of the same kind of goods, and the price or value of the one of them, we are able, by the application of this principle, to find the price or value of the other. For as the goods are supposed to be of the same kind, that is, equal in every thing but quantity, the prices must have just the same ratio that the quantities have, for there is nothing to give them a different one; and thus the proportion must be,

As the quantity of which the price is known,
Is to that of which the price is sought;
So is the known price,
To the price sought.

And it follows that, if we multiply the quantity of which we are seeking the price by the price that is given, the product will also be the product of the other quantity and the price which is wanted; but if the product be divided by one of the factors, the quotient must always be the other; and hence if we divide the product thus found by the other quantity, the quotient will give us the price sought.

In like manner, if there be any two quantities of the same kind with each other, with the one of which a quantity of a different kind is in any way connected, then a quantity of the same kind with this one, and connected with the one of the former two just as it is connected with the other, may be found by the application of proportion.

For instance, if there were two numbers of workmen given, and the quantity of work done by the one, then the quantity done by the other might be found.

If there were two sums of money, and the quantity of any kind of goods which could be purchased by the one of them be given, the quantity which the other could purchase may be found.

If any two quantities representing powers or causes and the effect produced by one of them were given, the effect which the other would produce could be found.

And generally, in every case where the quantity depending upon the other increases or diminishes in the same manner as that upon which it depends, if there be two states of the one, and the state of the other answering one of them, the state of that one, answering to the other state of the first may be found.

Also if the quantities were so related to each other, that as the one increased the other became less, and the state of one of them answering to one of two states of the other were given, the state of the other one answering to the other of these might be found. Thus, for instance, if it required a certain number of men working a certain number of hours in order to dress a garden, it is evident that if more men were employed they would need less time; and if more hours were allowed fewer men would be needed; and that, therefore, according as the one were increased the other would have to be diminished. In all such cases the whole quantity or thing would be expressed by the product of the two circumstances, and therefore that product would have to be always the same; thus, if the garden could be dressed by 10 men in 12 hours, the whole labour of dressing it would be expressed by 120—the product of 10 and 12; and it would be of no consequence whether it were done by 120 men working for 1 hour, by 1 man working 120 hours, or by any number of men working for any number of hours, provided the product of the two numbers made 120. In these cases it is obvious, that if the numbers expressing two corresponding states were multiplied, and their product divided by a number corresponding to another state of one of the quantities, the quotient would represent the state of the other quantity.

Hence one can see generally how, when two quantities which have a proportion are given, a quantity may be found having the same proportion to a third one, that the one of these has to the other; for one would only have so to arrange the given quantities, as that the first and second should be of the same kind, and so placed that the one wanted should be the fourth one, and this being done, the product of the second and third divided by the first would always give the fourth or quantity wanted.

The only conditions required to bring three quantities within the proportion are, that two of them should be of the same kind with each other, that the third one should be of the same kind with that which is required, and related to one of those that are of the same kind in the same way, that the quantity wanted is related to the other. When this is the case the following is in every application the

Rule for proportion.—Write down that quantity which is of the same kind and in the same circumstances with the quantity sought, for the third term of the proportion. Find out whether the quantity sought should be greater or less than that one; and make the greater or the less of the other two the second one accordingly. Then let the quantities be of the same denomination, multiply the second and third, divide their product by the first, and the quotient will be the quantity sought, in the same denomination as the second one.

When only one quality or circumstance of two quantities is compared, the proportion or ratio is called *simple;* but when two or more are compared, it is called *compound.* Thus, simple numbers or lines have each only one quality—*how many,* in the case of the number, and *how long* in the case of the line; but a number which stands for pounds, or yards, or any thing else, has two qualities—*how many* and *of what;* and an area or surface has also two qualities—*how long* and *how broad;* thus, when we say the proportion of *5 shillings to* 6 *francs,* that proportion depends partly upon the two numbers 5 and 6, and partly upon the value of the things named by the words "shillings" and "francs;" and the proportion of the whole of the one to the whole of the other is compounded of the proportion of these; and we have occasion to apply that very general and useful principle which has been mentioned already, that "when the whole value of any thing depends upon two or more circumstances, and varies as each of them is varied, the whole value is expressed by their product."

In the present instance the proportion of 5 shillings to 6 francs, is compounded of these two proportions,—5 : 6 and *shilling : franc;* and, unless we have some means of finding out numbers which will express the last of these proportions we shall not be able to tell what the proportion of 5 shillings to 6 francs is; nor to say that they are equal or not equal. If, however, we are told or find out that *shilling* means 12 *pence* and that *franc* means 10 *pence,* then as the 12 and 10 are both numbers of the same kind, we are warranted in saying that the proportion of "5 shillings to 6 francs" is made up, or compounded of the two proportions of 5 to 6 and 12 to 10; or by the products of the corresponding terms 5 and 12, and 6 and 10. But these products, being both 60, are equal; and therefore the proportion of 5 shillings to 6 francs, is a proportion or ratio of equality.

Things which have the same number of the same qualities may be always compared together; but if one of them has even one quality which the other has not, they cease to be subjects of perfect comparison; and though we may know the nature and value of each of them singly, we are not able to say which is the less or the more valuable of the two.

This doctrine of proposition, though at first sight, or to those who have not been accustomed to accurate reasoning, it may appear to be a matter of mere arithmetic or geometry and on that account not worthy of the time and labour that are necessary in order to understand it, is notwithstanding the most useful in the whole business of education; and that, not so much on account of its merely arithmetical and geometrical applications, as, because no one can think or reason accurately upon any one subject without it.

Every thing that we do, is done in the expectation of some effect that it is to have, either upon ourselves or upon others; and as that effect has not taken place, and therefore cannot be known at the time that we resolve upon doing, we can have no rational motive for our resolving to do or not to do any thing, but that which we derive through the medium of proportion. We have seen by the experience of others, or felt in our own case, that certain consequences have always happened from the doing of a certain thing, and therefore we reason by proportion, that when the thing is again done, the consequences will again follow; and whenever we find that the consequences which we had reason to expect do not follow, then we infer that there is some circumstance in the case which fails, which was not in the case that succeeded.

Being able to know where the circumstances are or are not the same, constitutes the whole difference between a well informed person and a fool; and, in ordinary matters at least, if people always were able to attend to this, and did attend to it, they would succeed much better in all that they do, and meet with far fewer disappointments in their intercourse with the world. Thus, a person who had never seen a candle, or been told the use of it, would neither know that it would burn, or that by burning it would enlighten a room; and one who had never seen that sugar melted, or tasted that it sweetened a cup of tea, would never think of using it for these purposes, any more than they would think of using a lump of stone.

These are to be sure very simple instances; but they are not more simple than any thing else which can be known; or rather, there is no part of knowledge more difficult than they are, provided that folks went about it in the proper way. The book, for instance, which you are now reading, is, whether it happens to be a sensible and useful book or not, a very curious matter; and the world was some thousands of years old before the united wisdom of all the people in it (and they had just the same abilities naturally as people have now) found out how to make such a book. Even now there were a great many things to be done before the book was fit for your reading. Before I could write it, I had to learn to read and write; then to have even a chance of doing it properly, I had not only to read a great number of other books, but to converse with a great number of persons, and to observe the progress of a great number of pupils, in order to find out those things in which written instructions appeared to me to be most useful for them. In all this, you will observe, that I may have failed, and the book may be of no use; but if I have so failed, then it must have been just for the want of that knowledge of all the circumstances, with the importance of which I am endeavouring to impress you, and which I am persuading you always to attend to, in order to prevent that which you so learned from being useless. Whether usefully or not, I must have had the art of writing, and I must have had writing materials, all of which are the result of a great deal of knowledge: the paper, for instance, is first sown in the ground as flax-seed, then it grows up and ripens, then the flax is peeled from the stalks, and prepared for the spinner. The spinner changes it into yarn; the weaver makes the yarn into linen, which is whitened by the bleacher, and sent to the linen draper's in order to be sold. It is purchased and used as a part of dress until it be no longer reckoned fit for that purpose, and then it is sold to the rag-merchant. The rag-merchant takes it to the paper-mill, where it is first torn to pieces, and then steeped and boiled in water till the whole has the appearance of thin starch or water gruel. The paper-maker has a frame made of fine wires, either laid close by the sides of each other, or woven like a piece of cloth. This frame, which is quite level, is the size of a sheet of paper, and has a little border, which partly regulates the thickness. He dips this frame into the vat containing the rags boiled up like starch, and it lifts out a sheet of paper. But the sheet of paper, when so lifted, is nothing more than a little coating of the starchy matter upon the frame, and has to be pressed between folds of moistened blanket, in order to give it as much consistency as that it may bear being lifted. When this is done it is dried, then it is dipped in glue or size to prevent the ink from running, as it does in blotting paper; then it is dried again, made up into quires and reams, and sent to the stationer, from whom it is bought when wanted.

This, you perceive, is a very long process; many hands are employed, and there must have been many heads at work in finding out all that these hands have to do.

But still, long as the process is, you have not yet got your book, neither am I prepared for writing it for you.

I must have a pen and ink. For the former purpose, I must either have a quill and prepare it with a knife, or I must have a pen of steel, silver, or some other metal. In either case I require, first, the miner, who digs, from perhaps nearly a mile below the surface of the ground, a substance which he calls an ore, and which he knows will, when properly treated, furnish the metal that is wanted; then, the ore must be taken to the smelter, who melts it out of the ore; and, lastly, the metal must be taken to the smith, or the cutler, who forms it into the instrument that I want. If that instrument is a penknife, I shall want a handle to it; and if that handle is to be ivory, some one must go half way round the world and fetch the tusk of the elephant.

After getting the knife, I must get a quill. This is pulled out of the wing of a goose after it is dead, or sometimes, barbarously, while it is alive; and, before it be fit for my cutting it into a pen, it must be prepared by the quill-dresser.

Ink is still wanting; and for this purpose I go (or, which is the same thing, somebody else goes) to the oak tree, and finds upon the leaves of it, knobs, like rough berries, which are not the natural production of the tree, but have been occasioned by a little fly, that wounded the leaf, and continued to make the knob grow upon it as a nest for her young. Having procured this substance, I next find out a kind of stone, which contains iron mixed with sulphur, and by pouring water upon that, I, after a considerable length of time get a green substance which I call copperas. This I mix with the knobs which the little fly made upon the oak leaves, and also with a portion of gum, which I get from another tree; and the whole, when steeped in water, furnishes me with ink.

Still, however, the book, such as you have it, is far from being obtained; types must be found, these types must be composed into pages, they must be daubed over with ink; sheets of paper must be pressed upon them, and these sheets must be collected into a volume.

It would consume far too much time to tell how each of these operations is done; and my object in the meantime is not to tell you that, but merely to impress upon you the immense quantity of labour and invention that are required, before a thing so simple as a little book, upon the simple elements of education, can be obtained. The operations are in fact so many, and the materials needed are so much scattered, that if any one had to find out all the materials, and to do all the work, a whole life would hardly be enough for making one single page; while not the wisest or most skilful person that ever lived ever found out one twentieth part as many curious principles and applications as are required to be done before the book is such as you see it.

Still, however, the existence of the book really depends upon all these circumstances, and if a single one of them had not taken place, the book would not have existed; or if any one of them had been different from what it was, the book also would have been different. If you had been furnished with the flax-seed, the ore, the goose, the elephants' tusk, the oak leaf, the fly, the gum, the water, and the other articles, and desired to go and make yourself a book out of them, you would have been very apt to think the person desiring you was foolish, or that at all events, the thing asked to be done was utterly impossible. But when the whole of this compound business is separated into those little parts of which it is compounded, it becomes very easy both to be understood and to be done; the different steps of the knowledge of it, are nothing but so many applications of the doctrine of proportion, or so many instances of reasoning, that that which has been brought about by circumstances once, can be brought about by the same circumstances again; and the different operations of the doing of it, are just so many little acts which any body could perform that had hands, and were willing to use them.

This knowledge, when it extends to a sufficient number of substances and things, is called *philosophy;* and the practical doing which is founded upon the philosophy is called art.

Philosophy comprises all that we can know, whether of the substances that exist in nature, the qualities of those substances, the changes which they undergo, or the uses to which they can be applied. This, however, is its most extensive sense; for the whole of our knowledge is commonly divided into two parts: the mere knowledge of the nature and appearance of things being called *history*, and the knowledge of their causes, changes, and effects upon each other being called *philosophy*.

These distinctions are applied to our knowledge both of mankind and of the external world. The history of mankind being merely a narrative or knowledge of the actions of men or of nations, or as they are sometimes called, of the events of society, and the philosophy of mankind being an enquiry into the principles of human nature, the causes which led to the events recorded in history, or the effects which followed from them. Thus, an account of the landing of Cæsar in England, and of the battles that he fought with the Britons, however full or minute, would be merely a part of history: while an enquiry into the motives which induced Cæsar to land in England, or an investigation of the effects which that event had upon the Romans, the Britons, or the world generally, would be an instance of the philosophy of society, or as it is called, of political philosophy.

In like manner, when we merely describe what is, or what happens, in external nature, without any reference to that which occasions what we see or may be occasioned by it, the description is a portion of natural history; but when we enquire to what that which we see is owing, or what it will produce, it is an instance of natural philosophy. Thus for instance, when we tell that we found the top of a mountain exceedingly cold, while the valley from which we ascended that mountain was warm, we merely state a fact in natural history; but, if we explain why the one is cold and the other warm, we do it by an application of natural philosophy. In like manner, if we merely tell that a stone fell from the top of the tower, we state an occurrence in history; but if, from the weight of the stone and the height from which it falls, we were to calculate the force with which it would strike the ground, the principles upon which the calculation would be made, would belong to natural philosophy.

So that history, properly means the description of what is, or what happens; and philosophy, inquires why such a thing is, how such an event happened, or what may be the consequences.

These two branches of knowledge are so intimately connected, and so mutually assist each other, that they cannot be completely studied, or at least, successfully applied separately—that is, one could not be well acquainted with any one department of history, without knowing the philosophy of that department; neither could one be well skilled in the philosophy, without a knowledge of the history. But though in our after experience, we acquire them together, and even in our school exercises, find constant occasion to refer from the one to the other; yet, as the philosophy differs from the history in this, that it has general principles independent of the particular things which are the subjects of it, it requires to be, to a certain extent known, before history, as a study, can be successfully begun.

Natural philosophy is divided into two great branches, according to the kind of changes to which it relates, and the method of bringing about those changes, or the powers or agencies by which they are brought about; and these great branches are again subdivided according to the classes of subjects or substances to which they are applied.

When the changes are attended by sensible motion of masses of matter that can be weighed or measured, over distances that can also be measured, they are called mechanical changes, and the philosophy which serves to explain them is called *mechanical philosophy*, or sometimes, *natural philosophy;* and when, on the other hand, the changes take place in portions of matter which are too small for being weighed or measured, and when the powers or agencies act by contact, and have not their action accompanied by any visible or sensible motion, the changes are said to be *chemical*, and the philosophy by which they are explained is called *chemical philosophy*, or *chemistry.*

Those two branches of the philosophy of nature, are however, so strictly connected, that there are some cases which fall indifferently under either of them; and some which cannot be explained in a satisfactory manner without the application of them both.

In this sketch, it is proposed to give the outlines, first of the one, and then of the other, in as brief a manner as is consistent with perspicuity.

CHAPTER V.

NATURAL PHILOSOPHY.

Natural Philosophy, (otherwise called mechanical philosophy or physics,) is that branch of knowledge, by which we are enabled to understand and explain all those changes that take place among material bodies, in which their substance is not altered in any thing save its form, and the place that it holds among other bodies. The means by which those changes are brought about, are called mechanical agents, mechanical powers, or mechanical forces; and the changes which they produce when they take place naturally, that is, without human interference, are called phenomena, or appearances.

Wherever we observe that a change has taken place—that a new phenomenon in appearance presents itself, we invariably conclude that some *cause* has been at work, and that this cause has been able to produce the change or effect that has been produced. Thus for instance, if at one time that we visit a place, we find a large mass of limestone rock compact and solid in the earth, and that next time we visit the same place, we find that this same rock has been broken into such pieces as that a man can lift them into a waggon, we conclude that some mechanical means, (the action of hammers and pickaxes, for instance,) has been employed to break, or as we term it, to quarry the stone; and if we find that the stone has lost its shining lustre, become bitter to the taste, and heats, hisses, and dissolves when it is put into water, we conclude that some *chemical* means, (such as burning the stone in a kiln,) has been resorted to.

Every change that can take place in bodies, either by natural means or by human contrivance, must be a change of the relative situation or external form of a body; or it must be a change of its internal structure—unless it be partly the one, and partly the other. The first class of changes are called mechanical, and the second chemical, and those names are given to the causes that produce them. Clay may, for instance, be kneaded and moulded into bricks by mechanical means, but it requires chemical means to harden or burn those bricks. In like manner, the sand and pebbles in the bed of the river, or upon the shore of the sea, are mixed and shaken together by mechanical means; but it would require chemical means, either natural or artificial, to combine and harden them into masses of stone. The motion of the water might move the pebbles from one place to another, without altering the nature of a single pebble; but the differently coloured and textured pebbles could not be fashioned into one uniform piece of stone without some alteration of their internal structure.

Strictly speaking, both mechanical philosophy and chemistry belong to *natural philosophy*, inasmuch as the phenomena which both explain, take place, as every thing takes place, in nature; but as the names *natural philosophy* and *chemistry* have been applied to the two branches of this philosophy, there is no use of changing them.

The things that require first to be known in natural philosophy, are the mechanical qualities or properties of matter, the powers or forces by which they are changed, and the laws of those powers, or the manner in which they act.

Matter is supposed to be in itself inactive, that is, incapable of producing any change upon itself; and this property is called its *inertia*. In consequence of this, it does not change its form or its place, without the action of some force; and it is altogether beyond our comprehension to imagine how it could be either produced or destroyed. We refer the production of it to the immediate action of God, as the great first cause or creator, and as we cannot suppose any thing to be impossible with that Being, we suppose that at his pleasure it would also cease to exist; but how he acted in the one case, or would act in the other, are matters altogether unlike any thing with which we are acquainted; and therefore they are too mysterious and sublime for our philosophy. Indeed, wherever we think of power or action, as apart from the thing which is the immediate agent, and the thing upon which that agent acts, we are driven to the same difficulty. For let but the slightest change, the simplest occurrence, happen, and we find that there is always something in it which we cannot understand, and which, therefore, we are unable to explain. A leaf falls from the tree, or we lift this book from the table. These are simple in themselves; and yet each of them is beyond the reach of our most careful enquiry. In the first instance, we may be able to say that the leaf was broken by the wind, or nipped by the frost, and that, its connexion with the tree being thus destroyed, it fell as a matter of course; and we may say that the book is lifted from the table in consequence of our having the will and the wish to lift it, putting our hand to it in the proper manner, and having sufficient strength; but when we have said this, we have not stated the cause— the real energy by which the events were brought about; we have only stated other events which took place in time before these, and to which we have usually found these following. *Why* the one should follow the other we cannot tell, any more than we can tell *how* the matter which forms the book or the leaf came at first into existence. Thus we are obliged to refer to the same invisible and all-powerful Being—the Author of matter, and the cause of all its forms and all their changes; and thus, if we take it aright, we cannot take one step in the most simple path of philosophy, without finding out that there is One, wiser and mightier than we, whom nature obeys in all her changes, and sets forth in all her productions, in a way calculated to excite in us emotion, awe, astonishment, and admiration, which we can feel towards no other being; and thus by pursuing our enquiries aright, every step that we take in the knowledge of nature, conducts us necessarily to a more perfect knowledge and more sincere adoration of nature's God.

When we speak of a power, we merely mean the number of things that we must combine, and the way in which we must combine them, in order that that which we have found by former experience to take place, may take place again;- and as each of these preceding events, or *causes*, as we call them, is in itself the last of matters, succession of events, of which we cannot so much as imagine the first, those which we call *causes* are all the *effects* of something that happened before, and those which we call *effects* are all to be the *causes* of something that shall happen afterwards. Thus I press the penknife against this quill, in a certain way, and with a certain degree of force, and by doing this the quill becomes separated into two parts. Now though, in common language, we say that the application of the knife is the cause of the quill's being separated, yet that knife and its pressure are effects —the one of the art of the cutler, and the other of my labour in applying it; and if we were in this manner to follow either the one or the other, we should find a succession of effects and causes—the cause uniformly becoming an effect as the event before it was thought of—till we could find no end of the succession. Indeed, at whatever point of this succession we feel ourselves disposed to stop, we come to precisely the same difficulty as though we pursued it to the unknown creation of the matter that forms the substances thought of.

But still this utter inability on our part to understand the invisible agency by which the events of nature are brought about, does not render that succession of events that we can perceive and understand, either less certain or less instructive. Nor is the extent of that which we can know, to be considered as of less value because there are other matters, which, from the very constitution of our nature, we cannot know. Experience is our unerring guide; for that "like circumstances, are invariably attended by like results," is just as universally and certainly true, as it would be, though we knew just as well how the matter of which a quill consists is originally made, as we know, how that quill is made into a pen.

This simple proposition is the foundation of the whole science of natural philosophy, and in order to turn it to proper account, we have only to make ourselves well acquainted with the appearances or qualities of bodies, and with the phenomena that arise from placing them in different relations, and also to be able to know what constitutes similarity of circumstances, and what are the results or consequences. For if we know these things, we have only to consider what happened in the former instance of those circumstances, and then we may rest well assured, that precisely the same will happen in any new instance.

All natural bodies appear as solids, as liquids, or in the state of air; and though the general principle of matter, simply considered—that of being destitute of any inherent power or energy by which it can move or change itself, be common to them all, yet the phenomena which each class presents, have so many peculiarities, as to warrant a subdivision of the science. Indeed, a subdivision still minuter than this becomes necessary, in order to a full understanding of natural philosophy; and thus it is divided into a considerable number of portions, of which the following are the principal.

Mechanics, which treats of the laws, of the balancing, and motion, of solid bodies, and the mechanical contrivances by which the less power or force may be multiplied or increased, so as to exceed the greater.

Hydrodynamics, which treats of the mechanism and motion of liquids.

Pneumatics, which treats of the mechanical properties of the air or atmosphere.

Optics, which treats of the mechanical properties, motions, laws, and operation of light.

Acoustics, which treats of the motion and laws of sound.

Electricity, *Galvanism*, and *Magnetism*, which treat of mechanical properties of certain substances or peculiarities of bodies, which are produced partly by mechanical and partly by chemical means, and which are either different in their nature, or modifications of the same peculiarity, produced by difference of circumstances.

Meteorology, which treats of the mechanical nature and laws of the various phenomena which take place in the atmosphere.

Astronomy, which treats of the appearances and motions of the celestial bodies, and the laws by which these motions are regulated.

Those divisions of natural philosophy are the foundations of all the mechanical arts,—at least of all of them in which the changes that are produced are external, and do not alter the nature or constitution of the pieces of matter that are employed.

MECHANICS.

Mechanics is, strictly speaking the knowledge of mechanical forces, as they exist in or are produced by combinations of pieces or masses of matter; and the first things to be learnt in this science are the properties of matter and the laws of motion.

The properties of matter are:

1. Inertia, or the disposition to remain unchanged either in place or in form without the operation of some external agent.

2. Impenetrability, or the disposition which every body or piece of matter has to maintain in the place which it occupies without permitting the same to be occupied by any other body.

In consequence of those two properties, (and the one of them is merely an inference from the other), it is inferred,

That every change which is produced is in proportion to the cause producing it.

That equal effects are produced by equal causes.

That in unequal effects the greater is produced by the greater cause.

That the effect produced is the measure of the cause.

That when two or more causes act in the same way the effect is equal to the sum of them all.

That when two causes act in an opposite way, the effect is their difference, and in the same way with the greater one.

That two bodies cannot occupy the same space at the same time.

3. Extension, or the space which any body fills, and which, as stated in a former chapter, has always three dimensions.

4. Elasticity, or the power of returning its form of magnitude, after the body has been bent or compressed. This, however, is not a general or uniform property of matter, but varies with different kinds of matter, and even with the same kind in different states; thus, cast iron, or iron just as it is melted out of the ore, if rapidly cooled, cannot be bent without breaking. Soft iron, which has not been hammered after being heated, remains bent, while iron which has been converted into steel, and hammered when cold, returns to its original shape after having been bent by a very considerable force. So also water in the state of ice may be bent a considerable way, and when in the state of steam may be made to occupy an endless variety of spaces, while water in the liquid state cannot have its bulk perceptibly altered. In considering the elasticity of bodies, therefore, nothing can be stated generally—the whole depending upon the particular elasticity of the body under consideration.

5. Mass, or quantity of matter. This is not strictly speaking a quality of matter, it is rather a general name by which the whole of any particular quantity of matter is expressed. But it depends upon a phenomenon which, in so far as we know, is connected with every piece of matter whether great or small, and by which we are enabled to compare the mass of one body with the mass of another. This phenomenon is called *gravitation*, and those who have more fancy and folly than philosophy

have given themselves more trouble and being more incomprehensible in enquiring into its causes, than upon any other part of the subject.

The cause, in fact, is just as inscrutable as the origin of matter, or as the active energies by which the appearance or situation of matter is changed; but the fact itself is perfectly familiar, and in as far as actual substances are concerned, universal. Thus, for instance, if we stretch out our hand and lay any thing, for instance a book, upon the upper side of it, that is, upon the side farthest away from the earth, the book remains there and presses upon our hand, producing a certain sensation which we call that of heaviness or weight—words which have nearly the same meaning as gravity. But if we place the book on the other side of our hand—that is, on the side nearest to the earth, we do not, even although it is the same surface of the hand, (the palm, for instance), to which the book is applied in both cases, observe the same result or feel the same sensation. In the latter case the book does not rest upon our hand at all, but leaves it and falls upon the table; or if that be out of the way, upon the floor; or if that be out of the way, again upon the surface of the earth; or if it be over a pit, it falls to the bottom of that,—or till it meet with some other body, an equal bulk of which is *weightier* than the book; or which, by reason of the cohesion or sticking together of its parts, prevents the book from going farther.

Every body which we can lift or raise up from the earth's surface has this tendency to move back again toward the earth unless it be prevented by the interposition of some other body; and as the same body at the same distance from the same point of the earth's surface always shows this tendency in the same degree, we are led to infer that equal gravitation is a proof of equal quantities of matter—or that gravitation is the mixture of the quantity of matter; and because the body falls not in consequence of any force directly applied to it, but merely because that which prevented its falling is removed, we call this tendency the *force of gravitation*—although of its nature as a force we be just as ignorant as we are of that of all other forces.

In consequence of the fact, that all bodies raised from the surface of the earth tend toward it again, and of the effect which the celestial bodies have upon each other, gravitation is assumed as a general property or rather phenomenon of matter; and when we take the simplest view of the law of its operation we say that, if any two pieces of matter, equal in every respect, were placed at any distance from each other, and left free to the action of gravitation, they would begin to move at the same instant, move at the same rate, and meet each other at exactly the middle of the distance; also, if two unequal bodies (say one of them containing twice as much matter as the other) were to be placed in a similar manner, the body which weighed 2 would move over 1, and that which weighed 1 would move over 2; so that they would meet at a point one-third of their whole distance from the greater body and two-thirds from the less.

The whole quantity of matter in any body, or the whole tendency that it has to fall or press upon that which supports it, is called the *absolute gravity* of the body, and is supposed to be the same whether the space which that matter occupies be greater or less.

The quantity of matter that exists in a given space of the body is called its *density;* and the quantity that is in the same space of several bodies is called their *specific gravity*. Thus, a pound of feathers and a pound of lead have the same absolute gravity; but the specific gravity of the lead is greater than that of the feathers, because the same space filled with lead weighs more.

The absolute gravity of bodies is known by weighing them, or by weighing a part and estimating the whole from that; and the specific is known by comparing the weight of equal bulks.

In deciding the absolute gravity we must have recourse to some uniform piece of matter, or force necessary to resist the action of gravitation; and in determining the specific gravity, we must take some one substance as a standard of comparison. For the latter purpose water is very convenient, because the weight of it is subject to fewer variations from changes of heat and cold than most other substances with which we are acquainted. Water is therefore supposed to weigh 1, and other substances more or less according to trial.

Besides the properties of matter, the laws of motion must be understood; and these are partly inferred from the properties of matter, and partly derived from experience. There are three general laws:

1. That a body always remains in a state of rest or of uniform motion in a straight line, unless the operation of some external force put it into motion, or change its direction or rule of moving. This follows from the assumed *inertia* or want of power to change its state, which forms the most general property, and is, in fact, the definition of matter.

2. That the change produced is always equal to, or in proportion to the force producing it, and the motion impressed by any one force is in a straight line in the direction of that force.

3. That action and reaction are equal; or that as much of the force is consumed or wasted as is the measure of the effect produced. Thus, if I push a body with any

force, (say two pounds,) then that body resists the push which I give to it with a force also of two pounds.

As bodies not only never change their state without the action of an external power, but resist the action of that power by the action of their inertia, it follows that, when one body in motion comes in contact with another, and communicates motion to it, no new motion has been generated or produced; for it is invariably found, that the motion that is gained by the one body is lost by the other. Thus the original cause or source of motion is just as impossible to be found out as the original cause or source of matter.

But as we cannot conceive any motion to be produced unless by the waste of another equal quantity of motion, so we cannot suppose any motion to be destroyed without supposing it to be converted into something that is equivalent. Thus, when one throws a stone, and breaks a pane of glass in the window. The motion appears to begin with that of the arm which flings the stone, and to end when the stone and the fragments of glass have reached the ground; but the motion of the arm consumed a portion of animal energy, and the motion of the stone and the fragments may be followed in the vibration of the air and the pressure of the pieces upon the earth; so that even in this case, the beginning and the end of the motion are alike unknown. When, therefore, we speak of a force as producing motion, we mean nothing else than some antecedent motion, by the change of which that referred to was produced.

When motion proceeds from one cause, or force, it is considered as uniform and in the same straight line. In this case it may be said to be simple, and the only variation of which it admits is that it may be quick or slow.

The particular quickness or slowness of any motion is called its *velocity*; and that is intimated by the space which a body passes over in a given time. If the spaces passed over be equal, the velocities are greater as the times are less, and less as the times are greater; and if the times are equal, the velocities are greater as the spaces are greater, and less as the spaces are less. Thus the velocities are in proportion as the spaces passed over directly, and as the times which elapse in passing over them inversely; and hence in equal velocities the product of the space and time must be the same.

The whole force which any body in motion possesses; that is, the motion that it could communicate to other bodies, or the resistance which it would require to stop it, is therefore the product of the quantity of matter by the space passed over in an equal time. Or if the masses, times, and spaces passed over, be given with regard to two bodies, their *momentum* or relative forces will be expressed by the product of the mass and space in each one, divided by the time.

From this it is easy to see how all uniform motions may be compared with each other.

Besides being in straight lines, motions may be in curves of any form, according to the power and direction of the forces producing; and they may be either *accelerated* or *retarded*. The acceleration or retardation may also be uniform, or it may be variable, according to almost any law of variation; and thus the whole doctrine of motion and moving bodies, though simple in its mere elements, may become complicated.

The tendency of a force, a single invariable force, being to cause a body to move in a straight line, the length of which varies with the force; it follows that all invariable forces may be represented by straight lines.

When a body is acted upon by two forces, the directions of which form an angle with each other, the body will not move in the direction of either of them, but in a direction intermediate between them; and the force which results will be equal to the diagonal of a parallelogram, of which the given forces are the containing sides, and having the direction of that parallelogram. Thus, if a ball were placed at the left hand corner of this sheet of paper, toward the top, and acted upon at the same time by two forces, one of which acting alone would drive it along the top of the sheet to the right hand corner, and the other of which would drive it down the left hand margin to the corner at the bottom, then the two acting together would, in the same time, drive it to the right hand corner at the bottom. A line drawn from one corner to the other, diagonally across the page, would express this resulting force; and, in the same way, if any two forces were to act at the same time with known intensities and in known directions, the compound force which they produced would be found in the same manner.

If motion be accelerated or retarded according to any law, it is assumed, that either the single force, by which it is produced, is accelerated or retarded, according to the same law; or that additional forces are successively introduced in the same direction, in the case of an accelerated motion, and in opposite directions, in the case of a retarded one.

If two forces, the one of them constant, and the other continually diminishing, act in opposite directions upon any body, that body will, whatever is their proportion at starting, ultimately overcome the other one, and the motion will at last be in the direction produced by it.

In the same piece of matter, the force of gravitation, or tendency which that piece of matter has toward the earth may always be regarded as an uniform force, and may be supposed ultimately to overcome any momentary impluse, however great, that the piece of matter may get in another direction. Thus, when we throw a ball from the hand, in a direction slanting upwards, we find that for a certain part of its course it ascends, and that for the remainder it descends. Now, it is perfectly evident, that all the time it is ascending, the force with which we throw it, or as it is called, the *projectile* force is greater than the force of gravitation, but that all the time it is descending the force of gravitation must be the greater of the two. Also, there must be one point of its path—the highest, which separates these two portions, and where the two forces must be exactly equal; and it is farther evident, that if, by any means, we could reach it at that point of its path, and urge it on with the same force of projection that it then has, it would neither rise higher from the earth nor sink nearer to it, but would continue to move at precisely the same distance from it as long as the two forces were made to balance each other.

Now, as the earth is a globe, the ball acted upon in the manner described, would move not in a straight true line, but in the circumference of a circle; and it would do this upon precisely the same principle as that upon which the ball driven in the direction of the top and edge of the sheet of paper, would move diagonally across the sheet to the opposite corner.

In order to understand this we must bear in mind that as the gravitation,—the tendency to pull, is not toward any particular portion of the earth, but to the whole of it considered as one mass of matter, the point to which any body tends to pull is that which is *immediately* under it at the time, or in other words, that the tendency of bodies that pull toward the earth, is always in the direction of its centre. As the body moves on, this direction will keep constantly changing with regard to the surface of the earth, so that if the portion of the projectile power and the disposition to pull were to be at any time overpowered with each other, the actual path of the ball would have the same relation to them that the diagonal of a parallelogram has to the sides containing the angle from which it is drawn.

But when the ball is at the top of its path, the force of projection has no tendency either to make it rise higher or sink lower, but merely to drive it forward in a straight line, while the force of gravitation makes it tend toward the earth in a direction at right angles to that line.

Hence we may lay it down as a general truth that, if a body be acted upon by two uniform and equal forces at right angles to each other, one of which always tends, or is directed to the same point, the body will move in a circle, the centre of which will be the point to which the successive powers tend.

In this case, the force which prevents the body from removing to a greater distance from the centre, is called a *centripetal* force; and that which tends to prevent it from approaching nearer to the centre, is called a *centrifugal* force.

The force of gravitation increases the nearer that any two bodies are to each other; and as this is the case, the same two forces of gravitation and projection could easily be imagined to support a body moving in a path different from a circle. Thus, if the bodies were nearer to each other at one point than at another, the force of projection would have to be increased as they approached. But the projective motion of the body depends wholly upon the force of projection; and, therefore, if the body was made to revolve in any other curve than a circle, its motion would have to be increased as it approached nearer to the point toward which the force of gravitation were directed. Thus, if the stone or ball were to be made to revolve round the earth in an ellipse or oval, that could be accomplished by supposing the earth any where within the oval, and so regulating the projectile force that it and the force of gravitation should always have the same proportion to each other.

This is a matter of calculation and of observation. The earth and all the planets, (as will be more particularly explained in the chapter on astronomy,) revolve about the sun, not in circles but in ovals; and this is accomplished by increasing the velocity as the distance from the sun is diminished. The two forces are not quantities of the same kind, and therefore their proportion to each other in any single case, cannot be expressed in numbers; but by comparing the cases it is found that the corresponding forces in each case, are the same parts of each other, that is, that the distances from the sun, and the velocities of motion obey a certain fixed law. The law is this: If the two distances from the sun be expressed in the same measure, and each multiplied twice by itself, and the times in which the revolutions, or equal parts of them, expressed in the same measures, be each multiplied once by itself, then the products resulting from the distances will have precisely the same proportion to each other as those arising from the times.

By this means, if we know the distance of one body from the other, and the time which it takes to perform its revolution; and also, either the time or the distance of another body, then we can easily find the other of these.

Since the quantity of matter moved, multiplied by the space that it is moved over, is the measure of the force which moves it; it follows, that the force employed, or which is the same thing, the motion, or effect produced in any two cases may be precisely the same thing, although both the quantities of matter moved, and the spaces over which they are moved may be different. The spaces moved over may always be represented by two lines; and since in equal forces or motions, the products of each quantity of matter, multiplied by the space that it moves over is equal, we have the spaces inversely as the quantities of matter; or supposing the spaces equal, we have the quantities of matter directly as the times; that is, the same force will carry double the weight over half the space in the same time, or over the same space in double the time.

This is the principle upon which all machines act, that enable us to perform motions, raise weights, or do any thing else that the power which we can exert simply could not be able to perform. Thus, a man is able to lift two hundred weight to the height of six feet in five minutes; but he has a single and indivisible mass of four hundred weight to raise to the same height; and how shall he accomplish that? He might do it thus: let him take a strong piece of wood, say 12 feet long, and fasten the weight which he wished to raise at the one end of it; suspend the piece of wood by a point 4 feet from that end, and then press down the extremity of the other end; and as that would, from the method in which the piece aforesaid is suspended, pass over 8 feet in the time that the four hundred weight were passing over four; or that the man's power of two hundred weight, moving over 8 feet in the same time that the weight moved over 4 feet, would make the product of the quantity of matter, and space passed over the same, and the man would raise the weight; but what he gained in power, he would lose in time, inasmuch as he would have to pass his end of the wood through 2 feet in the time that the weight was passing over 1 foot.

A piece of wood, or any other inflexible matter used in this way, is called a *lever*, and the point at which it is suspended is called the *fulcrum*. The lever is the simplest of what are called the *mechanical powers*—that is, the simple machines by which a small force may be made to overcome a great resistance, by moving proportionally quicker.

The general purposes to which those mechanical powers or contrivances are applied, are the raising of weights, the overcoming of the *cohesion* of bodies, and the overcoming of friction, or the resistance which we feel when we attempt to make one body slide along the surface of another; and before we can overcome any of these, we must exert a certain quantity of force, or which is the same thing, expend a certain quantity of motion.

A common scale-beam is a lever suspended by the centre, and thus the beam is in *equilibrio*—that is, the ends of it remain at rest equally near the earth, when there is the same weight in the scale at each end; and therefore we can by its means easily find the weight of bodies. If we were to make the one arm of a scale-beam twice as long as the other, we should require to put twice as much weight into the scale attached to the short arm, as into that attached to the long one.

There are three kinds of levers; first, when the fulcrum, or centre upon which the lever turns is placed between the power and the resistance, as in pincers, scissars, &c. Second, when the fulcrum is at one end, and the power at the other, with the resistance between them, as in the case of oars, where the water is the fulcrum, the hand of the rower the power, and the side of the boat the resistance;

or in nut-crackers, where the joint is the fulcrum, the hand applied the power, and the nut the resistance. Third, when the fulcrum is at one end, the resistance at the other, and the power between them, as in the case of common tongs.

In all these cases, the principle is the same: if the power and resistance be at the same distance from the fulcrum they are equal to each other; and when they are at unequal distances, the power and resistance are inversely in their respective distances. Hence, in scissars, pincers, and other instruments of the first kind, the power of the instrument is greatest when the blades are short, and the handles long. In those of the second kind, the power is greatest when the resistance is nearest the fulcrum: and in that of the third kind, the effect produced is always less than the force applied, and diminishes as the instrument is grasped nearer to the centre of motion.

The second mechanical power is the *wheel and axle;* in which a large resistance applied to the axle may be overcome by a small power applied to the wheel. The wheel and axle is nothing more than a lever, the long end of which is half the diameter of the wheel, and the short end half that of the axle. By encreasing the number of which, the power, or the motion, which is the same thing, may be varied to an unlimited extent. Thus, if a large and small wheel have teeth that act in each other, the large one having, say 120 teeth, and the small one 12, a power of 1, applied to the small wheel, will overcome a resistance of 10 applied to the large one; but the large one will move only once round for every 10 turns of the small one. Clocks and watches, and a variety of other machines are made upon this principle. The first wheel of the clock, (the 'scapement wheel,) is by the motion of the pendulum, made to turn round once in a minute;

then, if a small wheel, attached to the same axle with it move another large wheel, containing 60 times as many teeth, that large wheel will move round once in an hour; and if a second small wheel be attached to the same axle, with the second great one, and be made to move a third great wheel, containing 12 times as many teeth, then this third great wheel will move round once in 12 hours, and complete the motion of the clock: all that is further required being to apply such a weight to the axle of the last great wheel, as will suffice to put the whole in motion.

The third mechanical power is the *pulley*. A pulley is a small wheel over which a rope is passed. A single pulley gives no advantage further than that, if it be placed above the point where a person stands, it may enable him to draw upwards to that point, or down to any point below him, or let down from it a weight without moving from his place. But if the rope be made to pass over several pullies opposed to each other, and drawn toward each other when the rope is pulled, the power that pulls at the rope will be multiplied by two for every time that a pulley is passed over: thus, suppose there are four pullies, there will be eight folds of rope, and when eight inches of the rope have been pulled, that will only amount to one such upon each fold, or the weight will only have moved over one circle, while the power applied has moved over eight inches; therefore, the power communicated by the four pullies is a power of eight. The pulley thus depends on the same general law as the lever—namely, that if the weight move over a space equal to any one part of that moved over by the power, the weight will be as many times the power as the fraction expressing that part.

The fourth mechanical power is the *inclined plane*, or *wedge*. This may easily be understood, when we say that it is easier to slide a weight up a smooth sloping surface than to lift it to the height of the upper end of that surface at once, but that it occupies greater time. The reason is that, except the *friction*, which need not be taken into the account, there is no *lifting*—no gravitation to be overcome when any body is moved sidewise, without being reared up; while, when it is raised up, there must be a quantity of power exerted sufficient for overcoming the whole of its gravity. The weight of any body upon an inclined plane is therefore in proportion to its weight raised perpendicularly, as the height of the plane is to its length. Thus, if a road slopes upward at the rate of one foot in ten, a horse will draw ten times as much up that road as he would lift directly from the ground. The *wedge* is nothing but two inclined planes joined together. It is used for overcoming the cohesion of bodies,—in cleaving wood, for instance.

The *screw*, which is the last of the mechanical powers that we shall notice, consists merely of two inclined planes, the one fastened to the outside of a cylinder; and the other to the inside of a box in which that cylinder works. The screw is generally moved round by a lever, and the power which it produces is estimated by comparing the length of that lever with the portion of the screw that rises or falls at one revolution. Thus, if the lever be twelve inches long, and the screw rise or sink one tenth part of an inch, a power equal to one pound weight, applied to the handle, will produce a power of 120 pounds at the end of the screw. The screw is generally used where great pressure is wished to be given, because, when made with a single thread, its friction prevents it from returning from the position into which it has been put, even after the power ceases to be applied to it.

All machines, however complicated, may be resolved into a combination of these simple powers; and the laws of their action, together with those of gravitation, form the whole theory of mechanics; but the practice is modified by the nature of the substances employed. No machine will perform the quantity of work that theory gives, because, in the majority of cases, about a third is lost in overcoming the friction.

HYDRODYNAMICS.

Hydrodynamics is usually divided into two parts: *hydrostatics*, which relates to the phenomena of liquids when at rest, and the pressure of solids when immersed in them; and *hydraulics*, which relates to the phenomena and laws of liquids when in motion.

A liquid, otherwise called a *non-elastic fluid*, to distinguish it from an air or gas, is a body whose parts are so minute that neither the naked eye nor the eye assisted by glasses can distinguish them; but of which the parts have so little cohesion that they may be separated by any force equal to overcome the mere gravity of the portions; which, when allowed to rest, invariably assume a level surface, or so dispose themselves as to be all equally distant from the centre of gravitation; and which present a uniform resistance to every part of any solid immersed in the liquid.

Though the general tendency of liquids be to gravitate toward the earth, yet where a liquid is confined in any vessel, it presses upon the sides of that vessel just in the same manner that it does upon the bottom. In consequence of this a vessel may be burst laterally, or even upwards, while the bottom remains perfectly whole.

The pressure of liquids upon the bottoms of the vessels that contain them is in the proportion of the area of the bottom, multiplied by the depth of the liquid, whatever may be the form of that vessel in other parts. In consequence of this a very small quantity of liquid may be made to sustain and even to raise a very great weight. Thus, if a long and narrow tube had its lower end bent upwards and formed into a cylinder, in which a water-tight piston or cover were made to move, and if the narrow part of the tube ascended about 33 feet higher than this cylinder; then, if the tube were one inch in area, and filled with water, that water would raise a weight of nearly 16 pounds upon every inch of the piston or cover of the cylinder; and if the surface of the cylinder were 100 inches, the tube filled with water, which would in that case contain about 14 pounds weight of water, would raise a weight of about 1600 pounds. No doubt the space over which this great weight would be raised would be proportionally smaller than that through which the water in the small tube would descend; but still, within that limited range, a very great power might be produced by a very small quantity of water.

When a solid, of precisely the same specific gravity, is plunged in a liquid, it will remain at rest in any part of that liquid: if it be of less specific gravity than the liquid, it will rise to the surface; and if it be of greater, it will sink to the bottom. When it rises to the surface, as much of it will still remain plunged in the liquid, as it takes of the liquid to equal it in weight. Thus, if any body, a ship for instance, floats with one half of its bulk in the water and the other half out, that body is just half the weight of water.

In consequence of this property of equal pressure in all directions, water, or any other fluid, will rise to the same height in any number of pits or vessels that have a communication with each other at their lower extremities. Water will, of its own accord, rise as high in a pipe as the surface in the fountain or cistern from which that pipe is supplied, but it will not rise higher without the application of some external force.

As the elastic fluids or airs have this property of pressing in all directions, in the same manner as non-elastic fluids or liquids, the ascent of vapour, smoke, and balloons, and the descent of rain, snow, and hail, in the atmosphere, depend upon the very same principles as the ascent of lighter, and the descent of heavier bodies in water.

Water, or any other non-elastic fluid, can be put in motion only by two causes—gravitation, and pressure when confined in vessels or channels. When acted upon by gravitation, the water invariably seeks the lowest places; but when acted upon by the pressure of an external force, it may be made to move laterally or upwards.

When water escapes from a hole in the side or top of a vessel, the velocity with which it escapes increases in proportion as the hole is below the surface of the water from which the vessel is supplied, and when this hole and the surface of the water come to be at the same level, an equilibrium takes place, and the water ceases to flow. The force with which it issues is not, however, in the same proportion as the height; for if, in a vessel in which, by a supply at the surface, water were always to be at the same height, one wished to have two holes of exactly the same size, but the one of which should discharge twice as much water in the same time as the other, then that which was to discharge the double quantity would have to be four times as far below the surface as the other one; or supposing the quantities of water to be expressed by any two numbers, the comparative distances of the equal apertures below the surface, would be expressed by the products arising from the multiplication of each of those numbers by itself.

Upon the relative force of water, when issuing from certain depths below the surface, and falling from certain heights, the whole properties of mills and other machines which are moved by water, depend; and upon its inelasticity and disposition to press equally in all directions, are founded hydraulic presses and forcing engines· though the latter partially depend upon pneumatic principles. The discharge of water by springs, and the raising of it by pumps, also depend partly upon the gravitation of the water, and partly upon changes in the pressure of the air; and therefore their action cannot be perfectly understood without some knowledge of

PNEUMATICS

This branch of natural philosophy treats of the mechanical properties of the air or atmosphere, and so far as the atmosphere is a fluid, and presses equally in all directions, the principles of hydrodynamics and pneumatics are precisely the same; but inasmuch as the air is elastic, while water and the other liquids are not, there are some doctrines in pneumatics which have nothing corresponding to them in the other science.

Pneumatics, as a part of natural philosophy, treats of the weight, pressure, and elasticity of the air, without any reference to the substances of which it is composed, or the changes which are produced in it by changes of heat and cold.

The weight or pressure of the air, considered as mere matter, is downward by gravitation, like that of all matter, and equally in all directions, as it is a fluid; but because it is elastic, that is, compressible into less space by weight, and expansible, so as to diffuse itself equally over a greater space when the pressure is removed, the different strata of it, that is, portions of it at different distances from the mean surface of the earth, or that surface at which the water settles into the great hollows and porous oceans, have different degrees of density, that is, contain different quantities of matter in the same space.

In consequence of this, the lowest portions, or those which are nearest the mean surface of the earth, are the most dense, because they are pressed by the weight of the whole column above them; while as one ascends higher and higher, the strata being pressed by still less and less, the expansive force acts, and the air is diffused over a greater space.

We can discover this elasticity of the air by a very simple experiment: for if we take a common drinking glass, which is deep in proportion to its width, and inverting it and holding it perfectly level, press it down into a basin of water, we find that the air, which completely filled it when it just touched the surface of the water, becomes less and less as we force it down; but if we keep the glass steady, so as that no portion of it shall escape in bubbles by the sides of the glass, we find that as we raise it to the surface, the air gradually resumes its former bulk, and again fills the glass, when it is brought just so as to touch the surface, without the admission of any new portion of air.

We may satisfy ourselves of the gravitation, or weight of the air, by an experiment equally simple; for if we fill the glass with water when it is under the surface, and keeping it perfectly steady, raise it gradually, we shall find that the water inside the glass stands at a higher level than in the basin. Now as the surface of any quantity of water, when not acted upon by any external force, is always perfectly level, whether it be in one vessel or in several vessels that have a communication with each other, the water within the glass could not stand higher than that in the basin, unless it were pressed upward; and as pressure upward beyond the surface of the rest of the fluid, is contrary alike to the nature of fluids and the principle of gravitation, there remains no means of accounting for the pressure of the water upwards into the glass, unless it be the weight of the air upon the surface of it.

But this simple experiment not only shows us that the air has weight, but, when properly performed, it shows us what that weight is. Any glass in common use, if filled and inverted under water, may be put on a plate, with only a very small portion of water round its lower edge, and removed in this way with the water filling it completely. But if we take a glass of more than 33 feet in height, we would find that, in ordinary states of the atmosphere, the water in the glass would not stand more than 33 feet above that in the basin. By this means we find that the total weight of the atmosphere is equal to almost 33 feet depth of water—that is, when taken at the mean level of the earth; and if we performed our experiment at an elevation, we would find that the pressure or weight of the atmosphere would not balance a column of water so high as this. A column of water of this height, and having its base or area one inch, weighs almost 16 pounds; so that the pressure of the atmosphere at the mean surface of this earth is almost 16 pounds upon every square inch; but as the air is a fluid, it presses equally in every direction and therefore, every inch of the surface of a body, whether that surface be upward, downward, or lateral, is pressed by the atmosphere with a weight of almost 16 pounds.

It is upon this property of the air that the action of the barometer or weather-glass depends, only in ordinary cases that instrument is filled with mercury instead of water. This is done because an inch of mercury is almost as heavy as a foot of water, and thus the tube of the barometer which, with water, would require a height of about 33 feet, only requires a height of so many inches with mercury. In making the instrument, the tube is filled with mercury, and the end of it, taking care that no air is admitted in the process, is inverted in a little vessel of the same fluid; and when this is done the mercury in the tube descends into the basin, till the column of mercury between the surface of the one and that of the other be of the same weight with a column of the atmosphere of the same thickness.

If the atmosphere were always of the same weight, the mercury in the barometer would always maintain the same height; but the height of the mercury varies, and from that we are led to infer corresponding variations in the weight of the atmosphere. How these variations are produced, is no part of pneumatics to explain, as little does it belong to that science to inquire into the effects of them. Sometimes, however, they are mechanical. Thus, for instance, when the air is in rapid motion, its pressure must be in a certain extent diminished; and hence the barometer will fall during violent and long continued winds. Also, when one body is falling freely through another it does not add to the weight of the whole, and even when it meets with partial resistance in falling, it only adds to the weight of that through which it falls, that portion of its own gravity which it loses by the partial resistance. Thus when water, in how minute drops soever, is falling through the air, the whole weight of the water is not added to that of the air; but if the water were suspended in the air so as only to move when the air in which it floated moved, the whole of its weight would be added to the weight of the air. Now the air, in certain states which depend upon heat and upon other causes, (probably electric ones,) with which we have hitherto been able to devise no means of becoming acquainted, has the power of taking up water by the process which we call *evaporation*, and holding it suspended in an invisible form. In these states, the whole weight of the water that is held in the state of vapour is added to that of the air, and the barometer in consequence stands high. But there are other states of the air in which it not only ceases to take up water by vapour alone, but deposits that which it had formerly taken up, and the portion so deposited begins to fall, often in the higher regions of the air before there be any appearance of it near the earth. The moment that this begins, the weight of the water which is in the act of falling is taken from that of the atmosphere, and the barometer sinks. In this way, the barometer serves not only for indicating the pressure of the atmosphere, but also for foretelling the changes of the weather; and foı this reason it is called the *weather-glass*. Besides those purposes, the barometer is successfully applied to the measuring of the heights of mountains; but in order to do this, the temperature and chemical state of the atmosphere have to be taken into the account, so that the operation does not depend wholly upon the principles of pneumatics. Supposing, however, that the temperature and chemical state are the same, and that the law of the difference of density, (which is a matter of calculation), of the atmosphere is known; the falling of the barometer is an easy means of determining the difference of elevation.

The pressure of the atmosphere is applied to many useful purposes; it is upon it that the action of common pumps depend. The pump-rod has a valve upon it which opens when used. When the rod is forced down into the barrel or tube of the pump, the air forces open the valve and escapes by it; and when the rod is again drawn up, the pressure of the air shuts the valve and the water rises. If the distance between the valve and the water be less than 33 feet, the operation will at last exhaust or extract all the air; and thus the valve will begin to lift water forced into the barrel of the pump by the pressure of the atmosphere upon the surface of the water in the pit or well below.

In like manner, if by any means we can extract the air from any vessel, the pressure of the atmosphere, driving an air-tight piston back again into that vessel, will furnish us with a power, which is very considerable in its energy, and which may be applied at any situation. That species of steam-engine called the atmospheric engine depends upon this principle; steam in a state of great elasticity produced by heat is let into a vessel, and drives a piston to the top of it; then the steam is, by a jet of cold water, condensed or converted into water; and the pressure of the atmosphere drives the piston back again into the vessel.

The elasticity of the air also furnishes us with a power of considerable energy; for by a pump which acts in the opposite way to a common pump, we may force air into a strong vessel till it be very much condensed; and, as the disposition which it has to expand increases with this condensation, the momentary removal of the condensation is attended by an effort on the part of the air to regain its former degree of expansion, which is productive of considerable effects. Air-guns are in this way charged, by forcing a great quantity of air into a small vessel; and when this is allowed suddenly to escape, it drives a bullet with a force similar to that of gunpowder; which is nothing else than a great and instantaneous expansion of air produced by the chemical operation of burning the combustibles of which the gunpowder is composed.

A vast number of amusing experiments may be performed by the *air pump;* a machine, the simplest operation of which consists in pumping or extracting the air out of a vessel called a receiver; and which, for the sake of observing what goes on within it, it is usually made of glass. But as none of the machines which are used for illustrating the principles of natural philosophy, (and which, when spoken of in the plural number, are called *apparatus,)* can be well explained without engravings, or skilfully used without verbal explanations and seeing the instruments themselves; the details must be left to the teacher.

OPTICS.

Optics explain the laws and properties of light; and as light is at once the most useful and the most beautiful substance in nature, optics is one of the most interesting divisions in natural philosophy.

Light proceeds from a luminous body in straight lines, which emanate from the body in all directions; and with a velocity so astonishingly great, that over any distance of which we can have a clear conception, its progress may be said to be instantaneous. It has been determined that the light of the celestial bodies moves at the rate of 195000 miles in one second of time; and as it has been mentioned in the section upon mechanics, that the momentum or force with which any moving body strikes an obstacle, is represented by the product of its quantity of matter and its velocity; it follows, that if the particles, or individual parts, of which light is composed were not as astonishingly small as their velocity is astonishingly great, their impulse would not only be more fatal to the human frame than cannon shot, but would dash the earth itself to pieces. They are so delicately fine, however, that they produce no effect whatever upon any of our senses, except that of vision; and none upon the earth, except producing and disclosing all those fascinating colours with which it is adorned.

Light is not only the means by which we become acquainted with colours, it is that by which we are enabled to understand forms and judge of magnitudes and distances. Thus, if we close our eyes and move our hand very slowly along the edge of the table, with the length of which, when our eyes are open, we are perfectly familiar, we find that we have no notion of its length, except from our feeling of the time that our hand takes to pass over it: so that if at two different trials we move it, so that the time of its moving feels only half as long in the one case as in the other; the table also will, in that case, feel only half as long as in the other.

The motion of light from any other source appears to be just as rapid as that from the celestial bodies; when we light a candle in the middle of a room, the light instantly diffuses itself to the remotest corner; and if we produce a light which can be seen over any tract of country, that light will be instantaneously seen over the whole extent of it however large.

In these cases indeed, the light becomes less intense as we remove from the body producing it, and when the quantity given out is but small, we lose sight of it altogether. This will be easily understood, when we consider that light always moves in straight lines, unless some object turn it aside, and that is obviously the case, as we can never make a beam of light turn round a corner. Taking one direction merely, there will, when light issues from a point, be only half the quantity of it in the same length at double the distance from the body; and taking the other direction, there will also be only half the quantity in double the breadth. In the same surface, there will therefore be only one-fourth of the quantity at double the distance. Thus, if we hold this book at the distance of one foot from the candle, there will fall a certain quantity of light upon it; if we hold it at two feet distance, there will fall one-fourth of the quantity; if at three feet, one-ninth; and generally, the quantity of light will diminish as the squares of the distances,—that is, as the products arising from the multiplication by itself of the number expressing each distance.

This may also be made familiar, by showing the effect of shadows. Thus, if we hold our finger near to the candle, and receive the shadow of it upon a book, the shadow will increase in size, as the book is removed further from the finger, or as the finger is brought nearer to the candle; and, if we make the shadow fall upon a plane surface, all the way from the candle, we shall perceive that it spreads out like a fan as it recedes, and that also, as it recedes, it becomes more indistinct. This indistinctness arises from two causes: the quantity of light with which the shadow (and that is merely an absence of light,) is compared, becomes less as one recedes; and the light from other bodies, is also thrown upon the shadow. Thus, if there be two candles, and if we place one finger with the point upon the table, we find three shadows, one dark one, which ends in a point, and which is longer or shorter according as the candles are nearer each other, or more remote; and two faint ones, which broaden as they recede from the candles. And if, instead of the second candle, we employed a looking glass or sheet of white paper, or any other surface which reflected the light, the effect would be the same in kind, and would differ only in degree, according to the reflecting power of the surface.

Although the sun obviously diffuses light around in the same manner as a common candle, and though the intensity of the light of the sun must thus, like the other, diminish either square of the distance, yet the sun is so large a mass, and the light which it sends forth is so powerful, that, throughout any space over which we can examine it, there is little variation of its intensity, and the rays of it are to all appearance parallel.

The two properties of light upon which the whole science of optics depends, and by which almost all the phenomena of vision are explained, are *refraction* and *reflection.*

When the rays of light pass through an uniform transparent medium, whether that medium be a solid such, as crystal, a liquid such as water, or an air such as the atmosphere, they pass directly through it in perfectly straight lines; and when they pass from one transparent medium to another of a different density, leaving the one and passing into the other at right angles to the surface of both, they also move in perfectly straight lines; but when they pass obliquely from one medium into another, they are turned aside from their original course, in consequence of their motion, rapid though it be, and minute as they are in themselves, being more difficult through the denser medium than through the rarer one.

When an oblique ray enters a dense medium, it is bent *toward the perpendicular,* and when it enters a rarer medium, it is bent *from the perpendicular;* the deflection, or angle at which it is bent, and which is called the angle of refraction, being the greater the more difference that there is in the density of the two media. This is the general law of *refraction,* but it cannot be well understood or illustrated, without attending also to the law of *reflection.*

The rays of light when they fall upon some substances, such as perfectly plain and colourless glass, pass through without sustaining any change; but when they fall upon other substances, they are either partially or wholly absorbed within the substance, wholly thrown back again from its surface, or partly absorbed, or partly thrown back and partly transmitted. The transmission which gives to a substance the quality of transparency, seems to depend upon the fineness, uniformity, and close contact of the particles of the substance; and the absorption seems to depend partly, and the reflection almost entirely, upon the surface.

When the whole of the rays are transmitted, the substance is colourless; when the whole are absorbed, it is black; and when the whole are reflected, it is white. The colours which are intermediate between these, depend upon the quantity and kind of the rays that are absorbed, or transmitted, and those that are reflected.

In order to judge of this, one must analyse a beam of white light. This may be done thus: take a triangular prism of glass, which is well polished, colourless, and of uniform texture; apply it to a beam of solid light, passing through a hole in a window shutter, or any other way; and the transmitted light will be instantly decomposed into seven rays of the most exquisite beauty and brightness. The position of these, beginning at the angle of the prism by which the refraction is produced, will be red, orange, yellow, blue, purple, and violet; of which the mixtures of three, the red, the yellow, and the blue, appear to produce all the other ones: red and yellow produce orange; yellow and blue, green; and blue and red, purple, or violet. These rays of light are separated in consequence of their having different degrees of refrangibility. The red is least so, and therefore it remains more in the original line, in which the white light, (the light of the sun,) falls upon the prism, and the others are separated from that according to their refrangibilities.

All the endless variety of colours that appear in nature, or are produced by art, depend upon this property of the rays of light. If a substance reflects only the red rays, it will appear red, and so of all the others, either singly, or in any proportion of which they may be mixed.

Bodies become visible to us only in consequence of light reflected from them; and they receive colour from the way in which that light is reflected; and some bodies which are made up of small portions of different substances alternating with each other, may appear of different colours, according to the position in which they are held with regard to the light and to the eye of the observer. What the change of surface is, that produces the difference of colour in the same substance, is not very well known, because the change effected in the texture of the substance, cannot be mechanically examined; but the fact is not upon that account the less certain. Thus, if a piece of silk be treated in one manner by the dyer, it will appear yellow, while if treated in another manner, it it will appear blue. Now if silk threads, of both these colours, be woven into a web, with the blue threads one way and the yellow threads the other, the web produced will appear to be of three colours, according to the light in which it is seen. One way the blue light only will be reflected, and it will appear blue; another, the yellow only, and it will appear yellow; and a third, the two will be reflected equally, and the colour will be green.

Thus we may assume it as a general truth, that though the shape which an object appears to have comes from its real shape, and the colour from its real texture, yet that both are apparent to our perception only in consequence of the light that is reflected from their surfaces.

The general law of the reflection of light is, that the angle at which it is reflected, is always equal to that at which it falls upon the reflecting surface; or, as it is usually called, because "the angle of *incidence* (that at which the light falls) is always equal to the angle of *reflection.*" This may be shown by any common mirror: let the mirror be placed upright against the middle of one wall of a room; place a candle on one of the adjoining walls, and place yourself against the other, so that you be just as far from the mirror and as far to the opposite side of it, and you will see the candle exactly in the centre of the mirror; also, if you move the candle and yourself equally, and uniformly apart from each other, the image will remain stationary; and if you move, leaving the candle stationary, the image will move in the same direction with you. Also, if you take a mirror and receive upon it a ray of light that comes through a hole in the window shutter, you may throw the reflection, or image of the ray, into any part of the room you please. If you hold it so that the ray be perpendicular to its surface, you will throw the reflection back again upon the aperture by which it entered; and if you slope it any way, you will throw the reflection to the same side.

After the nature of reflection is known, there are many pleasing ways of satisfying ourself of the truth of the refraction. Thus, if you take a basin of water and put a straight stick slanting into it, so that one part of it be out of the water and the other in, the stick will appear straight no longer, for the portion in the water will appear more sloped than the other, in consequence of a bend upwards which it receives at the surface of the water. Also, if any object (a shilling for instance) which the pouring in of water will not move, be placed in the empty basin, and you retire till the shilling is just concealed by the edge; then, if another person pours water into the basin, the shilling will gradually make its appearance. The reason of both of these phenomena is, that the rays of light from the objects under the water, and by means of which only the objects can be seen, when they pass from the water into the air (which is from a denser medium into a rarer one) are bent downwards. Upon the same principle, the sun appears in the morning a little before it is actually up, that is, before a straight line joining it and the eye of an observer would be clear of the earth.

The reflective power of the atmosphere, which distributes in all directions a portion of the light that passes through it, produces also some very convenient effects. Were it not for that, the setting of the sun would be followed and his way preceded by total darkness, and every shadow would also be competely dark; but the reflection of the atmosphere prevents the former results, and that of terrestrial objects the latter.

The light which is reflected from any object is always capable of exhibiting the form and colour of that object; but then it is so *attenuated*—so rare—has its particles so small and so distinct from each other, that these do not become visible without some particular contrivance. This contrivance is a convex surface, if the rays are to pass through it, from and into a medium less dense and compact than itself, or a concave or hollow substance when the rays are to be reflected from it into a rarer medium. The eye is furnished with such a contrivance as this. There is in it a substance called the lens, which is thick at the middle and thin at the extremities, so that all the rays of light which fall upon it are collected or concentrated to a single point in the interior of the eye; and by this means the rays, which come from each object and follow the inner part, become so powerful that the form and colour of the object are perceived.

We may construct such an apparatus artificially, by taking a piece of glass, or any other perfectly transparent substance, making it thick at the middle and thin at the edges, and giving it a perfectly polished surface. Such an object is called a *burning glass*, because it also concentrates the heat of the sun—a *magnifying glass*, because objects seen through it appear larger—and a *convex lens* from its shape.

Well, if we take this lens, and, darkening the room every where else, apply it to a hole in the window-shutter, we shall find a picture of any object that may be without represented upon the wall, a piece of paper, or any other substance, which we hold a little way from the lens. By moving the lens backwards and forwards, we find that the image or picture is more perfect at one place than at any other; this is the point toward which the rays that fall upon the lens are collected, and it is called the *focus* of the lens; because, if any inflammable body were held in it, the sun shining upon the lens, that body would be set on fire.

On the other hand, if we were to apply a convex or hollow mirror to a hole in the roof—placing the mirror slanting, so that it were directed half way between the surrounding objects and the floor, the pictures of these objects would, if the room were otherwise darkened, fall upon the floor in the same manner as that transmitted by the lens fell upon the wall or screens.

Though the one of these contrivances acts by refraction and the other by reflection, they both produce the same effect, and produce it by similar means; namely, by condensing or concentrating the rays of light that are reflected from objects.

In order to understand why convex lenses and concave mirrors make objects which are seen through the former, or by reflection from the latter, appear to be larger than they really are, we have to consider what it is upon which the apparent magnitude of objects depends. Now, when I stand near the window, I can see a whole row of houses or a number of fields through one small pane of glass,—that is, the pane of glass appears to be *larger* than they: increase to my view, and it covers them all and something more. We can in this case perceive that, however far the two lines that meet at our eye and touch the sides of the pane may be extended, they will always show to us an equality of breadth; and if we take the whole boundaries of the pane, we find that they always inclose an equality of surface. Hence we say, that the magnitude of objects depends upon the angle under which they are seen; or, as it is called, upon *the visual angle*. In consequence of this, the magnitude of any object increases as that object is brought nearer to the eye, and diminished as it is removed to a greater distance. In the case of a line, the lineal angle, under which it is seen, varies with the length of the lines at equal distance, and with the distances, in the case of equal lines; but in the case of a surface, the variation is as the square of the line or the distance.

It is upon this principle that the art of *perspective*, in so far as it represents form and magnitude, depends; and the perspective of colours, or *aërial perspective* as it is called, depends upon the disposition of the rays of light, and consequently of the colours which those rays produce when carried to different distances: as the distance is increased, a tinge of *blue*, the most refrangible of the three primitive colours, comes in from the refraction of the *lateral* light from other objects; and when the distance is very great, all distinction of colour is lost, and the very remote mountains melt into the azure of the sky.

The convex lenses and concave mirrors act by bending the rays toward each other, and thus increasing the visual angle; and lenses and mirrors of an opposite form diminish by declining the rays of light, and making them form smaller visual angles. Spectacles for old persons, telescopes of all kinds, and microscopes,—every contrivance, in short, by which the apparent magnitude of objects is increased, depends upon the conveying or concentration of the rays of light; and spectacles for those who are near-sighted, and all other contrivances by which the apparent magnitude of objects is diminished, depend upon the scattering or divergence of the rays of light. The one is just the reverse of the other; and in a telescope in which there is a combination of lenses, if one look in at the object-glass, any object will appear as much diminished as it appears increased when one looks in at the eye-glass.

The applications are very numerous, and most of them are very beautiful; but if the doctrines of refraction and reflection be well understood, the science of optics becomes as simple as it is delightful.

ACOUSTICS.

Acoustics is the science of sounds, and the principle upon which it depends is the elasticity of bodies. Sound is produced only in the air, and the cause of it is understood to be the beating of the elastic body against the air when it is thrown into a state of vibration.

Sound travels through the air at the rate of about 1·142 feet in a second, or nearly 13 miles in a minute, and hence one is enabled to calculate the distance of any event that is accompanied by a flash of light and a report. Thus, for instance, if one observed a flash of lightning and in 30 seconds, or half a minute afterwards, heard the accompanying peal of thunder, the thunder would be at the distance of six miles and a half, and so on in other cases.

The pulsations of sound proceed from the sonorous body in all directions, aud thus become weakened by distance, though at a more rapid rate than the colours in vision.

Almost any solid substance conducts sound. Thus, if a watch be laid upon an end of a beam of timber, however long, the beating of the watch will be distinctly heard at the other end of the beam if the ear is put close to it. In the same manner, if one fasten a string of any kind to the poker, take the string in the teeth, and (shutting the ears and letting the poker swing freely) hit it against the fender, it will sound like a bell.

Sound may, like light, be reflected, or concentrated, or dissipated: and upon these principles, echoes, whispering galleries, and the impossibility of hearing in rooms of certain forms are explained.

Upon this principle, also, are explained those contrivancies called speaking dolls and invisible girls, where the sound is conveyed in tubes, and concentrated by being made to strike against concave mirrors. Of surfaces, those that are the smoothest are the best conductors of sound, and of bodies, those that have the most elasticity are the best producers of it. Sound may be produced although one of the bodies that are brought into collision may have very little elasticity. Thus, water is among the most inelastic of substances, and yet the roar of a cataract may be perfectly deafening.

ELECTRICITY, GALVANISM, AND MAGNETISM.

1. *Electricity.*

This is a peculiar state of bodies—a state of which all bodies seem to be, in a certain degree, susceptible, and which is generally supposed to depend upon a peculiar fluid, which like light, has no gravitation that can be estimated or even known. It is also probable, that in all states, the electric matter (whatever it is,) is diffused among all bodies, animate and inanimate, in a state of equilibrium—that is, in such a manner that each has, as it were, its *natural quantity*, and has no tendency to impart to others, or to abstract from them. What that natural quantity is, how it is combined with bodies, and whether the same bulk or the same weight of all bodies contain the same or different quantities, we have no means of knowing, neither do we know whether the qualities of bodies do or do not depend upon this electricity. We know of its existence only when the equilibrium is destroyed, and one body, in some manner apparent to the senses, gives out electricity to the other bodies.

It is probable that no change whatever can take place without a disturbance of the electric equilibrium, though in some cases the disturbance be so small, that we are unable to perceive it. Thus, if any two bodies be rubbed together, if a whole body be torn asunder, or heated, or cooled, or melted, or frozen, or evaporated—or in short, have any change that we can name performed upon it, the equilibrium of electricity is destroyed, and the body is to a greater or less extent brought to what we would call an electric state.

The usual phenomena, or appearances, that accompany this state are, a tendency in the electric body to attract other bodies towards it, and then to drive them away; and if the body be what is called strongly electrified, it emits sparks of fire, in a manner more or less violent, and those sparks may be rendered so powerful as to be instantly fatal to animal life, and instantly to fuse or melt substances, which the greatest intensity of ordinary fires is unable to fuse, or at least fuses with great difficulty.

With regard to this *disposable electricity*, there are remarkable differences between different substances. In some of these it can be excited easily and to a high degree, while in others, no labour will produce the same effects; thus, if you take a piece of sealing wax, and rub it till it becomes heated, it will attract and lift small bits of paper, and if you take a very thick sheet of the coarsest brown wrapping-paper that you can find, hold it over the fire till it be at the point of kindling, and then, laying it upon a chair which has a hair-cloth cushion, rub it smartly with a dry piece of silk or woollen, it will become so strongly electric as to give out brilliant sparks, and if you hold it against your face, you will feel a sensation, as if the poker were discharging something at you; but if you rub the poker, or heat and rub the fire shovel, no such effects will be visible.

Substances in which electricity is easily excited are called *electric* substances, or *electrics;* and those in which it is excited with difficulty are called *conducting* substances, or *conductors.* Being an electric, has always some connexion with dryness, and being a conductor, with moistness; and, in as far as regards electricity, the electric is supposed to have the power of retaining the electric fluid after it has become sensible, while the conductor is supposed to give it out to other substances the moment that it becomes sensible. Thus, it is possible that as much electricity is really excited by rubbing the poker as by rubbing the sealing-wax; but the quantity excited remains, or is accumulated in the wax, but not in the poker.

A conducting substance may be made an electric, by insulating it, that is, by placing it upon electric substances: thus, if the poker be laid upon the tops of two tall glasses that are perfectly dry, the air being perfectly dry at the same time; the poker may be made an electric, or (which is the same thing) it may be charged with electricity; for if electrics in a high state of excitement be brought into contact with it when it is thus insulated, it will receive their excess of electricity, and retain it until some conducting substance be brought in contact with it. If the glasses and the air were both perfectly dry, there is every reason to conclude, that the insulated poker would retain the electricity with which it were charged for any length of time; but as the air always contains some moisture, this can never practically be the case. Under favourable circumstances, however, if a large cylinder or plate of glass mounted on a stand the feet of which are glass, baked wood, or any non-conductor, and rubbed for some time with a piece of silk, upon which a mixture of quicksilver and lead is spread; and if a metallic cylinder be placed near it, and have sharp points projecting from it and directed toward the glass, the glass will give out electricity in a succession of crackling flames toward the metallic cylinder. If the metallic cylinder is connected with the earth by a conducting substance, as for instance by an iron chain, the electricity which that cylinder receives from the glass will not be accumulated in it, but will pass off by the conducting substance and disappear; but if the metallic cylinder be insulated, the electricity will accumulate in it; and if any conducting substance be brought near to it, the accumulated quantity will be discharged into that substance with a flash of light and a report.

This arrangement of substances forms what is called *an electric machine.* The glass is usually so contrived as that it can be turned round with the rubber pressing against it; and the three parts, the *rubber*, the glass *cylinder*, or *plate,* and the metallic cylinder, or conductor, are placed so that the glass may be always insulated, and supported upon non-conducting substances; and the others insulated or not according to circumstances. If the rubber is not insulated the electricity appears to be drawn from the earth by its connexion, and conveyed to the conductor, where it accumulates if that be insulated; but when the rubber is insulated and the conductor not, then the electricity which becomes visible appears to come by its connexion with the earth; and if in this case the conductor be insulated, it is brought into a state of what is called *negative* electricity,—that is, it appears to have *less* than the substances connected with the earth. If, when the electric machine has been worked for some time with the rubber connected with the earth, and the conductor not, you bring your finger near to the conductor, you will perceive a cone of flame issuing from the conductor, and entering your finger with its point; and if the conductor has been highly charged, you will feel a smart shock. On the other hand, if the rubber has been insulated, and the machine worked, the conductor will draw a cone of flame from your finger, and you will feel pain at the surface whence the flame issues.

In like manner, if you place yourself upon a stool with glass feet, and hold in your hand a chain connected with the conductor, you will (if the rubber is not insulated) become charged with an excess of electricity, and enabled to give shocks to other persons, or to fire spirits of wine by touching with your finger; and if the rubber be insulated, you will be placed in a state for receiving shocks from those who are not connected with the machine.

Thus we can, by rubbing an electric and receiving the electricity that is thereby excited into a conductor which is insulated, or drawing the electricity from that conductor, either communicate to it such an excess of electricity as shall enable it to impart electricity to other substances, or abstract electricity from them with a violence proportional to the difference that there is between the state of the insulated conductor, and that of the other conducting substances that we apply to it.

When, however, the conductor, which first receives the electricity, is connected with earth by an unbroken chain of good conductors, it passes away without effort; but if a non-conducting substance break the connexion to a considerable extent, the electricity will be accumulated; and if in this case one touch the disjoined conductors, one will receive a shock violent in proportion to the accumulation of electricity.

One of the best means of obtaining electricity in a powerful state is, to take a glass jar or phial, the outside and inside of which are both covered with tinfoil to within a small distance of the top, and the stopper of which has a wire which touches either by itself or by a chain the coating inside, and which terminates externally in a metallic knob or ball. If this phial or jar be well dried, and placed with the knob in contact with the conductor of the electric machine, and the external coating having a communication with the earth, the inside coating may be highly charged with electricity while the outside retains the same state as the bodies around. The glass, being a non-conductor, prevents the communication of the electricity from the interior coating in any other way than by the wire and ball; and thus, if these are avoided, the charged phial may be moved from place to place without the escape of the electricity. If, however, one were to touch the external coating with the finger of one hand, and the ball of the wire with that of the other, a shock would be given, severe in proportion to the extent of the internal coating and the degree to which it were charged; and a number of phials connected with one ball might thus be charged, which would form what is called an electric battery; the discharge of which may be made very powerful.

From what has been said of the method of charging and discharging an insulated conductor, it will be perceived that the electric state of the conductor is produced only where other conducting substances do not connect it with the earth; and that when any conducting substance is thus insulated, it may become either electric to an excess, or to a deficiency according to circumstances.

Water is one of the best conductors, and dry atmospheric air one of the worst, and thus an electric; hence when a cloud, which is nothing else than a portion of water divided into minute drops, is floating in the air, it may, by the friction or rubbing of one current of air upon another, or by some other cause, which is out of the reach of our observation, become either more or less electrified than the earth, or than other clouds in the air. Now as long as those clouds which are in different states of electricity are so far separated from each other by the intervention of dry air, as that the one cannot communicate its excess to the other, and thereby restore the equilibrium, they remain unaltered just like the insulated conductor, or the phial; but when they come within the distance at which electricity can be communicated, they impart the excess, in a succession of flickering sparks when the clouds are very near to each other, and of a bright flash and accompanying report when they are at a distance, without being so far asunder as that the electricity cannot be communicated. Also when a cloud, in a different state of electricity from the earth, floats so far above the surface, as that the excess cannot pass from the one to the other, no effect is produced; but when the cloud descends to within the proper distance, the excess is given out with a brilliant flame and loud explosion, and this force is sometimes so great, that rocks are shattered to pieces, trees splintered, buildings set on fire, and animals killed.

These are the well known natural phenomena of lightning and thunder—the lightning being the flame produced by the electricity, and the thunder, the sound produced by the violence with which one part of the atmosphere strikes against the other parts. The flame of the lightning consumes one part of the atmosphere, (the oxygen, to be explained in the next chapter,) and the heat expands the other to an incalculably greater bulk. The expansion is merely momentary, and ere any measurable time has elapsed, it is again condensed, and the separated parts of the atmosphere are dashed against each other. The flame of lightning is always directed to the best conductor that is nearest to it; and as this is apt to change with its position, it is sometimes zigzag in its appearance. Points, especially if metallic, are the best conductors, and hence, in places where damage is dreaded from lightning, thunder-rods are erected for the protection of buildings. The point of the rod, rising above the building, attracts the electricity, and by communicating with the earth, conveys it there without danger to the building. If, however, the rod were to be broken, and the parts separated to a distance from each other, damage would be the consequence; and if one were, in a violent storm, to approach the upper part of the broken rod, or to touch it with a better conductor than itself, one's temerity would be rewarded with the loss of life.

2. *Galvanism.*

Galvanism, though similar to electricity in some of its effects, yet does not appear to be the same either in its nature or its mode of production.

Electricity is caused by what appears to be wholly mechanical means, and cannot exist if moisture be present; while galvanism is always accompanied by chemical action, requires a portion of moisture, and decomposes it into the two airs of which it is made up. Another thing, galvanism does not give such a shock to living animals; but it can affect them, so as to produce motion of the parts after life is extinct.

The simplest way of rendering the galvanic action apparent, is to take a small piece of the metal called zinc, and a small piece of silver, to put one of them between the teeth and the upper lip, and the other between the teeth and the under lip; then, upon bringing the edges of them into contact, a peculiary offensive taste will be produced; and if the eyes are closed at the time of the contact, a faint flame will be perceived as often as the two pieces of metal are made to touch each other.

The way, however, in which the effects are rendered the most striking, is by the use of the *galvanic pile,* or the *galvanic trough.* The pile consists of a succession of pieces of copper, zinc, and cloth, or pasteboard, moistened in a solution of common salt, or of any acid or saline substance that will act upon the metals. It is arranged so that the pieces follow each other regularly, and that the one metal forms the bottom plate and the other the top. Then, if a wire from the top plate be brought into contact with a wire from the bottom plate, an action is produced, violent in proportion to the size and number of the plates.

The trough has the metallic plates arranged across it at small intervals, which when the trough is made to act are filled with a solution, similar to that in which the cloth or pasteboard of the pile is moistened; and the metals are arranged so as to begin with the one, and alternating them regularly, end with the other. When the wires are brought into contact, they appear to convey toward each other a portion each of one of the two component parts of water, oxygen and hydrogen, (see Chemistry,)—the oxygen coming from the zinc, and the hydrogen from the copper. Hydrogen is one of the most inflammable of substances, and oxygen the best supporter of inflammation, so that when the wires are brought nearly into contact, they produce the most intensely powerful heat with which we are acquainted—a heat which makes an iron wire burn like a taper, burns charcoal under water with a most dazzling light, and has enabled chemists to perform experiments, and make discoveries of which, without this power, they would have remained ignorant.

It has not been, and probably cannot be, perfectly ascertained, whether electricity and galvanism be substances, or mere states of action; or whether they be different, or merely modifications of the same; but still that does not lessen the utility of their effects.

3. *Magnetism.*

This is a state of bodies far more confined in its range than electricity and galvanism, though certainly not less useful in its application. A peculiar species of iron ore, called the *natural* magnet, or the *loadstone*, has this quality in a considerable degree; and pieces of iron and steel are attracted or drawn towards it, and (especially steel, which is not rusted) they may become possessed of the same power, by being rubbed with the natural magnet.

Every magnetic body, when so placed as that it can assume whatever direction it pleases, ranges itself in a certain way; and if it be so placed as to turn finely upon a centre, it retains its position, although that upon which it is poised be turned round. When it is in the form of a small rod or needle, the one end of it is directed nearly toward that point which we call the north; and the other toward that which we call the south. It does not point directly to these; and the deviation is different at different places, and at the same place at different times; but still, the true north may, in most cases be nearly ascertained from the position of the magnetic needle; and hence its great use to seamen, in guiding them when they can see neither the land nor the heavenly bodies.

The opposite ends, in opposite *poles*, as they are called, of two magnets, attract each other, and adhere with considerable force when they are powerful; but the same poles repel each other.

When any piece of iron is put in that position in which the magnetic needle would arrange itself in free space, it becomes to a certain extent a magnet. Thus, if a common compass, with the glass removed from the box, be placed upon a table near the north edge, and the poker held in the position of the north and south, with the south end near the north of the compass, and the north end sloping downwards, the poker will become a magnet, and the south end of it will attract, and be attracted by the north of the compass. But, if the poker be reversed, that is, if the south end of it be kept steady, and the whole turned upon that end, so that the other end become the south one, the north and south of the poker will be reversed; and the north end of it being now nearest to the north end of the compass, they will repel each other; and if the magnet of the compass be very active, and delicately poised, its poles will be reversed by the change of the south round to the north.

If the south end of the magnet be held to the north end of a compass, and drawn round the box, the compass will follow after it; but if the north end be held to the north, and moved round the box, it will drive the compass round before it.

The compass of a ship is affected by the iron of the ship, and also by certain rocks which contain iron and other matters.

The cause of magnetism is altogether unknown; for though it can be imparted only to certain substances in certain states, and though a change in the state of the substance destroys it, yet it is attended with no mechanical or chemical change which we can consider as being peculiarly magnetic.

The several sections of this chapter contain a few of the leading principles in the different parts of mechanical philosophy, stated in as simple a manner as is perhaps consistent with the nature of such subjects; and if they are studied with care, it is hoped that the pupil will be prepared for hearing lectures or reading extended works, on the different branches of the science with proper advantage.

The next general division of knowledge, and the one which completes the theory of natural philosophy, and that enables us to proceed to the historical and descriptive application, is Chemistry, to a brief outline of which the next chapter shall be devoted.

CHAPTER VI.

SKETCH OF CHEMISTRY.

The object of Chemistry is to find the constituent parts or substances of which bodies are composed; the proportions which those parts have to each other, the laws which hold them together, or enable one to separate them, and the new combinations which those parts, taken in different quantities, or in a different arrangement, would form.

Thus the most simple division of the science is into:

First, substances which are accounted simple;

Second, those which are compound; and,

Thirdly, the powers by which compounds may be separated, or simple substances formed into compounds.

But, before we can proceed to explain these, it is necessary to mention the mechanical forms, in one or another, which all bodies are found to exist. These are *solids* and *fluids*, both of which have the same signification in chemistry as in common language; and fluids are subdivided into *liquids*, and *airs* or *gases*.

Part I.—Simple Substances.

When in the language of chemistry any body is called simple, it is not understood to be asserted that it positively consists of only one part or ingredient; all that is meant is, that it is a substance which we have never been able to decompose into two or more different substances; and which therefore we cannot prove to be a compound.

Of those simple substances, the number of course has diminished as the science of chemistry has improved. Thus at one time, pure water, and the air which we breathe, were both regarded as simple substances, but experiment has proved that water is a compound of two airs, or gases; and that the air which we breathe consists always of two gases, having very different properties, and sometimes of many others.

Simple substances are either *confinable*, that is, we can hold them in vessels of some sort or other, and thus be able to see and examine them in their separate state; or they are *unconfinable*, or such that we cannot examine them separately, but are led to infer their existence and properties from the changes which they produce in other substances.

The *confinable simple* substances may be divided into four kinds:

1. *Simple supporters of combustion*, or substances in which the operation of burning can be carried on. There are only two, *oxygen* and *chlorine*.

OXYGEN is an air or *gas*. It is colourless, invisible, capable of being expanded or compressed without any limit but that of the power which we are able to apply to it, and combustibles burn better and brighter in it than in common air, and animals can breathe much longer in an equal quantity of it without suffocation. When substances are burnt, or when animals breathe in it, its quantity is always diminished, and when the process is continued long enough, it may be altogether exhausted. It forms about a fifth part of common atmospheric air, and when it is by any means removed, the remaining portion of the air will neither support flame nor animal life. Its specific gravity or comparative weight is greater than that of common air, in the proportion of nearly one eleventh part. Oxygen combines with a great many substances, and the compounds have a variety of properties, some of which will be explained hereafter.

Chlorine is, like oxygen, an air or gas, but it is very different in its nature and properties. It is yellowish green, cannot be breathed pure without instant suffocation, and causes coughing and pain when mixed even in small quantities with common air. Combustibles not only burn in it, but some of the most inflammable of them take fire in it of their own accord. It is rather more than two and a half times the weight of common air. It completely destroys vegetable colours, and therefore is of great use in bleaching. It may be combined with water, and the water may be frozen without displacing it; but it is separated by heat, and also by exposure to light. It unites with other substances, and forms compounds.

2. *Simple combustibles*, or substances which can be burnt, but which have not yet been decomposed. There are four of these: *hydrogen, carbon, phosphorus, sulphur*, and *boracium.*

Hydrogen is a gas, and it is the lightest substance with which we are acquainted—100 inches of it not weighing more than 7½ inches of common air, and hence balloons filled with it rise in the atmosphere. No combustible will burn in it; and no animal can continue to breathe it. When brought near a hot iron, or a flaming taper, it takes fire; and if it be mixed with half its bulk of oxygen, it burns instantly with a loud explosion. If this mixture be burnt in a close vessel, a quantity of water equal in weight to the two gases is produced, and hence it is inferred, that oxygen in the proportion of 1 in bulk, mixed with hydrogen in the proportion of 2, forms water.

Or, taking the gases by weight, 17 parts of water contain 15 of oxygen, and 2 of hydrogen. Equal bulks of hydrogen and chlorine, when exposed to light, unite with an explosion, and form a new gas of the same weight, which is called *muriatic acid* gas.

CARBON. Though the name of this substance be derived from that of common charcoal, such as that which results from burning wood partially covered up from the air, yet it is found pure only in a substance, very different, as one would think. This substance is no other than that most hard, beautiful, and costly of all natural substances, the *diamond;* which, when heated to nearly the degree at which silver melts, takes fire, burns wholly away, and combining with oxygen, forms carbonic acid gas, in the same manner and proportion as common charcoal. *Plumbago,* or *black lead,* the substance of which pencils for drawing and writing are made, is also mostly composed of charcoal, for it burns in the same way, and produces the same product as diamond or charcoal, only, about one twentieth of the whole is left in iron. So that, in its composition, this small quantity of iron forms the only difference between the soft and dull substance of a pencil, and the hard and brilliant one, a diamond. The black colour of charcoal is remarkably durable, the substance itself never rots, and it prevents, and even corrects the putrefaction of other substances. When perfectly pure, it is the best tooth powder that can be used. Carbon is not acted upon by chlorine in any of its forms, even though brought to a much greater degree of heat than that which suffices to burn diamond in the open air. Hence books or other matters that are painted or printed in black, the colouring matter of which is carbon, may be bleached in chlorine without destroying the colours.

Carbon combines with hydrogen, and forms *carbureted* hydrogen, of which every hundred parts contain 28 of hydrogen and 72 of carbon. Another gas, termed *super-carbureted hydrogen*, is formed by the union of 85 parts of carbon with 15 of hydrogen. This last mentioned is also called *olifient* gas, and the two together, or any of them singly, form the substance which is used for *gas lights.*

Carbonic acid gas is composed of 28 parts of carbon, and 72 of oxygen. It is very heavy, and instantly destroys both flame and animal life. When 39 parts of carbon are combined with 61 of oxygen, *carbonic oxide* is formed.

PHOSPHORUS. Phosphorus is a light substance, usually obtained by distilling burnt bones: it is so remarkably inflammable, that it takes fire when rubbed. It may easily be cut with a knife, and is about one and three fourths the weight of water. It is luminous or shining in the dark: when heated to a temperature considerably less than that of boiling water, it burns, and is converted into *phosphoric* acid, consisting of 100 parts of phosphorus to 114 of oxygen. It also unites with a smaller proportion of oxygen, and forms *phosphoric oxide.*

Burned in chlorine, it forms a white compound, which water separates into phosphoric and muriatic acids.

When about 91 parts of phosphorus are united with about 9 of hydrogen, a gas called phosphureted hydrogen is formed, which has a peculiarly offensive odour.

When taken internally, unless in very minute quantities, it is a poison.

SULPHUR. This substance is well known: it is not altered in the air, neither can it be dissolved in water. When heated, it first melts, and afterwards burns with a very offensive smell.

Sulphur by burning, combines with oxygen in two proportions: equal parts of sulphur and oxygen form *sulphurous acid*, and two parts of sulphur with three of oxygen form *sulphuric acid.*

Sulphur also combines with hydrogen: 187 parts of it, and 13 of hydrogen, form sulphuretted hydrogen.

Combined with an equal portion of phosphorus, it often takes fire of its own accord, and the compound cannot be made without considerable hazard.

Boracium is obtained from the substance usually called borax, which is a compound of boracium and oxygen, in the proportion of 2 of oxygen to one of boracium. It is olive coloured, hard and brittle, and like carbon, will bear any degree of heat without melting, or being otherwise changed, if oxygen be carefully excluded from it.

Of these pure simple combustibles, one (hydrogen) is, when pure, always in the form of an air or gas, two (sulphur and phosphorus) may be easily melted and even changed into gases, so that they may be examined in any of the three general states, and two (carbon and boracium) are incapable of being changed by heat without the presence of oxygen. When the proportions in which substances unite with each other are stated in numbers, these always mean the comparative weights, because the bulk changes with change of heat, while the weight does not.

3. Of *simple incombustibles*, there is only one. *Azote* or *nitrogen,* which gets the first of these names because, though it does not, like chlorine, act as a poison, yet it will not support animal life; and it gets the other, because when 30 parts of it are combined with 70 of oxygen, it forms *nitrous* acid. It is invisible, has all the mechanical properties of common air, and when pure, is more remarkable for its negative than for its positive qualities. If nitrous acid lose a part of its oxygen it becomes *nitrous gas,* but the moment that it comes again into contact with oxygen, it becomes liquid. There is another form which contains still less oxygen, which supports both life and flame.

Azote does not combine with chlorine. Indeed its combinations with the other simple substances are not many. One part by measure of azotic gas and three parts of hydrogen, though they be both colourless airs, form a solid substance of a peculiarly pungent odour called ammonia, or volatile alkali.

4. *Metals.* These are exceedingly numerous.

They have a peculiar lustre, or shining appearance, which is called metallic, and they are all opaque, that is they do not admit light to pass through them. The only exception is gold leaf, and this probably on account of its extreme thinness. It appears green when held up against the light. Some are found *native,* or as metals, others as *ores* combined with other substances.

Most metals combine with oxygen in various proportions, and all these combinations are called *oxides*; but various distinctions are given to them according to the quantity of oxygen. That which has the least, is called the *protoxide*, the second the *deutoxide*, the third the *teroxide*, and so on, adding the Greek names of the numbers, till one come to that which contains the greatest quantity of oxygen with which the metal can be united, that is called the *peroxide.*

GOLD. This metal is always found native. It is soft, has neither taste nor smell; it is between 19 and 20 times the weight of water, may be beaten into leaves or drawn into wires of astonishing fineness. It melts in not a very strong heat; but even in the most intense and long continued heat it is only partially destroyed. Exposure to the air does not alter even its lustre.

Gold forms two combinations with oxygen, the *protoxide* which is purple, and the *peroxide,* which is yellow. It unites with chlorine, and forms chloride of gold, a yellow salt, having a strong taste, and which easily becomes liquid.

It unites with phosphorus and forms *phosphuret* of gold, which is whiter than gold and brittle.

It unites with most of the other metals, and the compounds (as well as all other compounds of different metals) are called alloys.

Gold when pure is called *virgin*, and is too soft for most purposes. *Standard* gold contains 22 parts pure and 2 of other metals; and the standard for jewellers contains one-fourth of other metals. The alloyed gold is red when most of the alloy is copper, and inclines to white when the alloy is silver.

PLATINUM. Platinum is heavier than gold; and looks something like silver, but it is not so bright. It cannot be melted, but when strongly heated, pieces of it may be welded or joined together like iron. It forms two combinations with oxygen, and one with phosphorus. It forms an alloy with most metals, but a very small portion of it completely destroys the colour of gold.

SILVER. Silver is harder than gold, and rather more than half the weight, being about 10½ times heavier than water. It may be both melted and hammered It combines with oxygen, with chlorine, with sulphur, and with phosphorus. It also combines with most other metals; and with gold it forms a natural alloy, one of silver to five gold.

MERCURY. This metal is white like silver, has a good deal of lustre, is about 13½ times the weight of water, and always fluid at the temperature of the atmosphere in England. It forms two combinations with oxygen, the *protoxide,* which is black, and and the *peroxide,* which is red. When one part of it is rubbed in a mortar, with two parts of sulphur, a black sulphuret is formed, which can be converted into a fine red powder, called vermillion. Its combinations with the other metals are called amalgams; and all these amalgams may be restored to the other metal by driving off the mercury by heat.

Palladium, **Rhodium**, **Iridium**, and **Osmium**, are metals that have been discovered in combination with crude platinum; but they are not very abundant, neither are they applied to many useful purposes.

Copper. This metal has a fine red colour, but it soon tarnishes by exposure to the air. Its taste and smell are disagreeable, and it is a poison: it is nearly 9 times heavier than water. It combines with oxygen, with sulphur, and phosphorus. It forms alloys with most of the metals.

Iron. Iron is well known; it is among the hardest of metals. It combines spontaneously with oxygen: exposure to the air rusts it, or converts the surface of it into the red oxide; and when it is burnt, or kept under water, it is converted into the black oxide. It also combines with sulphur, with phosphorus, and with carbon. Of these combinations, the *carburets* are the most important: with a small quantity of carbon it becomes steel, with more it is cast iron, and with an excess it is black lead. The surface of it may be *case hardened,* that is, receive all the hardness and polish of steel, while the interior retains all the toughness of iron. Worked iron is made by beating cast iron with heavy hammers, till the grains or crystals be flattened, and worked iron is converted into steel, by being kept in a furnace along with charcoal. Iron combines with many of the metals, but cannot be combined with copper or mercury, without great difficulty. Iron is strongly attracted by the magnet, and when converted into steel and properly hardened, it retains its magnetic power for a considerable length of time.

Nickel. Nickel is a white metal like silver, heavier than iron, but softer, and may be hammered both hot and cold. It is magnetic, and may be made into artificial magnets, like steel. It combines with oxygen, is always found combined with a small portion of carbon, and it unites with sulphur and phosphorus, but not with the simple incombustibles.

TIN. Tin is nearly of the same weight as iron; it is very easily melted, and may be rolled or hammered into very thin plates. It forms two oxides with oxygen; with chlorine it forms a peculiar fuming liquid. It combines with phosphorus and sulphur; and if equal portions of the peroxide and sulphur be gradually heated, they form a compound called, from its colour, mosaic gold. It forms alloys with most metals. With copper, when the tin is about one tenth of the whole, the compound is bronze; when about one-fourth, bell-metal; and when a third, the metal for the mirrors of telescopes.

LEAD. Lead is much heavier than tin, being more than eleven times the weight of water. It is poisonous. It combines with oxygen, one of the oxides being yellow and another red. It combines with phosphorus and with sulphur. The combination with the latter, called *galena*, and crystallized in cubes, being the form in which lead is most commonly found.

BISMUTH is reddish, and very brittle. It combines with oxygen and with phosphorus.

ANTIMONY is grey, rather hard and brittle. It combines with oxygen, phosphorus, and sulphur, and forms alloys. With tin it forms pewter, and with lead and antimony, the metal of which printers' types are made.

ARSENIC is grey and brittle. The white oxide is a most deadly poison, and the yellow, which is used as a paint, is also poisonous.

COBALT. Cobalt is grey and brittle. The protoxide is of a fine blue colour.

Tellurium, Uranium, Molybdenum, Chromium Titanium, Columbium, and Cerium, are not much used. Some of their oxides form beautiful colours for painting, but they are apt to change.

Zinc is of a brilliant white. It forms oxides, and combines with most of the simple combustibles. Mixed with copper it forms *brass*, or in another way, *pinchbeck.*

The unconfinable simple substances, (if substances they be, for their nature is very obscure,) are *light*, *heat*, *electricity*, and *magnetism*.

1. Light. The mechanical properties of this delightful substance have been already explained, under the title, Optics, so that there only remains to be considered the chemical effects which it produces in other bodies. Light has the power of entering into bodies, and remaining in them for some time after they cease to be exposed to it. Various substances become luminous when heated, without losing any perceptible portion of their weight. It occasions the green colour of plants. It decomposes nitric acid, and reduces the oxides of some of the metals; but those chemical properties do not appear to belong to the coloured rays explained in optics, but to be out of the spectrum altogether, just beyond the violet ray. Light is produced by the sun and stars, by burning, by heat, and by striking one body against another. All substances become light, or give out light when heated to a certain degree, with the exception of the airs or gases.

2. Heat. In common language, heat either means the sensation of warmth that we feel, or the cause that produces this sensation. The latter is the sense in which it is used in chemistry; and the cause of heat is in chemical language called *caloric*.

Caloric usually accompanies light; and in the spectrum of seven colours, occasioned by passing the beams of the sun through a prism, the heating power is greatest at the red ray, or side opposite to that on which the chemical effects are produced.

Caloric radiates from the surfaces of heated bodies with great rapidity; but it makes its way through them much more slowly, and through some much more slowly than others. Thus if a black glove be put on the one hand, and a white one on the other, and both held equally near the fire, that which has the black will feel hot, while the other remains unaffected. The facility with which bodies allow heat to pass through them, is called their conducting power; and the facility with which they give out heat is called their radiating power. If the surface of a body throw back the heat, or turn it in another direction, it is called a reflecting surface. The rapidity of heating or cooling depends on the nature of the surface. Black surfaces are much more easily heated and cooled than white ones, and rough ones are much more easily heated than smooth; thus, if a piece of polished steel and a piece of rough or black varnished steel be held equally near the fire, the rough one will become so hot as to burn the finger, while the polished one remains cold.

Our feelings are very fallacious tests of heat; for if there be taken three basins, one containing cold water, another water as hot as the hand can bear it, and a third lukewarm water; then if one hand be for some time kept in the cold, and the other in the hot, and then both plunged in the lukewarm, the one hand will feel a sensation of heat, and the other of cold.

The metals are the best conductors of heat, then stone, then brick, glass, dry wood, feathers, and wool, liquids, and gases.

Caloric always tends to diffuse itself equally, by the heated body giving it out to the cool one, and this is much sooner accomplished among good conductors, such as the metals, than among bad ones, such as fur or wool.

Caloric is the most important and powerful of chemical agents, and it has three separate effects: it changes the bulk of bodies; it changes their state; and it changes the combination of their parts.

When bodies are heated, they increase in bulk,—those which are the worst conductors increasing most rapidly. The only exception to this is water, which does not sensibly expand, though ever so much heated.

The same quantity of the same substance may be supposed to expand equally with equal degrees of heat; and upon this principle the *thermometer* is constructed.

Caloric changes the state of bodies, from solids to fluids, and from fluids to airs. It is probable that at some degree of cold, or absence of caloric, all bodies would be solid. There are some which are always fluid at some places, and often solid at others; and water, for instance, may be solid or fluid at the same place, by changes of heat. In cold weather it is solid, in the state of ice; in temperate weather it is liquid, in the state of water; and by adding caloric in sufficient quantity, it may be evaporated, and become invisible, as an air or gas.

In every case, a change from a solid state to one less solid, is accompanied by an absorption of caloric; and a change toward solidity is accompanied by a giving out of caloric.

Every fluid may therefore be regarded as some solid dissolved or melted in caloric, or the matter of heat, just as a lump of sugar is melted in water,—the only difference being, that the caloric is not, like the water, a substance that can be weighed, measured, or in any way taken cognizance of, unless by the effects which it produces.

The degree of heat at which any substance changes from the solid to the liquid state is called the *melting point* of that substance; and that at which it begins to evaporate is called the *boiling point*. If the changes the opposite way be considered, the melting point is called the point of *congelation* or *freezing*; and the boiling point, the point of *condensation*. Thus 32° (the ° signifies degrees) of the common thermometer, is the freezing point of water, or the melting point of ice; and 212° is the evaporating point of water, or the condensing point of the vapour, into which water is converted.

These points are always the sums in the same substance, under the same circumstances; but they are not the same in any two substances. Thus, in water we can obtain all the three states within a very limited range; but there are some solids which no heat that has been yet produced is capable of melting; some liquids, pure spirits of wine, for instance, which no degree of cold that has been produced is capable of freezing; and some gases, indeed almost all gases, when unmixed with other substances, are incapable of being either condensed into fluids or frozen into solids.

If ice be freely exposed to the air—the great natural agent in effecting uniformity of temperature, or of the distribution of caloric among bodies—it invariably melts whenever the temperature is raised above 32°; and if water be freely exposed to the air it as invariably changes into vapour whenever it is raised above 212°.

In like manner, as different bodies melt or evaporate at different degrees of heat, different degrees are required to produce the same apparent changes of temperature in them; that is, if two different bodies, at different degrees of temperature, be mixed together in equal weights, the weight of the mixture is not, as one would suppose, half the sum of the temperatures of the ingredients, but variable with changes of bodies, and therefore determinable only by experiment. Thus, if a quantity of snow, at the freezing temperature, be mixed with a quantity of common salt, at a temperature and in an atmosphere considerably warmer than the snow, the compound will not only be as cold as the snow but a good deal colder.

When equal weights of bodies, at different temperatures, are thus mixed together, and the temperature of the result observed, the number of degrees of heat that it is necessary to abstract from one body in order to produce a certain degree of temperature in another is discovered; and this is called the *relative caloric* in the body.

The quantity of heat which is necessary for the preserving of a body in a particular state, is called its *latent caloric*, or *latent heat;* because that heat is not perceptible to the senses. When bodies are frozen and condensed, they give out their latent heat; and when they are melted, or evaporated, they absorb a certain portion of the sensible, or even of the latent heat of other bodies.

It is upon this principle that *spontaneous evaporation*, or the drying up of water or any other liquid, without the artificial application of heat, is effected; the heat which converts the water into vapour is taken from the air and from surrounding objects. Hence the cooling effect of streams, falls, and fountains of water, in the sultry months; hence the cooling of a glass of water by covering it with moist blotting paper, or of the hand by dipping it even into hot water and holding it to the air to dry; and hence the chilliness of fens and marshes in the cold season, and the chilliness and danger of damp clothes.

There is no means of ascertaining the positive quantity of latent caloric in any body; all that we can do is, within certain limits, to know the comparative degrees.

It is in consequence of their different capacities for caloric that we are enabled to employ heat in effecting the separation of the component parts of bodies. Thus, for instance, common salt may be obtained by boiling sea water, and brandy, or any other spirit, by boiling a solution of properly prepared vegetable matter. In the case of the salt, the water having less capacity for caloric (as might be inferred from what was mentioned in the case of mixing salt with snow) is converted into vapour; and this conversion absorbs so much caloric, that the salt crystallizes, that is, freezes or becomes solid. In the case of the brandy, it having less capacity for caloric than the water, is drawn off in the form of vapour; and this vapour is condensed by exposing it to vessels colder than itself.

Compounds that are formed by combustion, or that require a great degree of heat for their formation, are separated with difficulty; as, for instance, it would be difficult to separate the flint and potash that form a wine glass, or the flint and clay that form a china cup; but compounds that are formed without combustion are much more easily separated.

There are some instances in which the parts of compounds are converted into gases at the same time, and yet may be obtained separately; but this separation depends not so much upon the disposition which these parts have to absorb caloric, as upon that which they have to unite with each other.

After understanding the nature of caloric, and the way in which it combines with bodies, the next subject of examination is the sources whence it is derived.

It may be stated generally, that the means of obtaining heat or caloric are always those by which a quantity of caloric is changed from being latent in some substance to being sensible, and free to be distributed among other substances. In this way it is produced from *the sun*, *combustion*, *percussion*, and *mixture*.

The latest conjecture respecting the heating power of the sun is that that luminary is not a great globe of fire, but a globe that may be inhabited by people like those upon the earth, that this globe has two sets of clouds in its atmosphere, the one nearest itself dark, and the outside one luminous and calorific.

The light of the sun heats all bodies that are not perfectly transparent, in proportion to the directness and length of time that they are exposed to its rays; and it heats them the more the darker their surfaces, and the more free that they are from any substance with which the heat can unite and form vapour. Thus, if there be two posts in the garden, one of which is painted green and the other black, the black one will be much warmer when the sun heats strongly upon them than the green one; and the green one, after it is completely dry upon the surface, will become much warmer than any leaf of a tree or shrub which is of the same shade of green.

In some cases the rays of the sun have so little influence as not sensibly to melt even the surface of ice, and in other cases they are so hot that one cannot bear them. This depends partly upon the length of time that the sun shines, partly upon the direction in which his rays fall, and partly upon the nature of the surface. It is upon these principles that we are enabled to explain the differences of climate that are found either in different countries or in the same country at different seasons of the year.

Upon ordinary surfaces the direct rays of the sun seldom produce a higher temperature than 120 degrees; but when collected by a burning glass, or reflected to a point by a concave mirror, they produce the most powerful heats with which we are acquainted. This is easily accounted for: suppose the surface of the glass or mirror, upon which the rays fall, to contain 100 inches, the whole to pass through it, or be reflected from it, (which they would be if the glass were perfectly transparent and the mirror perfectly smooth,) and the focus or point into which they were collected to be the 100th part of an inch, then the heat at that point would be 10,000 times that of the rays falling upon the glass or mirror.

Combustion, or the operation of burning, is thus explained: the supporter of combustion—the oxygen or the chlorine, is decomposed into, the base, whatever it is, which, dissolved in caloric, enables it to exist in the state of a gas,—and the caloric; and the combustible (which seems to be a combination of some base with light) is decomposed into that base and that light at the same instant; then the instant that they are loosed from their former combination, the bases of the supporter (the oxygen or chlorine) and of the combustible unite into one new compound, which is a confinable substance, and the heat of the supporter and the light of the combustible unite into another new compound, which is sensible as flame at the instant of its production, but which, being inconfinable, diffuses itself among other bodies and disappears. Thus in the case of sulphur burnt in oxygen, the light of the sulphur and the heat of the oxygen combine and form flame, while the bases of both unite and form sulphuric acid, or oil of vitriol. When the two substances, the supporter and the combustible, are both perfectly pure, the compound formed by these bases has precisely the same weight as they both; and hence light and caloric, as well as the compound which they are thus understood to form during combustion, appear to have no weight, and are therefore called imponderable.

It is also to be observed, that in all cases of combustion, the product, or compound of the bases of the supporter and combustible, occupies less space than these previously occupied; and that this diminution of space is always great in proportion to the intensity of the heat. Thus, in the case of a common fire, when we take and blow upon it with a pair of bellows, and therefore force a greater quantity of oxygen into it, it always burns with greater brightness and intensity.

Oxygen and chlorine are, as formerly mentioned, the only simple supporters of combustion that are known; and by analyzing, or separating into their component parts, the compound ones, they are not only always found to contain oxygen or chlorine, but it is found that it is always the oxygen or the chlorine that enters into the new combination.

There are five compound supporters of combustion: atmospheric air, nitrous oxide, nitric acid, nitrous gas, and euchlorine gas; the combustibles are either the simple ones, which have been already enumerated, or compound bodies, into which these enter as component parts; and all bodies which do not come within the one or the other of these classes are called incombustible.

The product of combustion, or the body that results from the operation of burning, is always *water*, or an *acid*, or an *oxide*.

There is another decomposition of oxygen, which is attended with the evolution of caloric, though not of light that may be here explained, and that is the heat which is produced by all the warm blooded animals, and which is supposed to be evolved in the operation of breathing, an operation without which no such animal can live. It was mentioned that animals cannot live except oxygen be contained in that which they inhale in breathing; and, though the experiment be a cruel one, it has been found that, if a mouse or other small animal, be confined in a jar of common air, over water, the quantity of air gradually becomes less, and the animal breathes with greater and greater signs of oppression, till the oxygen of the air and its life be extinguished together. Now the probability is that the oxygen of the air is decomposed in the lungs, or perhaps by the whole mass of the blood, that its base combines with that fluid, and that its caloric is evolved and becomes sensible as animal heat. When near approaching dissolution, the breathing of the animal becomes difficult and the circulation of the blood feeble and languid, the extremities of the body begin to be affected by a coldness from which external applications can hardly free them; and soon after the currents of the breathing and the blood cease to flow, the same stubborn and irremovable rigour seizes the whole body.

Percussion, or the action of one body upon another produces the extenuation of heat in two ways; either when the one body is beaten with the other,—as iron may be hammered till it becomes red hot, so that a candle may be lighted by it; by a single collision of two bodies,—as in the case of a flint and steel, in which minute portions of the steel are thrown off in a state of active combustion sufficient to kindle gunpowder or tinder; or by the continued friction or rubbing of one body against another,—as by rubbing two pieces of lath together with sufficient force and rapidity, and for a sufficient length of time, they may both be set on fire.

In all these and similar cases, the heat is supposed to be produced by the condensation or compression of the body, by which means it is made to evolve or render sensible a portion of its latent caloric. The iron hammered, or struck by the flint, has the caloric, or fire, forced out of it as it were; and in the case of rubbing the two pieces of wood, the fire comes mutually from both. This is rendered more certain by the fact, that when air, or any other expansive fluid is expanded it becomes cold, or takes caloric from the surrounding objects; and when it is condensed it becomes warm, or gives out caloric to the surrounding bodies. If the condensation of common air be rapid and violent, the heat produced may be so great as to kindle tinder.

Mixture of different substances is the fourth source from which change of temperature, or of the quantity of sensible caloric, is obtained.

The change of temperature produced by mixture is sometimes an increase of heat, and sometimes of cold; and it varies with different substances, so as in some cases to be very great, and in others barely perceptible.

The dissolving of powdered Glaubers' salt in water produces a great degree of cold; and the same salt dissolved in muriatic acid produces a degree of cold still greater. Intense cold is also produced by pouring nitric or sulphuric acid upon snow, or by mixing snow with muriate of lime, or with potash; these are called freezing mixtures, and the last three are sufficient to freeze mercury, but the solid which is thus formed is too cold for being touched with the finger.

On the other hand, the mixture of sulphuric acid and water is hotter than water when it boils. Water mixed with quicklime, with nitric acid, or with spirits, also produces heat in different degrees; and the mixture of sulphuric acid with quicklime produces a very great heat.

In all those cases, the heating is accompanied by a change toward solidity, or a diminution of bulk, in the compound or some of its components, while the cooling is accompanied by change toward fluidity in the same. Thus, in the case of the snow and salt, the cold is produced by the melting of both these substances.

ELECTICITY produces very powerful effects, both in the dry way, and when humid in the state called *galvanism;* both of these when properly applied produce changes even more difficult than those produced by common heat. The effects of *magnetism* are not so remarkable. It still, however, remains a matter of doubt whether any or all of these are to be accounted substances.

II. COMPOUND BODIES, or those which consist of two or more component parts intimately united so as to form a body having chemical appearances and qualities different from those of any of the parts.

When compounds consist of simple parts, or are effected by the union of two or more substances, each of which is in its simple state, the compound is called *primary;* and when the component parts, or any of them, are compounds, the body is called a *secondary* compound. These will form two sections.

First, The primary compounds are: alkalis, earths, oxides, acids, compounds of chlorine, and compound combustibles.

1. *The alkalis* have a caustic burning taste; they are volatilized or evaporated by heat; they dissolve in water; they mix with oil and form soap, and with some of the earths and form glass; they combine with the acids and destroy their acidity; and they change the blue colour of vegetables to green.

There are three alkalis: ammonia, potash, and soda: the first is sometimes called the animal alkali, the second the vegetable alkali, and the third the mineral alkali.

Ammonia is composed of 81½ parts of azote or nitrogen, and 18½ parts of hydrogen in every 100 parts. It is a gas, but water absorbs it in great quantities—780 times its bulk. It is this which is known by the name of spirits of hartshorn. It detonates in oxygen; and by this means the whole oxygen and hydrogen may be separated and only the azote left. When mixed with chlorine it burns. It unites with sulphur, is decomposed by phosphorus, and may be changed into prussic acid by passing through red hot charcoal. It decomposes several of the metals; and the compounds which it forms with gold and silver detonates with violent explosions. The base of ammonia is supposed to be a metal called *ammonium*, which cannot be obtained in a separate state.

Potash, or as some call it, oxide of potassium, consists of about 84 parts of a peculiar metallic base, called potassium, and 16 parts of oxygen to every hundred parts of the potash. It is, when pure, exceedingly corrosive, and destroys most animal and vegetable substances. Potash is obtained from the ashes of almost any burnt vegetable.

Soda is found native in the earth, or may be obtained from the ashes of several marine plants. In its general properties when uncompounded, it does not differ much from potash. Soda is much used in the manufacture of glass and soap. Its metallic base is called *sodium;* and the alkali itself contains about 10 parts more of oxygen in the 100 than potash.

2. *The earths* are divided into *alkaline earths*, or those having the properties of alkalis, and *earths proper*. The proper earths are insoluble in water when in a state of

combination with carbonic acid; they have little or no smell or taste; they are all white powders when pure; and all of them resist the action of ordinary fires.

The alkaline earths are four in number: lime, magnesia, barytes, and strontian. All these, like potash and soda are deutoxides of peculiar metals; which, after them, are called *calcium, magnesium, barium*, and *strontium.* These metals, when exposed to the air, take back their portion of oxygen and are converted into their respective earths; in taking the oxygen from water they decompose it with combustion.

Lime is found in great quantities. United with carbonic acid it forms marble, limestone, and chalk; and with sulphuric acid, alabaster. The former is burnt into lime, and the latter into plaster of Paris. Lime deprived of the acid is caustic. It combines with oxygen, sulphur, phosphorus, and chlorine, and hydrogen, but not with azote.

Magnesia, when pure, has little taste and no smell. It does not dissolve in water; nor combine with any of the simple combustibles except sulphur. It does not combine with the alkalis or with azote. Its base does not decompose water with the same rapidity as the other alkaline metals.

Barytes, when pure, is grey, very acrid to the taste, and poisonous. It combines with oxygen, phosphorus and sulphur, but not with azote or the metals. It gets its name from the great weight of the salt that it forms with sulphuric acid.

Strontian is by no means common. It resembles barytes in its properties, only it is not poisonous. It combines with sulphur and phosphorus, but not with oxygen, azote, the alkalis, the other earths, or the metals.

The earths proper are five: alumina, yttria, glucina, zirconia, and silica.

Alumina is a soft white powder exactly twice the weight of water. It has no effect upon the vegetable colours, and does not combine with oxygen, azote, the simple combustibles, or the metals. Potash and soda combine with it in solution; lime and it melt together. It cannot be crystallized by art, but it is found naturally in that beautiful gem the sapphire. It is the substance which gives ductility to clay; and as it attracts and retains moisture more than most substances, all unburnt compounds of clay are moist.

Yttria is white and more than double the weight of alumina. It does not combine with oxygen or with the simple combustibles.

Glucina is found in the emerald and beryl. It is a soft white powder, having nearly the same properties as yttria, only it is much lighter than that earth.

Zirconia is found in the hyacinth. It is a hard powder, of nearly four and a half times the weight of water. When violently heated it assumes the appearance of unglazed china, or porcelain biscuit.

Silica is the principal ingredient in flint, rock crystal, and various other stones. It is a fine white powder, but harsh and incapable of being made into a paste, like alumina. With the alkalis it melts into glass; and with alumina it partially combines when heated, and forms porcelain or china ware.

The earths proper are all the deutoxides of peculiar metals, in the same manner as the alkaline earths.

3. *Oxides.* The combinations of oxygen have either the properties of *acids*—sourness of taste, uniting with water, changing vegetable blues to reds, and forming *salts* with alkalis, earths, and the oxides of metals,—or they have not. When they have not these properties,

they are called *oxides;* and when they have, they are called *acids.*

The oxides of the metals are very numerous, and it has been mentioned that the alkalis and earths are deutoxides, or second oxides. The oxides of simple substances are those of hydrogen, carbon, and azote.

Oxide of hydrogen, or water, contains 7½ parts of oxygen to one of hydrogen. It is one of the most abundant substances in nature. Water is not altered by heat, further than being converted into steam, which may be again wholly condensed by cold. When cold, the simple combustibles do not act upon it; but at a red heat, charcoal decomposes it into oxygen and hydrogen. Gold, platinum, silver, and copper, do not act upon it; but most of the other metals do, when assisted by heat. It combines with the alkalis, partially with the alkaline earths, with acids, with salts, and with many other compound substances. These combinations are sometimes liquid, like water; and sometimes solid, like the body with which it unites. When liquid, they are called *solutions;* and when solid, *hydrates:* water in any quantity may be added to a solution, but a hydrate takes it up in some fixed proportion. The hydrates mostly form into crystals; and the water that becomes solid in them is called their water of crystallization. The metallic hydrates have mostly strong tastes and lively colours, and are soluble in acids.

Oxide of carbon, is a gas, lighter than common air. It is fatal to flame and animal life; 100 parts of it contain 59 oxygen and 41 carbon. It is not much acted upon by other substances; and it burns with a blue flame, giving but little light.

Oxides of azote. Of these there are two: *nitrous oxide* and *nitrous gas*. The former being respirable, and when taken into the lungs producing a very peculiar species of intoxication; and the latter being fatal to animal life.

4. *Acids*. These are very numerous, very active, and very important substances. They are usually divided into three classes: acid products of combustion, acid supporters of combustion, and acid combustibles.

The acid products of combustion consist of oxygen united with a simple combustible as a base. They are incombustible; most of them bear a strong heat without decomposition, the joint action of heat and a combustible decomposes them. When there are two acids formed from the same simple combustible, that which has the greatest proportion of oxygen terminates in *ic*, and that which has the least in *ous*. They are: sulphuric and sulphurous, from sulphur; phosphoric and phosphorous, from phosphorus; carbonic, from carbon; boracic, from boracium; and fluoric, from an unexamined base,—in all 7. When the acid which ends in *ic* combines with any base, the name of the compound ends in *ate*; and when the acid ends in *ous*, the compound ends in *ite*.

Sulphuric acid, consists of 60 parts oxygen and 40 sulphur. It is colourless and very acrid. When highly concentrated it is nearly twice as heavy as water. It does not combine with oxygen or azote, but it does with the simple combustibles, when heated. It acts on most metals, but not on gold and platinum. With the alkalis, earths, and metals, it forms salts, called *sulphates*.

Sulphurous acid contains less oxygen. It is a gas almost 2¼ times as heavy as common air. When heated, it loses part of its sulphur and becomes sulphuric acid. Its properties are similar to those of that.

Phosphoric acid resembles glass, but it absorbs moisture and softens into an oily fluid. It does not act powerfully on metals. The salts, which it forms with the alkalis and earths, are called phosphates. Some of them, as phosphate of lime, burn upon being put in water.

Phosphorous acid is a colourless liquid; but when exposed to the air it absorbs oxygen, and is converted into phosphoric acid.

Carbonic acid is a gas, 1½ times the weight of air, and may thus, though perfectly invisible, be poured from one vessel into another, like water; and as it instantly extinguishes flame, a very amusing experiment is made, by pouring it upon a light, placed at the bottom of a glass jar. Its composition is 72 oxygen and 28 carbon: the salts which it forms are called *carbonates*.

Boracic acid consists of 67 parts of oxygen and 33 of boracium. It acts on few of the metals. The salts which it forms are *borates*. One of them, borate of soda, or common borax, possesses strong detergent qualities, and assists in the melting of various earths and metals.

Fluoric acid is a gas, destructive of combustion and life. Combined with lime it forms Derbyshire spar. It corrodes glass, and is used for etching upon that substance, as nitric acid is for etching upon metals.

The *acid supporters of combustion* have for their bases a simple incombustible, or a metal. Two acids have the former base, the *nitric* and *nitrous*; the former consisting of about 70 parts oxygen and 30 azote, and the latter of a smaller portion of oxygen.

Nitric acid is called *aqua fortis* and *spirits of nitre*. It is very corrosive. It burns spontaneously with all the simple combustibles except hydrogen, and with that when heated to redness. It oxidises all the metals except gold, platinum, and titanium; and, mixed with muriatic acid, it dissolves gold. The salts which it forms are called nitrates. *Nitrous* acid has never been obtained in a separate state.

The *metallic* acid supporters of combustion are the *arsenic*, the *tungetic*, the *molybdic*, the *chromic*, and the *columbic*.

Combustible acids. These all consist of combinations of the same three ingredients, arranged in different proportions, and are obtained from vegetable or animal substances. The ingredients of which they are composed are carbon, hydrogen, and oxygen. They are distinguished into four classes, and named from the substances from which they are obtained.

The first class are crystallizable (may be obtained solid) and also may be evaporated by heat. These are some of them: the *acetic* (vinegar), *benzoic*, *sebacic*, *succinic*, *moroxolic*, *camphoric*, and *oxalic* (acid of sugar, a deadly poison).

The second class can be obtained in crystals, but not evaporated. They are: the *mellitic*, *tartaric*, *citric*, *kinic*, *saclactic*, and *uric*; which last, besides the three ingredients common to them all, contains a portion of azote.

The third class contains the *malic*, *suboric*, and *formic* which cannot be obtained in crystals.

The fourth, or calorific class, contains the *prussic*, which combined with iron, in the form of Prussian blue, is obtained from the calcination of dried blood with potash in a close vessel: the *gallic* and *tannin*, both obtained from excrescences formed upon the leaves of the oak by insects. Combined with the metals, these acids form salts of various colours, and various degrees of permanence.

In as far as the composition of all the acids in these four classes has been accurately ascertained, oxygen forms the chief ingredient in them all (with the exception of the acetic, in which carbon predominates) and hydrogen the smallest ingredient.

5. *Compounds of chlorine.* Of these there are two: *euchloric acid,* which is a compound of chlorine and hydrogen; and *muriatic acid,* which is a compound of chlorine, in the proportion of about 97 parts with 3 parts of hydrogen. *Muriatic* is the most active of the acids, and forms many important salts, which are called *muriates,* or *hydrochlorates;* but from the small quantity of hydrogen, and the possibility of its being evolved in the composition, they are often considered as combinations of chlorine with the bases, and thus called *chlorates.* Some of them, such as common salt, which is *muriate of soda,* or *chlorate of sodium,* are among the most useful of substances for culinary purposes; and others, such as the muriate of mercury, are deadly poisons.

6. *Compound combustibles.* The principal ingredients of these substances are carbon and hydrogen, or carbon, hydrogen, and oxygen. They include almost all animal and vegetable substances, together with some minerals, supposed to be of animal or vegetable origin; but those which it is necessary to mention in a mere outline of the elements of chemistry, may be classed under the four divisions of alcohol, (or spirits,) ethers, oils, and bitumens. The first being almost exclusively a vegetable product, the second a combination of that product with acids, the third being partly vegetable and partly animal, and the fourth being purely mineral.

Alcohol, which, when pure, is called spirit of wine, is obtained from wine, beer, or other fermented liquors subjected to distillation. The common spirit that is distilled for the purposes of ordinary use is not pure alcohol; but draws its peculiar taste from a portion of the essential oil of the substance from which it is obtained; but if it be distilled a second time, the first part of it is without colour or flavour, and is called rectified spirits. When the alcohol is wished to be obtained perfectly free from water, it is poured upon muriate of lime red hot, and the product subjected to distillation. That which is obtained is the purest alcohol known. It is tasteless and colourless, and weighs a very little more than three-fourths of the same measure of water. Alcohol is composed of oxygen, carbon, hydrogen, azote, and a very small portion of ashes. It has no effect on hydrogen and carbon, and very little on sulphur and phosphorus. It dissolves the alkalis, and most of the resins and bitumens,—forming varnishes with the latter. It is very inflammable; and phosphuretted alcohol, dropt into water, takes fire spontaneously. It dissolves several of the salts; such as the chlorates, nitrates, and acetates; but it has no effect upon the sulphates.

Ethers.—These are obtained by mixing the acids with alcohol. They are named after the acids by which they are produced. *Sulphuric ether* is fragrant, and so volatile that it evaporates in the act of being poured out. When applied to the skin it produces a sensation of intense cold. It is a powerful solvent; and unites with all the oils and bitumens, but not with the gums. When it is pure it is lighter than pure spirit. It is composed of carbon, oxygen, and hydrogen. *Nitric ether* contains a portion of azote; and *muriatic* ether, a little muriatic acid. The other ethers which have been formed, but not particularly analyzed, are the *acetic* and the *phosphoric*.

Oils.—These are of two kinds: volatile or essential oils, and fixed or fat oils.

Volatile oils are almost wholly derived from vegetables. They have a burning taste and pungent odour. They unite with alcohol, and partially with water. They evaporate without leaving any stain. They all boil, or are evaporated by heat, and none of them require to be heated above the boiling point of water. They also evaporate in the open air and diffuse their fragrance. They do this whether they be in the plants from which they are obtained, or obtained from those plants by squeezing or by distillation. It is to them that all plants owe their odours. They dissolve in ether and in the fixed oils; but they do not form soaps with the alkalis and earths.

Fixed oils are obtained both from vegetable and animal substances. They feel greasy, have a mild taste, do not mix with water or with alcohol. They are very combustible and may all be melted by a gentle heat; but none of them boil under 600°. They are chiefly obtained from the seeds of plants and the livers of animals. They are all lighter than water. Some of them have the property of absorbing oxygen and becoming solid; and these are called drying oils. They unite with the volatile oils, with bitumens, and with resins. With the alkalis they form soaps, which are soluble in water, and used as detergents; and with the earths and metallic oxides they also form soaps, but these are not soluble in water. Water which is pumped or otherwise obtained from a great depth in the earth, and not exposed to the air for a considerable time, is apt to hold some of the earths and metallic oxides in solution. In this case it is said to be hard; and if one attempts to use soap in washing one's hands with it, the alkali of the soap partly combines with these and leaves the oil upon the surface of the water, and the oil partly combines with them and forms an earthy soap not soluble in water. The consistency of the soap produced depends upon the alkali that is united with the oil. Oil with ammonia forms a white creamy fluid; with potash it forms soft soap; and with soda, hard soap. Scented soaps, or those which have a fragrance communicated to them receive that from a volatile or essential oil; which, though it renders the soap more agreeable to the sense of smelling, yet injures it as a detergent, and communicates to it an acridity which is injurious to the skin. For the same reason the essential oils, when applied to the skin, or to the hair, even mixed with fat oils, injure them more than they would be injured by fat oil alone.

When animal or vegetable substances are exposed to a greater heat than that of boiling water, they often give out oils that have a dark colour, an acrid taste, a disagreeable smell, and properties similar to the essential oils. These are called *empyneumatic oils.* The disagreeable odour, offensive taste, and pernicious qualities of the impure alcohol sold under the name of spirits are, in a considerable degree, owing to these oils.

Bitumens are of two kinds: bituminous oils and bitumens.

The bituminous oils resemble in many of their properties the essential oils. There are two of them: naphtha and maltha. The former is light oil found in the earth, and possessing all the properties of the essential oils; the latter is a solid white substance found in Lake Baikal in the north of Asia, which also possesses the same properties. They are both highly inflammable.

The bitumens are either hard, or they are of the consistence of tar. They are usually black or brown, and the pieces, when broken, have a shining surface. They have a peculiar *pitchy* smell; they burn. They do not dissolve in alcohol or water; but they do in ether and the fixed oils. They are, asphaltum, mineral tar, mineral caoutchouc, and retinasphaltum. The first is a brownish black substance which breaks like glass; the second is a solution of the first in naphtha; the third is a peculiar substance, almost insoluble, and resembling India-rubber; and the fourth is a compound of resin, asphaltum, and a little earth. Besides these, pit coal—the most useful mineral in cold climates, is a compound bitumen, mixed with various ingredients. Charcoal and bitumen (which may be distilled off as *coal tar*) are its principal components.

Secondly, The secondary compounds, or those substances of which one or more of the ingredients is a compound, are usually arranged into five combinations.

1. The combinations of the earths with each other, and with the metallic oxides. These form various species of *stones*, some of them of great hardness and brilliancy; and their colours are owing to the metallic oxides which are combined with them,—the same metal producing many different colours.

2. Combinations of the earths with alkalis. These form the various descriptions of *glass*, which is, in some places, as in Iceland, found native, but mostly formed artificially by the application of a strong heat. Glass combined in some proportions with metallic oxides forms *paste*, of which the imitations of the precious stones are made; and in other combinations it forms those opaque and coloured substances, having a beautifully smooth surface and of great durability, which are termed enamels.

3. Combinations of acids with alkalis, earths, or metallic oxides. The products of these combinations are called *salts*. They are of three kinds, according to the base with which the acid is united. When that base is an alkali, the salt is called a *neutral salt*, because the properties of the acid and the alkali are both neutralized; when the base is an earth, the product is called an *earthy salt;* and when the base is a metal, the product is called

a *metallic salt*. The number of these salts is very great; for there are not only as many as there are acids and bases, the number of which is very considerable; but there are in some cases two or more formed by different proportions of the same acid and base; and there are others which contain more than one base. The salts are denominated from the acid they contain, with the word "of" and the name of the base. Thus, *sulphate of soda* is the name of the salt formed by combining sulphuric acid with soda. If the acid were united with two bases, the names of both would be added: thus, *tartrate of potash and soda* would imply that the tartaric acid was combined both with potash and with soda. Sometimes the salt will combine with an additional quantity of the acid, and then the word "super" is prefixed: thus, *supertartrate of potash* means a salt, having more tartaric acid than the tartrate. In other cases, the salt will combine with an additional quantity of the base, and these are distinguished by prefixing *sub* to the name of the acid: thus, *submuriate of mercury* is a salt containing more mercury than the muriate. One particular class of salts, found by the union of chlorine with the alkalis and alkaline earths, and usually termed *hyper-oxymuriates*, have the singular property of exploding with very great violence when they are mixed with combustibles, and then heated, rubbed, or struck. Thus, for instance, a very small portion of hyper-oxymuriate of potash, mixed with sulphur and struck with a hammer, will produce a louder report than the discharging of a fowling piece. Some of these would, with sulphur and charcoal, form very powerful gunpowder; but they are apt to explode in the making. Common gunpowder is made by mixing nitrate of potash with sulphur and charcoal. When crystallized salts are heated to a certain extent, they all give out more or less of their water of crystallization. Thus, when common alum (sulphate of alumina), which is transparent, is heated, it gives out a quantity of water, and becomes gritty and opaque. The muriates melt in water; and are dissolved in sulphuric acid, which combines with the base. The carbonates may be decomposed by heat, or by muriatic or nitric acid. Most of the sulphates melt in water; but heat, without some other agency, does not separate their ingredients. The nitrates melt in water, and are decomposed by heat and by sulphuric acid. The acetates melt in water, and are decomposed by heat and by sulphuric acid. In order to obtain a complete knowledge of the salts, (or indeed of any other class of substances,) one must have recourse to the more extended works on chemistry; the best of which for general purposes are those by Mr. Thomson, (the late) Dr. John Murray, and the dictionary by Dr. Ure.

4. Hydrosulphurets are the combinations of sulphuretted hydrogen with the alkalis and earths: they combine very readily with the metals and metallic oxides, and thus enable us to separate these from the alkalis and earths.

5. The soaps. The composition, kinds, and leading properties of these has been already noticed.

III. CHEMICAL POWERS AND AGENCIES.

The real powers and agencies which the chemist employs reside in those very substances which form the objects of his enquiry; and all that remains for him to do is how to apply them to each other in such a manner as that they shall accomplish the end which he has in view. This is a matter to be determined by experience, and he who wishes to discover something new, must avail himself of that which was previously known. To accomplish this, the substances are mixed and exposed to the action of caloric, or they are exposed to the action of caloric without mixture.

The object of the mixture may be either to obtain a compound of the two substances, as when we melt sugar in water, or melt flint and an alkali into glass; or it may be to obtain some component part of one of the substances mixed, by the other combining with the substance that we mix with it: thus, when we pour sulphuric acid upon powdered chalk (which is carbonate of lime,) if we know any thing of chemistry, we must be aware, that we cannot obtain a compound of these two substances, or a sulphuro-carbonet of lime; for the moment that we pour the sulphur upon the mass, that mass is thrown into a violent effervescence, the sulphuric acid combines with the lime, forming plaster of Paris, or sulphate of lime; and the carbonic acid is driven off in the form of a gas, and may be collected in vessels previously filled with water. In like manner when, by the operation of a common fire, we combine oxygen with pit coal, it would be in vain for us to attempt to combine the oxygen with all the parts of that compound in its uncompounded state; for the heat necessary for the combination either drives off in vapour, or converts into gas, all the parts of the coal that are not metallic or earthy, and all that remains is, coke or charcoal from the imperfect combustion, ashes from the earths, and oxides from the metals; and if the charcoal be again subjected to combustion, the whole that remains are the ashes and oxides, small in quantity in proportion to the goodness of the pit coal.

Thus, in order to carry on this process of mixture, either without the accompaniment of heat or with it, we must know the relative tendencies that different substances have to unite with each other. Those tendencies are, for the want of a better name, called AFFINITIES. When the union between the substances is easily dissolved, as in the case of lime, and carbonic acid, which may be separated by burning, we say the affinity is *weak;* and when they can with difficulty be separated, as in the case of sulphuric acid, and lime which cannot be separated by heat, we say that the affinity is *strong*. When one substance can separate another from a third with which it was formerly united, we say that the affinity between the parts of the new compound is *stronger* than that between the parts of the old; and when a substance which we try fails in accomplishing the separation, we say that it has a *weaker* affinity. Those affinities are all the results of experience, and those results are found accurately stated in the larger works on chemistry.

When we wish to obtain any substance, (as, for instance, potash,) from any combination in which it exists, if heat will not do it, we must proceed either to mix the compound with something that will unite with the other ingredients and leave the potash, or something that will unite with the potash, and leave the other ingredients. If we can accomplish the former, our labour is at an end —either the new compound will crystallize, or be thrown down to the bottom of the liquid, or be left in solution in that liquid; or the potash will be in one of these states, and whichever way it be, we can by washing, drying, filtering, or some other mechanical means, obtain whatever we want without any further application of chemistry. But if the substance wished to be obtained separate, (the potash,) combines with the substance, then this new compound would have to be operated upon once, either by the application of heat to drive off the new substance, or by the mixture of another new substance, which shall be more strongly attracted by the former new substance, than by the potash.

The variety of those effects produced by mixture, is very great, and the results are very curious. Sometimes, when the union of two substances is so intimate that no other substance will separate them by combining with the one and not with the other, the purpose may be effected by making a third, or even a fourth, combine with the two, and then that which in the simple combination it was impossible to produce, is produced with ease in the compound one.

When the properties of all the simple substances, and of the primary and other compounds which they form, are known, and the methods of decomposing and composing them, and the apparatus and processes by which these are accomplished, understood, the student has acquired the elements of the science, and is enabled to proceed to the chemical examination of nature.

That is a wide and a delightful field; for whithersoever we go, or whatsoever be the subject of our examination, we every where find not only the most fertile sources of usefulness, but the most delightful instances of superlative beauty and aptness in the things produced, and thence are led to admire and to venerate the most consummate wisdom, in the great and incomprehensible Being by whom they have been produced.

The whole of this field of observation and enquiry may be divided into five portions, according to the situation and constitution of those products of nature with which we can become acquainted. The air, the waters, and the earth, the vegetables that grow, and the animals that live.

1. In the atmosphere there are two subjects of consideration—the substances of which it is composed, and the changes which it can be made to undergo.

The substances of which the atmosphere or air is composed, are oxygen and azote, in the proportion of about 23 of the former to 77 of the latter; but in addition to these, it usually contains carbonic acid and water, and also a small portion of the essential oils in a state of vapour. The average quantity of vapour in the atmosphere may be about one 75th part of its bulk; but this varies with difference of weather, and also at different places.

The changes which take place in the atmosphere are partly of a chemical and partly of a mechanical nature, although the original cause of both classes of changes appears to be chemical. The atmosphere is composed of substances, the bulk, aud consequently the pressure of which is very liable to be changed by change of temperature, and also by change of disposition in the atmosphere itself with regard to moisture, or rather to its capacity of receiving moisture. When the atmosphere is in a state much disposed to receive moisture, or when, in common language, it is said to be peculiarly dry, the portion of it which passes over the surface of other bodies rapidly, absorbs moisture from them. This moisture is converted into vapour, and dissipated through the dry atmosphere, so that no part of it is visible. It does not appear, however, that the combination of the vapour with the atmosphere is chemical; it is rather merely mechanical; and when the process is going on rapidly, there is always a certain obscuration or mistiness in the atmosphere.

Difference of temperature is accompanied by a difference of capacity for moisture or vapour, and so is difference of motion in the strata. Thus, two strata of air of different degrees of temperature, have not only different quantities of moisture held in solution, that which has the highest temperature having the greater; but the point at which they meet may in consequence of its stagnation, by the friction of the contrary currents, have a less capacity for moisture than either. The different degrees of electrical affection in the atmosphere may also produce a different capacity for moisture in the different strata.

Whatever the cause may be, when the atmosphere begins to show a disposition to part with the moisture it contains, the surface of the earth, in places which naturally produce moisture, become more moist, from the circumstance of that which they give out not being evaporated as it is produced; or, as it is expressed in common language, "the springs come out to welcome the rain." When even the upper strata of the atmosphere begin to deposit the water which they held in a state of minute division, and before that water has accumulated into such masses as to appear in clouds, and obscure the blueness of the sky, the weight of the air becomes less, and the barometer sinks. The reason of this will appear, when we consider that one substance when falling through another does not add to the weight of it, because, in that case, the substance through which it falls bears no part of the pressure. Upon this principle, the moment that any part of the dissolved moisture begins to accumulate, into even the smallest particles of sensible dew, those particles become specifically heavier than the same bulk of the atmosphere, begin tó descend, and therefore, their weight is taken off, and the thermometer shows a lighter state of the atmosphere.

As the particles descend, they strike against other particles of humidity; and as two portions of water have a stronger affinity for each other than they have for air, they unite. In proportion as more of them unite, they begin to descend with the greater rapidity, till at length they acquire a mass and weight which the atmosphere is unable to support; and so they fall to the earth in the form of dew or rain in different sized drops, according to the height from which it begins to fall—that which falls from the greatest height being always in the largest drops, in consequence of the drops meeting and uniting with more on their descent.

The further up into the atmosphere that one ascends, the cold becomes the greater, both because the air is more rarified, and therefore has a greater capacity for latent caloric, and because it is at a greater distance from the heat produced by, or reflected from the earth's surface. Hence, if the drops come from a very great height, even when it is comparatively warm upon the surface, they are congealed into ice, and fall in hail; the size of the pieces of which always encrease with the warmth of the climate, and weather in which it falls.

The waters, the solid strata of the earth, and the various parts of which animals and vegetables are composed also offer an inexhaustible fund of observation, information, and pleasure to the chemist; and, like the natural philosopher and natural historian, he cannot go to any place where the book of wisdom is not opened to him; nor can he be put in a region so desolate, as not to afford both information and pleasure.

Still, however, when all that can be known has been examined, one finds that nature is still the most skilful chemist, and that though she be abundantly communicative to those who study her aright, there are certain secrets in her working, which she will not communicate to the greatest adept, and which she herself yet accomplishes by the most simple means. Thus, no wit of man can form carbonate of lime; but there is not an oyster in the sea, or a little shelled insect in the pond, but which can perform the operation with the most perfect certainty. This may be a little humbling to our pride, but it should raise our admiration of that which, alone, is worthy of being admired.

Every plant and every animal, too, is a chemical apparatus, the mechanism and manner of working of which are wholly unknown to us. Thus the rose tree in the shrubbery gets aid from nothing but the soil in which it is planted, the atmosphere in which it rears its stem, and the dew and rain that fall upon and water it; and yet out of these simple and unlikely elements, it contrives to form, to colour, and to scent, the most beautiful, the most gay, and the most fragrant of nature's productions. Now, though we can analyse this rose after it is formed, though we can tell to the smallest fraction of a grain what are the simple substances of which it is made up, the whole of our skill and labour cannot mould a single leaf, or paint and perfume a single bud.

With animal life we are left still further behind; because that life, evidently of a more delicate and ethereal nature, eludes our every research, and mocks the very depth of our wisdom. To our analysis, the blood, the flesh, and the bones of all animals, are composed of the same ingredients, in nearly the same proportions, and yet the materials which the one has recourse to for a supply are the simple grasses, and those which the other has, are the substances of other animals. Enough, therefore, is left for us, to force us to the confession that He who ordained all things is mightier in power, and more consummate in wisdom than we; and, indeed, the further that we extend our knowledge, either of chemistry or of any other science, the more will those truths be impressed upon our minds.

CHAPTER VII.

ASTRONOMY.

The canopy of heaven that appears to be expanded over us, like a dome of azure, glowing with the sun by day, and sparkling with countless of thousands of stars by night, is not only the most splendid page in the book of nature, but it is the page which mankind, when left to the undirected and unbiassed exercise of their own powers, have, in all ages and countries, stretched with the first and fondest avidity. The dome itself is so vast in its magnitude, so perfect in its form, and so delicate in its colour, that no one who looks upon it can fail to be struck with admiration; and then the lights which it by turns displays, their varied and varying places, and the effect which the more brilliant ones have, in dispelling that darkness which covers the earth when they are obscured, have made ignorant and superstitious nations to consider them as the habitations of so many gods, if not of the gods themselves, while the more enlightened cannot fail to regard them as the noblest works of the Almighty Creator.

At first, the earth appears to us to be an extended plane, of which the only inequalities are the hills and vallies, and trees and works of art; and upon the circumference of a circular portion of this, of which the place upon which we stand ever appears to be the centre, the dome of the heavens seems to rest, while the sun, the moon, and the stars, appear to perform their motions over it from the east toward the west.

But when we examine the earth with a little closer attention, we find that it is not a plane, but a convex surface, of which the place where we stand appears to be the summit, or greatest height; and the rest sinks down in proportion as it recedes—we see objects that are near us to the very bottom, of those that are a little more remote, we see only the upper parts, while of those in the extreme distance, we can see only the summits. When our view extends over land, the knowledge thus obtained is not so striking, because of the inequalities of the surface; but when we look over a smooth sea, of which we cannot see the opposite shore, it is quite perfect; we remain at rest, and a vessel glides close by—we can see the whole of it down to the water's edge; it sails on—the hull disappears—next the lower sails—then the upper ones—the topmasts—all are gone in regular succession. If the vessel were at rest, and we moved on, the appearance would be exactly the same; and if we moved toward the ship, or the ship toward us, from a great distance, the appearance would be exactly reversed; the upper sails—the lower ones—the hull, would come successively into view. These results, and any one may observe them, could not possibly take place, if the earth were not a convex surface; and as they take place wherever one happens to be situated, the earth must have a surface that is uniformly convex, and of which any point may be considered as the summit. This is the property of a globe or sphere, and of no body but that, as may be seen by taking a billiard ball, or perfectly round orange, and placing it every possible way upon a table; and hence we are led to conclude, from common observation, that the earth is a globe. We might come to the same conclusion, by merely thinking on the subject; for the sun and stars rise from under the earth on the one side, and set below it on the other; but if it were a plane, we could not possibly imagine a boundary to it, whereas, by being a globe, though its surface as returning uniformly into itself has no boundary, yet the solid of the globe may be either great or small. If a billiard-ball be perfectly round or globular, and all of the same colour, we can trace no beginning or end of its surface, any more than we can of the circumference of a circle, or the length of a plain ring.

The dome of heaven itself is, however, the most incomprehensible part of that which seems to enclose our abode. Wherever we move, we seem to remain in the centre of that; and though we travel ever so far in any direction, we find that we are no farther from the sky in the direction that we left, and no nearer to it on that in which we set out. If our direction were westward, for instance, the sky toward the west would, at our setting out, appear to rest upon the tops of the western hills; but when we had reached these, we would find that it had flitted at our approach, and reposed upon plains or hills still farther to the west. It would be the same, if we moved in any other direction; and therefore we are forced to conclude, that this blue dome of the sky is not a fixed substance, or indeed a substance having form at all, but merely an appearance which space puts on to our eyes; and which, being connected with the eye, and having that for its centre, shifts as the eye is shifted.

If we reflect upon the subject, we soon find that space, or extension, is not a thing to which we can set bounds at all, even in imagination; for supposing that we should begin at the point where we now are, and reckon any object—a star on the blue sky, for instance, to be placed at as great a distance from us as one could repeat in numbers in a whole life-time, there would still remain the same question to be put, that we naturally put when we observe new hills appearing in the distance, when we travel a road for the first time: "what is beyond?" we would ask; and though the same question were put and answered ten thousand millions of times, it would remain just as apt and as unavoidable as ever. Be one place wheresoever it might, and the direction upward, downward, or to any side, the distance would have no limit; one substance or kind of matter might succeed to another, till the number were more than we could count; but of the limit of extensions just as that of number or of duration, we could not possibly form any notion. When we take a point of time, ever so long gone by, or ever so long to come, we can always with propriety ask, "what happened before the one?" or "what shall happen after the other;" and just in the same manner when we imagine a point of distance ever so far remote, that point is just as much entitled to be considered, as the centre of space or extension, as the point where we ourselves are. As the boundaries of space, considered in itself, are too vast for even our imaginations, so the distance into which we look while we turn our eyes to the blue heavens, is too much for our distinguishing any difference of distance, and therefore it appears all equally distant, or in the form of a hollow dome or half globe.

Not so with the celestial bodies that we discover in that space; for there are some of them which we can, by the naked eye, examine with a portion, at least, of that minuteness that we can examine distant objects upon the earth; and there are objects which we can so far examine by the aid of our magnifying glasses and mirrors, while there are others still upon which all the inventions of our art produce not the slightest effect.

Of the moon we can discover a good deal; we see from the part on which the light of the sun shines being light and the rest dark, and also from the changes and form of the line that separates the enlightened part from the dark, that the moon must be a globe with a rough surface like the earth, and that it has no light of its own, but shines merely by reflecting the light of the sun, just as we could make a looking-glass or a piece of white paper reflect the light of a candle. From the nature of light, as explained in the section on optics, it will be recollected that a convex surface, such as that of a globe, disperses the rays of light that fall upon it, and thus the quantity of light which the moon reflects must be less than that which the sun casts upon the same surface. This also agrees with what we see, for the brightest moonlight is faint compared with the weakest light of the sun; and this is a confirmation of the truth of our reasoning.

There are a few of the stars which when examined by the unassisted eye do not twinkle as the other stars do, but are steady in their light, while they are continually changing their places, not only at different times of the night, but with regard to the other stars, the greater number of which do not alter their situations with regard to each other. The stars which are thus steady in their light, but which change their places, present, when examined by telescopes of sufficient power, similar appearances to those that are presented by the moon; and thus we are led to conclude that they too are globes of matter which shine not in consequence of any power of illumination in themselves, but merely because, like the moon, they reflect the light of the sun. These bodies are called *planets,* and some of them are found to be accompanied by smaller ones, of an apparently similar nature, which are called secondary planets, or *satellites* or *moons.*

The sun also, when seen through a piece of coloured or smoked glass, or seen through a fog, appears to be a well defined surface, of which we can tell the form and judge of the apparent dimensions; and when we look at the sun through a magnifying glass the dimensions are enlarged; so that, though the sun does not, like the planets and moons appear to reflect light derived from any other body, but rather to shine in consequence of some power of illumination in itself, yet it, like the others, is in a certain extent within the range of our instruments of observation.

When, however, we direct our view, even when aided by the best telescopes that art has been able to invent, to those stars which twinkle and do not change their places though the number be greatly encreased, no two of them appear to have a distinct form or dimensions of which we can form any estimate; and thus all the knowledge that we obtain of them is that they are shining bodies, situate so remote, that no means which we can use, can bring them to our more intimate acquaintance.

The result of those observations, and they are such as any body could make, is one step in astronomical knowledge. By them we ascertain that there is a certain number of globes, all of which derive light from the same sun that illuminates our earth; that that sun derives its illuminating power from no external source that we can point out, and that the fixed stars are situate at too remote a distance for deriving light from our sun, that, therefore, they may be supposed to shine without it in the same way that the sun appears to shine without any external source of illumination.

The sun which brings the radiance of day to the earth, appears to bring it to a number of other globes; but beyond the sun, and those objects of his bounty, there appear to be luminous bodies without end, far too remote for being scrutinized by us, or having much influence upon the globe that we inhabit. Remote as they are, those bodies have various degrees of brightness—some are so radiant, that the light from them can not only penetrate a thin cloud, but can produce through refraction in the minute particles of which it consists, a little cloud of light, and others are so remote that the best telescopes show us only a glimmer that is barely visible. But does the best telescope that we have disclose them all? We have no reason to think so; for, always as the telescope has been rendered more powerful, the number has been increased, and hence, we may conclude that, if the telescopes could be improved without limit, the number of stars would appear without limit also.

Indeed, we have just as great difficulty in imagining an end to the number of those luminous bodies, or to the distances at which they are placed from us, as we have in imagining a limit to extension itself; and as we cannot for an instant suppose that the almighty and all-wise Creator could make anything in vain, we are led to the splendid conclusion, that suns without number and diffused without limit, each enlightening its system of planets, all of which are peopled with life, fill up the universality of space, and proclaim the Godhead of him by whom they have been called into being and can be commanded out of it, in characters too sublime for human contemplation, and utterly beyond the grasp of the most powerful human intellect.

To those fixed stars, numerous and beautiful as they are, our philosophy will not reach, and, therefore, our considerations respecting them must all tend to and terminate in veneration for their mighty Author. We can, however, trace their positions with regard to each other, not only in that hemisphere which presents itself to our view, at any one time or any one place, but throughout the whole of the surrounding space; and we can make a mimic representation of those stupendous heavens upon the surface of a little ball or globe, marking the stars upon it, arranging them into groups, and giving names to the individuals and the groups, so that we can point them out in the heavens. This mimic representation we call a *celestial globe*; and we can make it of any size that we find convenient. If it were to be a perfect representation, it should be hollow, and we should be placed in the centre of it; but as this form would be both expensive and inconvenient, we make it a reverse of the heavens, and contemplate it from without.

As, in consequence of the immeasurable distance of all the stars, the actual heavens, beyond the sun and planets, put on the form of a perfect hollow sphere, with the earth in its centre; and, as the effect of the motions is precisely the same, though in the opposite direction, whether we consider this sphere to be moving round the earth or the earth to be turning round within it, the sphere serves us for referring to the place of the sun and planets as well as the stars, and enables us to know that portion of the celestial bodies that comes within the reach of our observation and reasoning.

The universe itself, having neither centre nor boundary, can have no distinction of distance, position or situation, other than what can be traced to the bodies that are found in it; and as to the inhabitants of the earth, the earth *appears* to be at rest and all the others in motion, the sun and planets each in its particular path or orbit, and the stars in one common path, in which they preserve the same apparent distances from each other, the earth is the proper point at which to begin to fix our positions.

The first or simplest position, and therefore the best one with which to begin, is that which we call the upright or *perpendicular*, and nature herself always points it out to us. We let fall a heavy body, or hang a heavy body by a thread, and in either case the heavy body tends directly to the whole mass of the earth, and therefore, if continued far enough downwards would pass through its centre. Now, if we imagine the line which is formed by the thread that suspends the heavy body or plummet, to be extended both ways till it should meet the space which appears as the blue dome of the heavens, that line would pass perpendicularly through the middle; the upper end would be in the centre of the hemisphere which is over our heads and visible; and the lower end would touch the centre of the hemisphere which is under our feet and hidden from our view by the earth.

The upper extremity of this perpendicular is called the *zenith* and the lower extremity the *nadir*.

Nature furnishes us also with the means of determining that position which is across, or *at right angles* to this. Water or any liquid stands with its surface *level*, and if we be upon a calm sea or lake and out of sight of the land, the portion of the heavens which is *up* or visible, will every where appear to touch the level surface of the water.

A level surface is called a *horizontal* surface, and the circumference at which the level surface of the sea (or the land) appears to meet the sky is called the *horizon*. Thus the horizon divides the celestial sphere into the visible and invisible hemispheres, the zenith being the centre of the former, and the nadir that of the latter.

Any circle passing through the zenith and nadir will divide the sphere, and also the horizon into two equal parts.

If a circle be supposed to be drawn through those points, and also through that point where the sun is at mid-day, such a circle is called a *meridian,* and divides the sphere into an eastern hemisphere toward the place where the sun rises, and a western hemisphere toward where the sun sets.

If a circle be drawn through the zenith and nadir so as to divide each of the semicircles into which the meridian divides the horizon into two equal parts, this circle would mark the east and west points of the horizon. Such a circle is called the vertical circle.

Around the horizon from any point to the opposite one is 180° ; and from the horizon across the zenith to the horizon again is also 180°.

From the zenith to the horizon measured in the shortest way is always 90°.

The number of those degrees that any celestial body is from the horizon is called its *altitude.*

The particular point of the horizon that would be met by a circle drawn from the zenith through the centre of the body to the horizon, is called the *bearing* of the body.

As the zenith is the point directly over, and the nadir the point directly under any place on the earth's surface, it follows that no two places upon the earth's surface can have the same zenith and nadir; and if two places be so situate as that a straight line passing through the centre of the earth would pass through them both, the zenith of each becomes the nadir of the other.

But since the zenith and nadir are not the same at any two places, it must follow that every place must have a different horizon, and that change of place will change either the bearing or the altitude, or both the bearing and altitude of the celestial bodies; and that, therefore, the two positions which are given us by the gravitation of a heavy body and the level surface of a liquid, though they answer well enough for all places considered in themselves, would not enable us to compare the positions of the celestial bodies at one place with their positions at another, so as to apply the result of the comparison to any useful purpose.

So that we must again have recourse to observation; and if, in England for instance, we continue to observe the stars during a clear night, we find, that while some are gradually appearing in the east and others gradually disappearing in the west in the southern portion of the heavens; that there are a considerable number, in the north, which do not pass below the horizon, but which, when they have made their nearest descent to it by the west, re-ascend again by the east, and appear to move round in circles which, though they all appear to have the same centre and are passed over in the same time, become smaller and smaller as the lowest point to which the star appears to descend gets higher above the horizon,—and if one trace the circles upward, toward the zenith, one comes to a particular star which appears to stand still while all the others move round it. The point where this star is situate is called the *north pole;* the star itself is called the north *pole star*; and, as it is north of all places, it serves as a universal reference of position for every point of the earth's surface.

If one were to be placed a great way southward upon the earth's surface, one would find a similar point in the south, around which the heavens would appear to revolve; and this point is called the *south* pole.

A line joining the north and south poles of the heavens would pass through the centre of the apparent surrounding sky, and also through the centre of the earth.

This line is called the *axis of the sphere*; and the portion of it which is within the earth is called the *axis of the earth.*

The extremities of the earth's axis are called its POLES.

Circles, whether of the sphere or of the earth, that are drawn from the one pole to the other are called meridians, and their direction is always north and south.

A circle which divides into two hemispheres, north and south, with a pole in the centre of each, is called the *equator* of the sphere, and the equator, or *equinoctial line* upon the earth.

The distance of any body north or south of the equator is called its *latitude;* and the distance between the meridians of two places is called their *difference of longitude.*

From these explanations it is easy to see how the celestial globe may be used for knowing the names and revolutions of the fixed stars.

The ball of the globe has the stars marked upon it as accurately as possible, according to their relative situations; they are arranged into *constellations* which are painted like real or imaginary animals and other figures, for the sake of more convenient reference; and various *great* and small circles, hereafter to be noticed, are drawn upon it. The ball has a wire or axis passing through its centre and poles; and this wire is fastened into a circle of brass in such a manner, that one edge of the circle, which is divided into degrees, divides the ball into two equal parts.

The ball, with its meridian, is let into two notches in a circle of wood or other matter, in such a manner as that it shall turn round in a vertical direction, and this circle, which is placed level, and called the *horizon,* divides it into two equal parts—an upper and an under hemisphere.

An *equator* is drawn upon the globe, dividing it into a northern and a southern hemisphere; and this equator is divided into 360 degrees.

Meridians are drawn upon the globe at every 15 degrees. There are thus 24 of these; and they are called *hour circles.*

A great circle is drawn, cutting the equator in two opposite points, and extending to about 23½ degrees northward of it on the one side, and 23½ degrees southward of it on the other. This circle is supposed to represent the sun's apparent annual path. It is called the *ecliptic;* and divided into 12 *signs* of 30 degrees each. The points in which the ecliptic cuts the equator are called the *equinoctial* points, and those at which it is farthest from the equator, and which are just midway between the former, are called the *tropical* points.

The poles of the ecliptic are marked at the same distance from the poles upon which the globe is suspended as the ecliptic is from the equator at its most distant points; circles are drawn from these points through the ecliptic, which mark the *celestial longitudes,* and small circles are drawn parallel to the ecliptic, which mark the *celestial latitudes.*

At the time of the vernal equinox, that is, when day and night are equal in the spring, the sun appears to be in that point of the ecliptic which crosses the equator northwards, and to proceed regularly over the ecliptic till it be again at the same point at the same time of the next year. This point is therefore taken as the beginning of the astronomical year, and of the celestial longitude;

and the longitude is counted in signs and degrees, which are marked by characters and numbers.

The horizon contains, inwards, next to the ball of the globe—*azimuths,* which are degrees counted from the north and south points, both ways to 90° at the east and west; *amplitudes,* which are counted from the east and west in the same manner, and the points of the compass, of which there are 32; then it contains two circles affixed to each other (the one consisting of the days of the year arranged into months, and the other the ecliptic divided into signs and degrees) in such a manner, as that the place of the sun in the ecliptic stands opposite to the day; and thus may be marked upon the globe itself for any day of the year. This contrivance is necessary for adjusting or rectifying the globe, so that it may apply to the appearances of the stars, because time is always accounted from the sun; and as the sun is always upon the meridian at 12 o'clock noon, if the sun's place, for any day, be brought to the meridian, the globe will be brought to the portion of the heavens for 12 o'clock noon of that day.

Both extremities of the axis of the globe are furnished with indices, which point to circles divided into 24 equal parts for hours.

The globe is also usually furnished with a *quadrant of altitude,* which may be fastened to the zenith, and which serves to measure the distance of any body from the zenith or the horizon.

As the fixed stars do not change their places, the applications of the celestial globe to them are not many. The principal one is:

To represent the appearance of the heavens at any place, for any hour. And the method of doing it is this:

Place the globe with the horizon level, and the meridian in the direction of north and south: then raise the pole of the hemisphere in which the place is as many degrees above the horizon as the latitude of the place; find the sun's place in the ecliptic for the day, bring it to the side of the meridian, set the hour index to 12, turn the globe round eastward if before noon, and westward if after; and the globe will represent the appearance of the heavens.

After this is done, the altitude and bearing of any star may be found by the quadrant; and the times of their rising, setting, passing the meridian, or being upon any point of the compass, or at any height within their range, may be found by turning round the globe upon its axis, till the star come to the required position, and the index will show the hour. Such is a very brief outline of Astronomy, in so far as it relates to the fixed stars, and the manner of representing their appearance by the celestial globe. In what has been said concerning these, it was not necessary to advert to the real motions of the earth, or of any of the planets, but merely to consider the apparent motion of the heavens that is produced by these. It now remains to give an equally brief outline of the particular bodies, the phenomena, and laws of

THE SOLAR SYSTEM.

The solar system, in as far as discovery has been made, consists of the sun, and twenty-nine other bodies, which revolve round the sun at distances increasing in the order in which they are mentioned, and periods of time increasing with those distances, though not at so rapid a rate as the distances themselves.

Mercury, the planet nearest to the sun, performs his revolution in 87 days and 23 hours.

Venus, the next in order, in 224 days, 17 hours.

These two, being nearer to the sun than the earth is are called the *inferior planets.*

The *Earth*, accompanied by the *moon*, performs its revolution in 365 days, 6 hours.

Mars, in 1 year and 322 days.

Ceres, in 4 years, 7 months, and 10 days.

Pallas, in the same period as Ceres.

Juno, in 5 years, 182 days.

Vesta, in 3 years, 66 days, and 4 hours.

Jupiter, accompanied by four moons, in 11 years, 315 days, 15 hours.

Saturn, accompanied by 7 moons, and 2 concentric rings, in 29 years, 161 days, and 19 hours.

The *Georgium Sidus*, accompanied by 6 moons, in 83 years, 342 days, 4 hours.

These, being farther from the sun than the earth is, are called superior planets.

The paths in which these planets move, are not circles, they are ellipses or ovals, having the sun situate in the longer diameter, and in such a manner as that the planet is nearest the sun when in the one extremity of that diameter, and farthest from the sun when in the other; and that it is at the mean or average distance from the sun, when half way between those points, in the circumference of the ellipse.

The point nearest to the sun is called the *perihelion;* the point farthest from the sun, the *aphelion;* and the line joining them is called the line of the *apsides.*

The distance of the sun from the middle of the line of the apsides, that is, from the centre of the ellipse, is called the *eccentricity* of the orbit; the place of the sun, the lower *focus;* and a point, as far on the other side of the centre, the *higher* focus. The eccentricity of none of the orbits is very great, that is, none of them deviate very much from circles.

The place of the heavens in which any planet would appear, if seen from the centre of the sun, is called its *heliocentric* place; and that in which it appears, as seen from the earth, its *geocentric* place. We evidently cannot see any planet except in the latter; but in order to have a clear notion of the system, we must imagine ourselves to see them all from the former.

The lines of the apsides of all the planets are not directed towards the same points of space, though they all pass through the circle of the sun; and the *orbits* or paths do not lie all in the same plane, although they all cut each other at small angles.

The ecliptic, spoken of already as the apparent annual path of the sun, is the real annual path of the earth; and whatever part of it the sun is said to be in, just implies that the earth is in the opposite one. This may be understood by a very simple experiment: place a candle upon the table in the middle of the room, walk round it, looking towards it all the time; and you will perceive that the candle appears to move round the room in the opposite direction, and that whatever place you are at, the candle always appears on the opposite wall. Just in a similar manner, when the earth is carried round the sun in the course of a year, the sun appears in that part of the heavens which is opposite to the earth. If, while you are performing this motion round the candle, the floor were not level, but sloped to one side, you would find that when you were on the high side of the floor, you would see the candle low upon the wall; when you were upon the low side you would see the candle high; and when you were upon the level direction of the floor, you would see the candle at the same height on the wall as yourself. The earth moves in this way with its orbit sloped to the plane of its equator, at an angle of 23½ degrees; this angle forms the deviation of the ecliptic from the equator, which has been already mentioned; and it is called the *obliquity* of the ecliptic.

The angles which the planes of the orbits of the other planets make with that of the earth, are called the obliquities of these orbits; and the two points in which they cut or intersect the earth's orbit are called the *nodes* of the planet's orbit; the one at which the planet begins as it were to rise above the earth's orbit is called the ascending node; and that at which it begins to sink below the earth's orbit is called the descending node.

The lines of the nodes of the planets, like the lines of the apsides, point to different parts of the surrounding heavens.

Not only have the *primary planets*, or those which move round the sun only, orbits differently inclined to each other's, and to that of the earth; but the secondary planets, or moons, have orbits differently inclined from their primaries, which again cut them in points which are called the nodes.

Those combinations of the orbits of the planets, together with the different rates at which they move, would occasion a great variety in their places and relations, both with regard to each other and to the fixed stars, as seen from the sun, which, with reference to them, is at rest in the centre of the whole system; and those irregularities are rendered vastly more complicated as seen from the earth, in consequence of the motion of the earth itself, and also of the effect which all the planets have in disturbing, by their gravitating force, the motions of each other.

Still, however, when the nature of their motions and the laws of their action upon each other are known, their positions, as seen from any point of the earth, at any time, whether past or present, may be determined with as much certainty as we can determine where the hour hand of a well regulated clock or watch shall be three hours after the time that we last saw it.

In order to have a notion of the appearance of any one of those planets in the different parts of its orbit, we must again have recourse to the simple and familiar apparatus of the candle in the room, only we must now have somebody to assist us, and some opaque objects to represent our planets—say oranges suspended by threads.

The candle is, as before, to be the only light in the room; and it will be found to illuminate only those sides of the oranges that are turned towards it,—the side toward the wall being always dark. This being the case, let the candle represent the sun, and we the earth, and let the assistant take the orange, and by it represent one of the inferior planets—say, Venus. In this case the planet is nearer the sun than the earth is, and so the assistant must carry it round the candle, nearer to it than we are. If, in the first instance, we move at the same time that the orange is moved, the whole appearance will be confused, therefore it is better to remain in one place, and let the assistant carry round the orange. Let the motion be begun from the point on the other side of the candle, it will represent the *superior conjunction* of the planet with the sun; and the orange, if held in the same line with the candle, will not be seen; but if held a little lower down, or higher up, it will appear, and the part of it illuminated by the candle will appear perfectly round.

If it be carried round toward our left hand, we being at a considerable distance, it will appear to move from the candle toward the left, and, as it advances, the illuminated part will decrease at the outside, till, when one fourth of the revolution is performed, it will appear at its greatest distance or elongation that way, and with half a circle illuminated.

As the motion is continued, it will appear to retreat toward the candle, the illuminated part still diminishing at the outside till it come into the line between us and the candle, and then it will be in its inferior conjunction, the whole of it that we see will be dark; and if be just as high as the candle, it will pass over the flame, and exhibit what is called a *transit* of Venus; but if it be either higher or lower, it will not obscure the candle, and would not itself be visible, if we were at a sufficient distance.

During the next quarter of the revolution it will appear to move from the candle toward the right, gradually becoming more and more illuminated upon the side opposite to that which was illuminated when it was upon the left; and when it has completed this third quarter of its revolution, it will appear at its greatest elongation toward that side, and will again have a half circle illuminated.

During the fourth quarter, it will retreat back again toward the candle, gradually becoming more and more illuminated, till when it arrives at the point from which it set out, it will again be in the superior conjunction as at first.

As seen from the earth, therefore, Venus will not appear to move in a circle or ellipse at all, but merely to travel across and across the sun, with a motion continually decreasing as it recedes, and accelerating as it returns, and exhibiting all the *phases,* or different illuminated forms, which the moon does between one full moon and another The distance to which the planet will appear elongated from the sun will depend upon its distance from that luminary compared with the distance of the earth; and as Venus is at a greater distance from the sun than Mercury, it will exhibit a greater elongation. The fact is, that the distance of Mercury is so small, that it is not visible to the unassisted eye, except in very peculiar situations, and even Venus is hidden for a time at both its conjunctions, unless when in the superior one it happens to be in one of the nodes of its orbit; and then it performs a *transit* like a beautifully defined black spot over the disc or face of the sun. When it is in the eastern half of its orbit, it is an evening star, and shines after sunset, longer or shorter according to the length or the shortness of its elongation; and when it is westward of the sun, it appears as a morning star, and rises early or late, according to the elongation.

If the object were to represent the appearance of any of the superior planets—say Jupiter, the assistant would have to carry the orange round both us and the candle; and in this case, the whole of the orange would appear illuminated, both when the candle were between it and us, and when we were between it and the candle; and though the illuminated part would never be so small as half a circle, it would be least at the two parts intermediate between these.

A superior planet could never make a transit over the body of the sun, because it could never come between the earth and the sun, even when in conjunction with that luminary.

The only other motion in an orbit which requires illustration, is that of a secondary planet round its primary; and this may be explained by the same simple apparatus —the candle, and the orange suspended by the thread. Let the motion to be explained be that of the moon round the earth; and let the candle as before represent the sun, yourself the earth, and the orange the moon: take the orange by the thread in your own hand, and removing to a distance, and holding up the orange in your extended arm, mark the changes of its appearance. If you begin with it between you and the candle, it will represent the moon at change; the whole of it will be dark toward you, and it will appear above the candle, or below it, or upon it, according to the elevation at which it is held. Turn round slowly toward the left, and a small crescent of light will appear on the right side of the orange, and gradually increase till you have moved a fourth round, when the one half of the side toward you will be illuminated and the other half dark; and it will then represent the moon as seen from the earth at the end of the first quarter. Continue moving till you have gone half way round; and the light will gradually increase till, when opposite to the candle, if your shadow fall not upon the orange, it will appear wholly light, and represent the full moon as seen from the earth. Move another fourth round, and the light will gradually diminish at the other side, till at the end of that fourth of the turning, the orange will a second time appear half illuminated, at a quarter of a circle to the right of the sun; and thus it will represent the moon at the end of the third quarter. Move over the remaining quarter, and the light will gradually fade till you come to the position at which you begun, and the orange will then represent the moon at change, the same as at the first.

In this operation there are two circumstances worthy of notice: first, though in the course of your turning round, the same side of the orange be always toward you, yet in the course of the turning, the orange has actually made a revolution round its own centre, inasmuch as that side which has been toward you, has been turned in succession toward the whole circumference of the room; and secondly, that if, when the orange were between you and the candle, it would hide the candle from you, and when it were opposite, you would prevent the light of the candle from falling upon it, if you did not hold it above or below the candle in the one case, and your own shadow in the other. From this we are enabled to infer—first, that as the moon presents always nearly the same face toward the earth, though not illuminated to the same extent, the moon must perform one revolution and no more, round its own centre, in the course of every *lunation*, or lunar month —that is, from the time of one change or new moon, to the next; and secondly, that if the sun, moon, and earth, be in the same straight line at the time of change, or when the moon, as viewed from the earth, is in the same point of the heavens as the sun, the moon will hide, or *eclipse* the sun to the inhabitants of the earth, and also, if they be all three in the same straight line at the time of full, that is, when to the inhabitants of the earth the moon is in the part of the heavens opposite to the sun, the earth will prevent the light of the sun from falling upon the moon—that is, the moon will be *eclipsed* to the inhabitants of the earth.

If the orbit, or path in which the moon revolves round the earth, moved in the same plane with that in which the earth revolves round the sun, the three bodies would be in the same straight line at every full moon, and at every change; and hence if this were the case, there would be an eclipse of the moon at every full, and of the sun at every change. But the orbit of the moon is not in the same plane with that of the earth: it cuts it in two points, called the nodes of the moon's orbit; and the one half lies as it were above the orbit of the earth, and the other half below. When the new or full moon happens to be in the node of the orbit, there is a total eclipse; and when it happens to be near the node there is a partial one; but when it is at some distance, the new moon is either above or below the sun, and the full moon either above or below the earth's shadow.

The satellites of the other planets exhibit the same phenomena with regard to their primaries, that the moon does with regard to the earth; so that when those of one are explained, one has only to make allowance for the differences of distance, magnitude, and time of revolution, and the explanation serves for all the others.

The revolution of each planet round the sun, determines its *year;* and the inclination of its orbit is the cause of its difference of seasons; but in the case of a planet revolving round the sun, as the light of the sun must always shine upon the side next to that luminary, if the planet had no other motion, the year would consist only of one day—that is, the different parts of its surface would be all successively illuminated only once in the course of a year; or, if it presented the same face always to the sun, as the moon does to the earth, the hemisphere of its surface exposed to the sun, would enjoy continual day, while the opposite hemisphere, or that turned away from the sun, would be involved in the darkness of continual night.

To obviate this, the primary planets, at least in so far as we have been able to determine by actual observation, have each another motion,—a rotation, or turning round their own axes; and, as the revolution round the sun determines the year, so this rotation round the axis produces the alternation of night and day. Thus, in the case of the earth while it is performing its annual revolution round the sun, it turns three hundred and sixty-five and one-fourth times round its own axis.

One can again illustrate this by means of the simple apparatus of the candle and the orange: for, if one hold the orange suspended by the thread, and, while moving it round the candle, twirl it round its own centre with such a degree of rapidity, as that it should be twirled 365¼ times in the course of its movement round the candle; then each part of it would have 365¼ days and nights in the course of the revolution or year.

Upon examining the orange, while suspended by the thread it is turning round its own centre, it will be perceived that there are two points which do not themselves turn round any thing, but which all the rest of the surface turns round, these are the points where the thread is inserted and the points directly and diametrically opposite. If one reflect for a little, one will be convinced that every globe which has a rotatory motion round its centre, must have two such fixed points. These points are called the poles; and if a straight line were drawn through the centre of the globe, so as to join the poles together, that line would be the polar diameter or axis, about which the planet turns.

If the polar axis be supposed to be continued from the poles toward the celestial space, its situation in that space would be the pole of the heavens, or the celestial pole with regard to that planet; and if the line passed through or very near any star which were seen from the planet, the inhabitants of the planet would call that the pole star; so that the north and south poles of the heavens, formerly mentioned, round which the sun, planets, and stars seem to revolve, are nothing but the points to which the ends of that line, round which, if we could see it from a distance, the earth would appear to turn; and the apparent motion of the heavens from east to west round this pole, is nothing more than the effect of the turning of the earth round its axis from west to east. Deceptions of our sight perfectly similar to this, and therefore perfectly explanatory of it may be found in the most familiar motions with which we are acquainted; and in all of which, until we think of it, things which are really at rest appear to be moving, while the observer, who is really moving, appears to be at rest. Thus, if with a smooth sea and favourable wind, we be sailing away from the shore or from a beacon, the shore or the beacon appears to be running away from us. If we be in the cabin of a vessel, the vessel may turn wholly round, if it does so smoothly, without our having the least notion that it has moved at all; if we whirl ourselves rapidly round upon our heel, all the objects about us will soon have the appearance of whirling the other way; and if we have whirled a considerable time and with great rapidity, this apparent motion of other things will, even after we stop, continue, so that we shall be incapable of standing in consequence of our involuntary attempts so to balance ourselves as to get the better of this motion,—if we be in a carriage with the blinds up, or be seated so that we cannot see out at the windows, then we have no notion whatever of the rate at which the coach is moving, or whether it be moving forward at all. We indeed feel the jolting of the carriage, and hear the noise of the wheels and the horses' feet, and as we are accustomed to associate these with a progressive motion, we naturally conclude that the carriage moves; but if we felt the same jolting and heard the same noise, we would conclude that the carriage were moving at the same rate, though meanwhile it were not advancing a single inch; and if we felt no jolt, and heard no sound, the carriage might move as from one end of England to the other, without one being at all aware of it. Every one who, shut up in a carriage as here supposed, has passed from the rough stone pavement of a street to a smooth gravelled road, must have felt that, upon leaving the former, the rate of motion was diminished, although upon looking out, it would have been found to be increased; and every one, who has passed from the smooth road to the rough pavement, must, from the additional jolting and clatter, have imagined that there was a great increase of motion; whereas upon examination it would have been found, that the rate had in reality become much slower. In like manner, if one shut one's eyes and run for a considerable time along a level road or lawn, one will, upon opening them, be quite astonished at the distance that we have run. From these simple matters, which are within every body's reach, we can see how very easy it is for us to be deceived in all cases of motion, when we, (or that upon which we remain without changing our place upon it), are moved.

If we look from the window of the cabin while the ship is turning round, all the objects that we see appear to move round us in the opposite direction; if we look from the window of the carriage as it drives along, the trees, houses, fields, and hills, appear to be running backwards; and the same appearance strikes us if, when we are running, we look suddenly to one side.

Another experiment comes still nearer to the cause of our being deceived with the appearance of motion: if we look from behind a screen that conceals a person holding a candle, the image of which is seen in a mirror, the effect upon the image will be the same whether the person holding the candle agitate that, or another person agitate the mirror; and if we shake our head while both candle and mirror remain steady, the appearance will still be precisely the same as if either of them were agitated.

These deceptions are easily explained: the rays of light from the object, (as mentioned in optics), produce vision by falling upon the *retina*, or innermost part of the eye; and if the image continues to fall upon precisely the same part of the eye, the body, of which that is the image, does not appear to move. When, however, it passes from one part of the retina to another, the sense of motion is produced; but as the motion of the eye is involuntary and we have no consciousness at it, unless by comparison with other objects, we always impart the motion to that which we see; unless an observation of other things convince us to the contrary.

In the case of terrestrial motions, or motions near the surface of the earth, the deception produced by the eye is merely momentary, because we have the fixed objects upon the earth's surface, with which to compare the successive places of the moving body; but in the case of the motions of the earth itself, there is no fixed point to which we can refer, and therefore we require the aids of philosophy and reasoning to correct our mistake. Let us, however, return to the orange hung by the thread, and whirling round the candle.

If the orange be not swung, but hangs perpendicularly down, the end of the thread will evidently have to be moved over a curve or orbit precisely similar to that in which the end of it that is attached to the orange moves; or if we suppose the thread to be extended straight toward the sky, the end of it would trace there a path exactly similar to that of the orange. Now a planet, the earth for instance, moves with the axis about which it turns always at the same inclination, or parallel to itself, in the same manner as the thread by which we suspend the orange; and, therefore, the portion of the heavens toward which the pole of the earth is, in the course of a year or revolution in its orbit, directed, is not a single point but a curve (an ellipse nearly circular) of the same form and dimensions as the orbit of the earth. This affords us the means of finding, not only the relative, but the absolute distances from the earth, and from each other of all celestial bodies, of which the situation is altered by the earth being in different places of this orbit, and also makes us sure of the immeasurable distance of those bodies whose places are not so altered.

This gives us an astonishing idea of the distance of the fixed stars, and of the magnitude of even that part of the universe which we can see. The mean distance of the earth from the sun is about 95,000,000 of miles, a distance greater than the swiftest mail-coach would travel in a thousand years, and two opposite points of the earth's orbit are double this distance asunder. Thus, at the longest day and at the shortest, the earth is at two points as far from each other as the swiftest mail-coach would travel in 2000 years, and from what has been said, it must be evident that the points of the heavens toward which the pole of the earth is turned at these times, must also be at this amazing distance from each other. But amazing as this distance is, it becomes so small as to be to the finest instruments absolutely nothing when removed to that place at which the pole star is situate. That star has a small daily motion, in consequence of its not being even within this immense oval of 190,000,000 of miles in diameter; but the oval itself is diminished to a mere point, so that the star appears to be no farther from its centre, when 95,000,000 of miles are added to it, than when 95,000,000 of miles are taken from it. But if the distance of the pole star be such, that 190,000,000 of miles neither increases by addition nor decreases by subtraction a distance which thus appears to be very small in itself, how far beyond our comprehension must be the remoteness of the pole; and how wonderful a thing must light be, that it can find its way where even investigation itself can hardly venture!

It is, however, impossible, even in volumes, far less in a brief chapter of one small volume, to give even a glance at a subject so glorious and so vast; but if the proper feeling be once awakened, the mind will speculate for itself, and seek for the data upon which to found its speculations in the works of those who have collected facts and made observations. All, therefore, that can farther be attempted in this sketch is to notice the magnitude and one or two of the more remarkable phenomena of the bodies which compose the solar system.

1. *The Sun.* This body is immensely large compared with the others in the system. Its diameter is 883,246 miles, and it contains 333,928 times as much matter as the earth, though that matter be not one-fourth as dense or heavy, bulk for bulk, as that of which the earth is composed,—being about one-seventh heavier than water. The sun has a motion round its own centre, or rather perhaps, round the centre of the system (which is never without the body of the sun) in about 25½ days. As seen from the earth its apparent diameter varies, being greater when the earth is nearer, and smaller when it is more remote. The mean diameter, as it appears to us, is a little greater than that of the sun.

2. *Mercury.* This planet is 3224 miles in diameter, and contains rather more than $\frac{3}{20}$ as much matter as the earth, while that matter is more than 9 times as dense as water. It is a fact worthy of notice, that the densities, or weights of equal bulks of the planets, become less and less as they recede from the sun, with the exception of Herschel or the Georgium Sidus, which is denser than Saturn, though more remote. The mean distance of Mercury from the sun is 37,000,000 of miles; and its mean apparent character is about $\frac{1}{20}$th, so that the disc or face of Mercury, though seen wholly illuminated, would not appear to be above the $\frac{4}{101}$ part of that of the sun.

3. *Venus* is 7687 miles in diameter, and contains about $\frac{9}{10}$ as much matter as the earth, and that matter is rather heavier than that of the earth, being rather more than 5 times the weight of water, while that on the earth is only $4\frac{1}{2}$ times. Venus is 68,000,000 of mils from the sun; and performs a rotation round its axis in about $23\frac{1}{3}$ hours. The apparent diameter of Venus is rather more than 5 times that of Mercury, so that it gives out about 25 times as much light.

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4. *The Earth* is nearly 7912 miles in circumference, its mean density is about $4\frac{1}{2}$ times that of water, it is 95,000,000 of miles from the sun, moves round the sun in 365 days 6 hours, and round its axis in a day, that axis being inclined 66° 32′ to the plane of its orbit, which makes the inclination of its equator to the orbit, in the obliquity of the ecliptic 23° 28′.

5. *The Moon.* The moon is about 2180 miles in diameter, and contains about $\frac{1}{40}$ of the quantity of matter, while bulk for bulk it is denser, being $5\frac{1}{2}$ times the weight of water, while the earth is only $4\frac{1}{2}$ times. The moon is 240,000 miles from the earth, and moves round it in rather more than $27\frac{1}{4}$ days, but as the earth, during that time, moves forward in its orbit, the path which the moon actually describes in the course of a *lunation* is not an ellipse like that of the primary planets, and the time from change to change is increased to about $29\frac{1}{2}$ days. Observation shows that the surface of the moon, like that of the earth is irregular, but there is reason to believe that no part of the moon can be covered with or even contain water.

6. *Mars* is considerably less than the earth, being 4189 miles in diameter. The quantity of matter that it contains is less than $\frac{1}{10}$ of that in the earth, and it is only about

3½ times the weight of water. Mars is 144,000,000 of miles distant from the sun, and performs a rotation round its axis in about 24½ hours.

7. *Ceres, Pallas, Juno,* and *Vesta,* are nearly at equal distances from the sun; their diameters are much smaller than that of the earth; and, from their proximity to each other, their peculiar forms, and the difference of some of their motions from those of the other planets, astronomers have conjectured that they are fragments of a greater planet which, at some period of the history of the system, has been dashed to pieces by the collision of a comet, or by some other cause beyond human scrutiny.

8. *Jupiter.* This is the largest body that has been discovered moving round the sun. Its diameter being about 89170 miles, or about 11 times that of the earth. The quantity of matter which it contains is about 312 times greater than that in the earth, while it is only a very little heavier than water. Jupiter is about 490 millions of miles from the sun, so that even when nearest to the earth it is more than four times as far off as that luminary. Hence, notwithstanding its great magnitude, its apparent bulk is considerably less than Venus. Jupiter turns round its axis in about 10 hours.

9. *Saturn* is about 79042 miles in diameter, and thus, next to Jupiter, the largest of the planets. Its quantity of matter is, however, less in proportion, for it is not half the weight of water. Saturn turns round its own axis in about 10 hours and a quarter.

10. *The Georgian planet,*—the remotest body of the system which has been hitherto discovered, is 35112 miles in diameter, and contains about 17 times as much matter as the earth. Its density is a very little less than that of water; and its rotation round its axis has not been discovered.

The moons which accompany Jupiter, Saturn, and the Georgian planet, exhibit nearly the same phenomena as that which accompanies the earth; so that, for having a general idea of the phenomena, it is not necessary to enter into the minute and very intricate details of them.

It has been mentioned already, that the orbits of the planets are not all in the same plane, but intersect the earth's orbit in two parts, diametrically opposite, which are called the nodes of these orbits; and it may now be observed, that neither the nodes nor the points of least and greatest distance remain in the same position with regard to absolute space, but have certain motions, which are called the processions of the nodes; and in the case of the earth, the procession of the equinoxes, because the nodes of the earth's orbit are the equinoxial parts, or position which the plane of the earth's orbit cuts that of its equator. Even the angles that the axes, about which the planets revolve, form with their respective orbits, are not invariable: that of the earth has been for a long time becoming less and less; and there is reason to conclude, that after the expiration of a very long period of years, it will again begin to increase, and that there are limits both ways which it cannot, according to the laws which appear to regulate the planetary motions, pass.

When all the revolutions, rotations, inclinations of orbits, and motions of the orbits themselves, and of their planes with respect to each other, are considered, it will naturally appear that the science of astronomy is one of the most difficult in the whole range of human inquiry; and it must be admitted that long and patient study, through many generations, has been required in order to perfect our knowledge of them; and that, notwithstanding that all the elements of this knowledge have been collected, it still takes a considerable time so to understand them as that one shall be able to tell where and under what aspect each of them, or even any one of them, shall be found at any period of time. But still the thing is within the limits of our accurate knowledge; and all those vast bodies in all the variety of their revolutions, obey laws which are just as simple and certain as that by which we are led to infer that a leaden bullet, which we drop from our hand, will after the lapse of a certain portion of time fall to the ground.

By the law of gravitation, as deduced from actual experiment, the tendency of any body to attract, or draw, other bodies towards it, is directly as the quantity of matter; and in the case of two bodies, inversely, as the square of their distances. Thus, if equal quantities of matter be equally distant from the earth, the attraction of the earth upon them, or, which is the same thing, the tendency which they have to fall to the earth, will be precisely the same,—that is, supposing that the bulk of each of them has the same relation to that in which they are; for when this latter circumstance is not the case, it may happen that the same absolute quantity of matter in two different bodies, may in the one case rise upward from the earth, and in the other fall down toward it: thus, a balloon which weighs four hundred pounds, may rise up in the air, and carry with it two men, while a piece of lead or gold of the very same quantity of matter, may require the strength of two men to prevent it from falling to the ground. In the case of the celestial bodies, however, there is no reason to think that the space in which they float is filled by any other medium which, like the atmosphere in the instance alluded to, alters, or overcomes their gravitation towards each other; and therefore it is laid down as a general law, that " the different bodies composing the solar system gravitate towards each other with forces directly as their weights, or quantities of matter, are inversely in the squares of their distances."

By the latter part of this proposition, it is meant, that if two bodies, containing equal quantities of matter, were to be so placed that one of them were at double the distance of the other, the remotest one would only have one-fourth of the weight of the other; that, if three times as distant, it would only have one-ninth of the weight, and so on.

Here again, however, we must not be misled by what we observe at the surface of the earth; for the gravitation toward the earth must be counted from its centre, and not from its surface; and therefore, if we were to remove a four pound weight to such a distance from the earth, as that it would gravitate or weigh just as much as a one pound weight at the surface, we would have to remove it to half the diameter, or nearly four thousand miles above the surface of the earth. Thus, though double the distance from the mean point of gravitation, in the whole mass of the earth, would certainly diminish the weight of any body to one-fourth, yet any difference of elevation which we can reach, produces but a very trifling distance. The greatest height that has been ascended does not exceed four miles, and the change produced by gravitation there would not produce an alteration of more than 1 in 2000,—that is, a piece of matter weighing 2001 pounds at the surface of the earth, would actually weigh about 2000 pounds, if raised four miles above that surface; and even this small difference would not be perceived by the common operation of weighing in scales, because the weight would become proportionally as much lighter as the thing weighed.

In consequence of the action of gravitation, it is found that when a body is made to whirl round in free space, the axis or line round which it whirls, always passes through its centre of gravity, or through that point which, if it were balanced or suspended, the whole of the body would be balanced or suspended. Thus, if we take a billiard-ball, or any other body that is a perfect globe, and, hanging it by a thread, twirl it round, it will revolve smoothly upon its centre, without any wriggling or moving toward any side. If however we fasten a bit of lead, a nail, a pretty large bit of sealing-wax, or any other thing to the one side of it, it will cease to move smoothly; for the side opposite to that to which the additional body is attached, will be thrown outwards, and the centre of gravity, and consequently that of rotation, will be brought nearer to the side to which the additional body is attached.

Thus in free space it is altogether impossible to make a weightier body revolve round a lighter one. To illustrate this, take two balls, fasten them together by a thread, tie another thread to that which connects them, in such a manner as that the two suspended be at the same height; then twirl round the thread, and mark the consequences. As they get a rotary motion, the balls will separate, and the separation will be greater as the thread is twirled more rapidly. If they be precisely of the same weight, they will move to equal distances, and revolve round the same circle, always diametrically opposite to each other; and if you observe, you will find that the single thread, to which the thread connecting them is attached, would, if produced downwards, pass exactly through the centre of the circle, in the circumference of which they revolve. If, however, the one ball be considerably heavier than the other, though they will still separate, the separation will not take place by an equal motion in them both: the small one will move farthest from the original position, and as you twirl them round, it will revolve about the large one. If the difference of their weights be very great—as for instance, if the one be a large ball of lead, and the other a small ball of cork, the large one will not appear to move in the circle at all, but merely to twirl round its own centre, round which also the small ball will appear to revolve, in a circle greater or less, according as the motion communicated to it is more or less rapid.

It is upon those simple principles, that the whole of the beautiful and complicated motions of the solar system, (and probably of the whole system of the universe) depend. True, we cannot perceive, unless by its effects, the Almighty hand which communicated and sustains the motion; and we do not perceive the threads, because these are of use only for preventing the balls with which we make our experiment, from falling to the earth in consequence of the nearness and superior magnitude of that body. It has been mentioned, that the nearest of the stars is more distant from all the planets in our system, than even imagination can conceive; and, as gravitation diminishes always as the squares of distances, the action of any star upon any of the planets or bodies in one system, must be incomprehensibly small compared with their actions upon each other, and especially with the action of so very powerful a body as the sun upon any or all of them. If the motion of the system were suspended, the whole of the bodies of which it is composed would fall toward their common centre of gravity, just by virtue of the same law, and in the same manner that a stone falls to the ground when any obstacle stops its motion through the sky. As that centre of gravity is within the body of the sun, the whole planets, if their motions were suspended, would fall directly toward the sun; and for the same reason, the centre of rotation, round which the whole solar system moves, must always be within the body of the sun.

When you whirl round the ball, you find that the greater its velocity, the farther it removes from the centre of gravity; and just in the same manner, the more rapid that the motion of any planet is, the greater power has it in overcoming the gravitation toward the sun. When it is in its perihelion, that is, in the point of its orbit nearest to the sun, it is moving with the greatest velocity; and this very velocity deflects it outwards, and makes it move in the semi-ellipse toward the aphelion, or point farthest from the sun. At this point the motion is the slowest, and therefore the tendency to overcome the gravitation is the least; and the planet, in consequence, tends inwards, until its velocity and power of overcoming the gravitation again become a meximum. It is not very easy, without a figure, to explain how this is brought about, and why either the departure from the sun does not go on increasing till the planet gets wholly out of the system; or why, on the other hand, when the planet has once began to approach nearer to the sun, it should not continue, until it actually come in contact with that luminary. It depends upon the angle which the two forces that act upon the planet make with each other. Those two forces, being equal, may be represented by equal lines,—the one directed toward the sun, and the other in the line of the planet's motion for the time. When the planet is in the perihelion or the aphelion, these two lines are at right angles, and the resulting force, which is midway between them (they being equal) would force the planet forward in a circle; but in the perihelion, the velocity drives the planet, and consequently the line of its force arising from motion, outward, so that the angle formed by that, and the force toward the sun, is greater than a right angle; and as the resulting force is still equidistant from these, the planet moves without the circle. On the other hand, the gravitation is a maximum when the planet is in the aphelion, and the angle of the two forces is less than a right angle, the half of which, or the resulting force is less than half a right angle, and thus the planet moves within the circle. In other words, while the planet is moving from the perihelion to the aphelion, that is, from the point nearest to the sun to the point most distant, its motion is continually retarded, and thus the force of gravitation is augmenting, and that of progression decreasing; when it arrives at the aphelion the forces are equal, but as a motion once generated does not instantly stop, the motion of gravitation overcomes the other, and because the angle is a right angle, augments that which in the other half of the ellipse it retarded; and thus from the aphelion to the perihelion, the projectile force is continually gaining upon that of gravitation, and overcomes it at the perihelion, just as itself was overcome by the other at the aphelion.

Thus, though the principle of gravitation does not throw any light upon the original causes of the planetary motions, yet it shows us how when a planet has once moved in an elliptic orbit, it must continue to move in that orbit. The projectile motion is called *centrifugal*, and the tendency to the centre, *centripetal*.

The same force of gravitation explains a number of other phenomena: because the equatorical, or middle parts of a globe move faster when it is whirled round, inasmuch as they move over more space in the same time than those near the poles, their gravitation must be diminished; and in consequence, if the power be not overcome by the cohesion of the substance itself, a globe which has a rotary motion should be flattened at the poles. The earth has, by actual measurement, been found to be so flattened, and therefore we conclude, that at some period of its history, the earth has been in such a state, as that the rotary motion has in so far overcome its cohesion.

The force of gravitation has farther effects, in deflecting the planets out of their places, and also in changing the form of their soft parts; thus, if the earth were near Jupiter, Jupiter would attract it; and the waters of the sea are raised into tides by the attraction of the sun and moon. The last of these, however, falls properly within the province of Geography, and the others are too abstruse for a mere sketch.

CHAPTER VIII.

GEOGRAPHY.

IN the systems of female education, the science of geography is but too frequently confined to the definition of a few terms, the application of which is not shown; a few wheelings round of the terrestrial globe, the meaning of which is not comprehended; and the commiting to memory of the names of a few seas, lands, kingdoms, cities, rivers, and mountains, the situation of which is not understood, and which are in consequence turned to their natural, and perhaps their intended purpose, when they are forgotten.

When used in its extended and more useful signification, Geography is that useful branch of knowledge which treats of the general appearance of the earth's surface, and investigates the causes why that appearance is different at different times and different places. Those appearances are produced partly by the form and motions of the earth itself, partly by the influence of the celestial bodies—the sun and the moon, and partly by the agency of the atmosphere; so that in order to understand the first and most simple elements of geography, one must be acquainted with natural philosophy, chemistry, and astronomy.

Nor is it the more general phenomena of the earth that come within the province of the geographer; for that province extends to the different descriptions of surface which the earth presents—the mountains into which that surface rises; the vallies and caverns into which it sinks; the rivers that water its slopes and plains; and the seas which fill the great basins or hollows, into which a great portion of it is scooped. The plants also which clothe the different regions, the animals by which those regions are inhabited, the people that claim dominion over them, together with all that they produce interesting or useful to man, as well as the events of which they have been the scenes, and the deeds of honour or of cruelty of which they preserve the memorials, are so many elements of geographical knowledge.

Geography is in fact a sort of connecting link for all our knowledge; because, all that has happened or been discovered, or is known, if we except the celestial bodies, has been done or found upon the earth, and therefore, without any impropriety, comes within the description of it.

In this sketch it is proposed,—First, to give some account of the figure and motions of the earth, with the influence of the celestial bodies in as far as they are concerned in producing the alternation of day and night, the succession of seasons, and the variations of climate. Secondly, to point out the effect of the celestial bodies, in producing tides in the ocean and the atmosphere. Thirdly, to notice the uses of the atmosphere in the distribution of that heat and moisture which are essential for the preservation of animal and of vegetable life. Fourthly, to point out the way in which the whole surface of the earth, or any part of it, may be artificially represented by globes and maps: and Fifthly, to give a very slight outline of the natural divisions; and point out how the details may be acquired with the greatest ease, and remembered with the greatest certainty.

1. THE FIGURE AND MOTIONS OF THE EARTH, &c.

The earth, as has already been mentioned, is nearly a globe, the diameter of which may, in round numbers be stated at 8000 miles; and the circumference at 25000. It revolves round the sun in 365¼ days, and round its own axis in 24 hours. It is flattened a little at the poles, so that the axis round which it turns is a little shorter than the equatorial diameter. The equator, or circumference midway between the poles, is supposed to be divided into 360 degrees of about 70 miles each. This equator lies in the direction of east and west; and the degrees of it are all of the same length. A meridian or semicircle, drawn from the one pole to the other, is divided into two equal parts by the equator; each of the quadrants into which the equator divides a meridian is divided into 90 degrees, which are called degrees of latitude, and counted from the equator to the poles, north and south. Hence there are only two points on the earth's surface that have 90 degrees of latitude, and these are the two poles. All places that are situate directly east or west of each other have the same latitude; and hence circles, whether in the north or south of the hemisphere, which are supposed to be parallel to the equator, are called parallels of latitude. Those circles diminish toward both poles, and are all less than the equator. As the earth is very nearly a perfect globe, the degrees of latitude may for ordinary purposes, be considered as all of the same length.

The degrees into which the equator, and circles parallel to the equator are divided, are called degrees of longitude. At the equator they are of the same length as the degrees of latitude; but they become smaller toward the poles, and at the poles they become 0.

The longitudes are begun at the meridian of some place (British geographers begin them at that of Greenwich, where the Royal Observatory is,) and counted 180° east, and 180° west; so that they meet at the meridian diametrically opposite to the first one. All places that lie directly north or south of each other, have the same longitude.

The distance which one place is north or south of another, is called the difference of latitude; and the distance which they are east or west of each other is called the difference of longitude. If the latitudes or longitudes be of the same kind, the difference is found by subtracting the less from the greater; but if they be of different kinds, the difference is found by adding them together.

When the difference of latitude and of longitude of two places is known, the distance between the two places may be found; and if the distance and difference of longitude be known, the difference of latitude may also be found; but when the distance and difference of latitude are known, the difference of longitude is not so easily determined, because the degrees of longitude are not all of the same lengths.

As the earth is a globe, a whole hemisphere, or half of it, must always be turned toward the sun, and shone upon by that luminary; but this half is continually shifting from east to west, in consequence of the earth's rotation from west to east, and it also shifts from north to south, and from south to north, in consequence of the angle which the earth's orbit (the ecliptic,) makes with its equator. The shifting from east to west is constant, in the same direction, and always nearly at the same rate—being 15 degrees of longitude in an hour, or the whole 360 in 24 hours—but the shifting from north to south, passes over only a certain space, slowly and unequally, and then returns. The space over which it passes is double the number of degrees in the obliquity of the ecliptic, or 47° nearly, and the time of performing the change from the one limit to the other and back again, is a whole year, that is, half a year for the change one way, and half a year for the change the other.

The equator is situate exactly in the middle of the space over which these changes northward and southward are made, and the time of passing from it to each tropic is one quarter of a year.

When the earth is in the nodes of its orbit, its equator is turned directly toward the sun, or the inhabitants of the equator have the sun rising directly in the east, passing directly over head at noon, and setting directly in the west. At these times, too, the poles are in the two extremities of the illuminated hemisphere, and the half of every parallel of latitude is illuminated and the other half not. At those times, therefore, day and night are equal throughout the world. The sun appears every where to rise in the east at 6 in the morning, and set in the west at 6 in the evening—the only difference is, that at noon the sun is as far from being directly over head as the place is from the equator; and as the equator is south of all the north latitudes and north of all the south ones, the inhabitants of the northern hemisphere will, when the earth is in either of its nodes, see the noon-day sun as far above the horizon in the south, as the latitudes of their respective places want of 90°, while those in the southern hemisphere will see the sun as far above the horizon in the north. At this time, therefore, the passage of the sun through the heavens will appear to be equally long in all places; and the only difference will be that the sun will appear lower and lower the nearer that the places of observation are to the poles, while at the poles themselves the sun will move round the horizon in the south at the north pole, and in the north at the south pole, with the one-half of its face on the disc above the horizon, and the other half below.

The earth is in its node, descending toward the south, on about the 22d of March, and in its node, ascending to the north, on about the 22d of September. On those two days, therefore, day and night are equal throughout the world, and for that reason, they are called the equinoctial days or equinoxes,—that which happens in March is called the spring or vernal equinox, and that which happens in September, the autumnal equinox.

From March till June, the earth continues to descend toward the south, and the sun is gradually vertical at noon, at latitudes farther and farther north, and the days in consequence lengthen in the northern hemisphere and shorten in the southern one till about the 22d of June, when the earth begins to ascend to the other node, at which it arrives in September, and day and night are again equal throughout the world. After this, the earth ascends from that node till December, during which time the day lengthens to more than 12 hours in the southern hemisphere, and shortens correspondingly in the northern, till about the 22d of December the earth has arrived at the other limit of its orbit, and the days in the two hemispheres gradually equalize till the earth arrives a second time at the descending node, when a second vernal equinox completes the astronomical year. The two points at which the earth begins its descent and its ascent, are called the tropical points, because, as seen from the earth, the sun appears to turn back, and the parallels of latitude at which the sun appears vertical at those times are called the tropics. These tropics are as far distant from the equator both ways as the obliquity of the earth's orbit, that is, each is at 23½° of its own latitude.

The distance from the equator of any place at which the sun appears directly over head at midday, is called the declination of the sun; and whatever declination the sun has, the pole toward which he declines is as many degrees within the light, and the other pole as many degrees within the darkness. Thus, when the sun is over head at the northern tropic, the north pole is 23½° within the light, and the south pole the same number of degrees within the darkness; and when the sun is over head at the southern tropic, those circumstances are reversed.

The earth's aphelion is in the time between the 22d of March and the 22d of September, and its perihelion in the other half of the year. But it was mentioned that the motion of a planet is slower toward the aphelion than toward the perihelion; therefore, the half of the year, from March to September is a little longer in absolute time than the other half.

From these observations, the changes of the seasons, in the two hemispheres, and for the different latitudes may be easily understood.

1. From March to June is the spring quarter in the northern hemisphere, and the autumnal one in the southern.

2. From June to September is the summer quarter in the northern hemisphere, and the winter one in the southern.

3. From September to December is the autumnal quarter in the northern hemisphere, and the spring one in the southern.

4. From December to March is the winter quarter in the northern hemisphere, and the summer one in the southern.

5. At the equator itself, the day is always of the same length with the night; and the sun always rises directly east and sets directly west—the only difference being that

the sun is as many degrees from the zenith at noon, and on the same side of the zenith, as its declination, but never more in any case than 23½°.

6. A space of as many degrees round the pole to which the sun has declined as the declination, has continual day, and an equal space round the other pole continual night.

7. In the other parts of both hemispheres, the difference of the lengths of the summer and the winter days increases with the latitude.

8. From 23½° north latitude, to 23½° south, the sun is in the zenith at noon twice in the course of the year. These times are half a year distant at the equator, and gradually approach nearer to each other, till, at the tropics, they meet at the midsummer days of the remainder of the respective hemispheres. This portion of the earth is called the torrid zone.

9. 23½° round each pole has at one time of the year more than 24 hours of sunshine at a time, and at another the same continuation of darkness. These portions are called the frigid or polar zones.

10. The intermediate portions are called the temperate zones.

Thus, though in the course of the year, the light of the sun falls upon all portions of the earth for an equal length of time, yet those portions are distributed in a very different manner. At the poles, the whole of the solar influence is collected into one day six months in length; at places within 23½° of the poles, there is a summer, having one long day, and a winter having one long night, and this is longer as one approaches the pole. From the end of those zones, that is from 66½ to 23½, or for 43° of latitude in the middle of each hemisphere, there are days less than 24 hours at all times, but longer in summer than in winter, and this difference becomes greater the nearer that one approaches to the pole. In the remainder, or middle zone of the earth, there is no great variation in the length of the day, while at the equator there is none at all.

If the rays of the sun acted with the same intensity upon all portions of the earth's surface, every latitude would, in the course of the year, enjoy the same portion of solar heat, and those parts which have the long summer day would then be absolutely burnt up. But the action of the sun must be in proportion to the quantity of rays which fall upon equal surfaces, and therefore the heat must be greatest where the sun is directly overhead; while, when the sun is in the horizon, the light, except in so far as it is refracted by the atmosphere, must pass over the surface without heating it at all. If, therefore, the axis of the earth had been at right angles to its orbit throughout the year, in the same manner as it is at the nodes, the equatorial regions of the earth would have been burnt up, while those at the poles would have been abandoned to the rigours of unchanging and unmitigated cold. But by the obliquity of the orbit, the equatorial heat is lessened, while that of the high latitudes is so collected into a summer, that it calls into life and preserves, vegetables which could not otherwise have existed; and as the trees and plants of those regions are so constituted that they remain denuded of their foliage and in a state of comparative death during the winter months, not only a very pleasing variety, but the most delightful utility is produced by the alternation of summer and winter. By this means our fields, which look bleak and barren during the winter, are, during the summer, clothed with beauty, and in the autumn loaded with crops; while in regions yet nearer the poles, the shortened summer, in consequence of the almost perpetual presence of the sun, is rendered even warmer than ours.

Nor has the bountiful Author of nature left the earth without some means of mitigating both the heat and the cold. Intense heat produces evaporation from all substances that contain humidity, and evaporation absorbs heat and thereby produces cold; and, on the other hand, when the cold acquires a certain degree of intensity, water passes into the state of ice, and thus gives out a considerable portion of heat.

The sun is the only celestial body that affects the temperature or climate of the earth: for the moon, though a nearer attendant, has no perceptible heating power; though the moon also performs important functions in another manner: it not only cheers us in the absence of the sun, and continues the longest with us when the absence of the sun is most severely felt, but it is the prinpal agent in producing those phenomena which are denominated

2. THE TIDES.

The tides of the ocean are phenomena with which every one who has looked upon that mighty "waste of waters," even for a single day, must be quite familiar: twice in every 24 hours, or nearly in every 24 hours, the waters retire from the land and leave a part of the bed of the ocean dry; and twice, in the same period of time, they return to their former limit. This does not, however, take place at the same hour in any two successive days, but occurs later and later every day, till in the lapse of about 29 days, it again happens at nearly the same hour as at the beginning of that period. When the tide ebbs away from the land, and has retreated to its greatest distance, it is said to be *low water;* and when it returns to its greatest height, it is said to be *high water.* In places where the form of the land, the mouth of a river, or currents in the sea, do not disturb the motion of the tides, the time from one high water to another is 12 hours 25 minutes, or that between high and low water, 6 hours 12½ minutes. At any place, those tides which happen at the same hours of the day, rise and fall very nearly the same height; but there is a very considerable difference in the rise and fall of those that happen at different hours. This difference is found to depend upon the appearance of the moon: the tides being uniformly highest at the new and full moons, that is, when the moon appears in the same part of the heavens with the sun and when it appears in the opposite part; and they are uniformly lowest when the moon has half its disc illuminated, whether it be an evening half moon and have its circular edge turned toward the west, or a morning half moon and have its circular edge turned toward the east. This variation is completed in the period of a lunation of 29½ days, and through all lunations it is nearly the same. When the tides have the greatest difference of high and low water, they are called *spring tides*; and when they have the least, they are called *neap tides*.

Besides this variation, which follows the monthly motion of the moon, there is another, though a less remarkable one, which follows the year, or the motion of the earth in its orbit. At the equinoxes the difference of the tides is the greatest possible, and at the *solstices*, that is, the midsummer and midwinter days, it is the least; but the times of these variations are so long, and the progress of them is so gradual, that they cannot be so well observed, or at any rate they are not so so striking as the others.

Those appearances and variations of the tides, lead us at once to their causes. The tides generally follow the motions of the moon; and the variations are produced by the positions of the moon and earth in relation to the sun; therefore, the tides generally are produced by the moon, and the variations are produced by the sun.

Let us inquire in what manner: It has been stated, that the action of bodies upon each other in consequence of their gravitation is, directly as their quantities of matter, and inversely as the squares of their distances; any portion of water at the surface of the sea must, therefore, be attracted by the earth, the moon, and the sun, directly as their quantities of matter, and inversely as the squares of their distances. The relative quantities of matter are: the sun 333,928,000, the earth 1000, and the moon 25; and water at the surface of the ocean is 4000 miles from (the centre of) the earth, 240,000 from the moon, and 95,000,000 from the sun. Now, if the sun's quantity of matter be multiplied twice by 4000, and the earth's quantity twice by 95,000,000, the products will express the relative attractions of the sun and earth, or the tendencies which any portion of water at the earth's surface has toward these bodies respectively. In like manner, if the moon's quantity of matter be multiplied twice by 4000, and the earth's twice by 240,000, the products will express the relative attractions of them. It is not necessary to fatigue ourselves with the calculation; all that is requisite is, to know how it could be done, and what the result is. Now the result is, that though the tendency toward the earth be so vastly greater that no perceptible change is made upon the largest quantity of matter that we could weigh, yet that if a whole hemisphere of the earth were covered with water, the attraction of the moon would raise the centre of it 5 feet, while that of the sun would raise it 2 feet.

Those considerations are quite sufficient to explain the leading phenomena of the tides; and the greater irregularities are explainable by the interruptions of the land, the different distances of the sun and moon at different times, and the action of the winds.

In order clearly to understand the matter, it is necessary to imagine that the earth is an uniform globe, covered with an uniform depth of water; to see what the appearances of the tides would be upon that; and then to consider how those appearances would be modified by the intervening lands. Now, if the earth were so uniform and so covered, the water would rise at the point directly under the moon, and also at the point directly opposite (because there the attraction toward the common centre of gravitation of the two bodies would be less), and it would also rise at the point immediately under the sun and at the opposite point, though to a less elevation, because the attraction of individual masses at the earth's surface is less toward the sun than toward the moon. Although the earth turned round its centre, the elevation would always be toward the luminaries,—that carried by the sun would travel westward round the earth in 24 hours; and, as the moon has a motion eastward, which though (being much slower than that of the earth,) it would not appear in any other way than by the moon's getting a little eastward every day, would make the part elevated by the moon to travel westward slower than that by the sun. When the two were in the same part of the heavens, their direct influence would be combined, and the water would be raised both on the side next them and on the opposite side, to a height equal to the sum of what they would produce singly. If they were in opposite parts of the heavens, their indirect influence would be united, because the upper elevation produced by each would concede with, and be added to, the under elevation produced by the other. But if they were 90 degrees distant, both high waters produced by the one, would fall upon the low waters produced by the other; and thus the effect would be the difference between the greater and the less; but the influence of the moon is the greater; and therefore the tides, through all their variations, follow the motions of the moon.

If the sun and moon were always in the plane of the earth's equator, and the earth covered with an uniform depth of water, the tides would be the same in every lunar month. The greatest height would appear to revolve round the equator in the space of 24 hours 50 minutes; and, as both the high water at the points to which the moon were in succession opposite, and also those upon the other side of the earth, would have the water attracted toward them, and away from the circumference of the respective hemispheres, the circle of low water would revolve from east to west in the plane of the meridian,—so that it would always be low water at the poles, and the differences of the tide would become less and less as one approached those points.

But both the celestial bodies, upon which the tides of the ocean depend, are sometimes on the equator, sometimes on the north side of it, and sometimes on the south; and sometimes the one of them is upon the one side of it, and the other upon the other. It has been mentioned too, that the orbit of the moon forms, with the orbit of the earth, an angle of about 5½ degrees; so that whether the sun appear on the one side of the equator or on the other, the moon may be either farther north or farther south than the sun. It is farther obvious that the new moon will always be on the same side of the equator as the sun; and that the full moon, (being diametrically opposite), will always be on the other side of it. These circumstances will not only give to the tides a variation depending upon the season of the year, but also are depending upon the time of the day.

If the earth were uniformly covered with water, the high water of spring tides would always take place at 12 o'clock; the high water, by both the luminaries being upon the same meridian above or below the horizon at change, and by their being upon opposite meridians, the one above the horizon and the other below, at full. In the summer half year, the spring tides at new moon would be produced by both luminaries being on the north side of the equator; and the spring tides at full moon by the sun being on the north and the moon on the south; and in the winter half year, those circumstances would be exactly reversed. Hence in both hemispheres, the high water of those spring tides which happen during the day would be higher than that of those which happen during the night; but in winter those circumstances would be reversed, and at the spring and autumnal equinoxes, the tides will be the same in both hemispheres.

Such would be the general appearances of the tides, if the earth were covered with an uniform depth of water: but that is not the case, and therefore the variations which are produced by the opposing shores of the land, and the inequalities of the bed of the ocean, make them so very complicated, that at any place they must be observed in order to be known.

It is only in great oceans that a complete tide can be raised; and hence lakes and inland seas have little or none. When the apparent motion of the tides toward the west is interrupted by the shores of the land, the water is turned toward the north or the south, and the tides follow each other in a circle: so that instead of coming from the east, as they would do if there were no interruption, they may come from any other point of the compass;

thus the tide, which is produced in the Atlantic, toward the equator, between Africa and America, is interrupted by the latter country. A portion of it, in consequence, moves northward along the American shores; there it is turned eastward by the ice in the polar sea, and thence it moves southward along the shores of Europe.

When only one tide comes to a place, the succession will be comparatively uniform; but it may happen, that in consequence of the channels between islands, two tides shall arrive either at the same time or at different times. If they arrive at the same time, they will occasion a higher tide than would otherwise happen; and if they arrive at different times, they may occasion either continual high water, or a succession of more than two tides in the course of the lunar day.

The gravitation toward the sun and moon produces tides in the atmosphere as well as in the water of the sea; and that is the cause why the weather is most unsettled when the tides are high. At new and at full moon the weather often changes; and at the time of the equinoxes, when the variation of the tide is the greatest, the weather is unusually stormy. Nor is it upon the atmosphere and the waters only that this gravitation has an effect, for certain affections even of the human mind, and certain diseases of the human body, are found to have their paroxysms when the attractions of the sun and moon are united, and their remissions when the attraction of the one is opposed to that of the other.

The tides of the ocean perform an important part in the economy of the world; by them the water which is heated at the equator, is carried down to the poles to mitigate the cold of those inhospitable regions; and the water which has been cooled at the poles is carried back to allay the burning heat at the equator. Thus in every provision that nature makes, and every change that her productions undergo, there are the most wonderful proofs of the wisdom of Him, by whom the whole is directed.

3. THE ATMOSPHERE.

The atmospheric fluid by which the globe is every where surrounded, is one of the most beautiful, most wonderful, and most useful of nature's productions. We ourselves feel, that without it we could not exist for many seconds. It is the breath of every thing that lives, and when any organised being is shut out from it, that being speedily languishes and dies. Each no doubt receives it in a different manner: man, and the warm-blooded animals receive it into the lungs; the insect tribes draw it through little pores on the surface of their bodies; the cold-blooded fishes take it from the water, and trees, plants, and flowers draw it in by their fluttering leaves; but all of them require it, and each of them is furnished with an apparatus, by which it can separate and appropriate to itself the portion which is essential to its own preservation and growth.

But this is not all: the atmosphere is as it were, the grand messenger of nature, the agent by which heat and moisture are diffused over the surface of the earth. Of all natural bodies, the air is the most susceptible to changes of temperature; for the moment that any portion of it is from any cause more heated or cooled, than that by which it is surrounded, the portion so heated or cooled speeds away, and never pauses until it come to some other body or place, where the excess may be given out, or the deficiency made up; and as, according to certain chemical states of it, the air can absorb, retain, or give out water; it carries drink to all the children of nature; and refreshes upon the arid heath and the brow of the mountain, those vegetables which without its friendly ministration would become parched, and die.

It would be impossible to explain the whole laws and uses of the atmosphere; but still it becomes those whose very life it is to know something of it, the more so that its dispensation is free, and that it preserves our lives without so much as an effort, or even a wish upon our part.

We may understand the great outlines of its action, by bearing in mind the following very simple considerations:

1. As the rays of the sun, when they fall perpendicularly upon any surface, must be either wholly absorbed by that surface or reflected back again into the atmosphere immediately over it, it follows that those regions of the earth upon which the rays of the sun fall most nearly in a perpendicular direction, must, both in the earth itself, and in the atmosphere over it, receive the greatest quantity of solar heat.

2. As the rays of the sun, when they pass parallel to any surface, can neither enter into that surface, nor be reflected to the atmosphere over it, it follows, that those portions of the earth upon which the sun falls most nearly in a parallel direction, must, both in the earth itself, and in the atmosphere over it, receive the least quantity of solar heat.

3. That in proportion as the direction of the rays approaches to the first of these portions, the heat will increase, and in proportion as it approaches to the second of them, the heat will diminish.

4. That, as the air becomes colder by expansion, and warmer by compression, and as the air in the upper regions of the atmosphere is more expanded, and that in the lower more condensed—in consequence of the difference

of pressure, it follows, that at every part of the earth's surface the air must become colder as we ascend to a greater height, till at some height above the surface it be found in such a state as that water could exist only in the solid form, as ice.

Putting these considerations together, we conclude that the surface of the earth and the atmosphere over it, are always the most heated at the point where the sun is vertical, or directly over head; and that the heat decreases as we recede from this point. But, in the course of every 24 hours, the sun is in succession over all the points of the circumference of a circle, which is either the equator, or some circle parallel to it, and not further from it than 23½ degrees of latitude, either north or south. Therefore, in the course of every day, the different points of such a circle as this will be all equally heated, and heated more than any other portion.

Where the greatest heat is applied, the air will be rarified or expanded, and thus becoming lighter, it will ascend into the atmosphere, expanding (from the removal of pressure,) and therefore, cooling as it ascends, while colder air will rush in from the sides to supply the deficiency. This colder air will come along the surface from the north and the south; and the regularity of the supply will diminish as one recedes toward the poles, and also at a space near to the circle at which the sun is vertical. But the point of greatest heat appears to move westward; and this will turn the current which moves from the north to one from the north-east; and that from the south to one from the south east. The currents which are thus produced are called *trade* winds, and they are perceptible only in wide seas, at some distance from the equator, because it is there only that the surface of the globe is uniform, and therefore equally affected by the action of the sun. Those trade winds shift northward in summer, and southward in winter; and when one ascends into high latitudes, or comes near the land, they cease to be perceived, because in such situations they are overcome by local causes, which produce variable winds.

It may be mentioned generally, that the cause of wind is difference of temperature, arising either from the different action of the sun, or from local causes in the earth, or the atmosphere. In all cases, the wind blows from the cold surface and to the warm one; but in the upper regions of the air, the current is in the opposite direction. Hence the refreshing air which, in warm weather comes from lakes and streams; hence the breezes which in warm climates and upon warm days, come from the sea; and hence the wind that blows from the direction in which a shower of rain, of snow, or of hail, is falling, and which bears a portion of that shower upon its wings.

If one were carefully to examine the whole of the earth's surface, one would be able at least to guess at the leading phenomena of the winds; but the disturbing causes are so numerous, that the subject is one of great difficulty and uncertainty.

The land under all circumstances, is a better conductor of heat than the ocean; and it becomes a better conductor in proportion as it is more dry and free from vegetable covering. Thus in cold countries, where, in consequence of the small conducting power of the water, and the motion of the tides, the water of the ocean preserves nearly the same degree of temperature all the year round, the land shows the greatest daily and annual changes of temperature. When the land gets cooled, the air from it will move toward the sea; and when it becomes warm again, the air from the sea will move toward the land. Also, when the sun is upon any side of the equator, the tendency of the winds upon the surface will be from the other hemisphere; and if it so happens that in the same direction north and south, the one hemisphere is chiefly land, and the other water, there will be produced those periodical winds which occur in the Indian seas, and which are called monsoons.

All those invariable or periodical winds depend upon the joint effects of solar heat and of gravitation—causes which are uniform, and therefore mild in their operation; but when these are suspended, or where the one of them crosses, and thereby destroys the other—or rather, where there is a mutual destruction, the other causes are let loose; and as every species of natural action is found to be violent in proportion as the heat of the sun during the day is greater, and as also the daily variation of temperature greater, those portions of the tropical seas where the trade winds and monsoons are suspended, are much more liable to be visited by storms than any other portion of the sea. The parallel over which the sun is, for a distance of a degree or two north and south, has no trade wind, and therefore calms, squalls, and violent storms of thunder and lightning are found in that region. About the longitude of China, the trade winds of the Pacific are interrupted by the monsoons of the Indian seas; and in these longitudes the storms, especially at the time when the monsoons are shifting, are violent. Southern Africa, toward the Cape of Good Hope is, at most seasons of the year, a remarkably dry country, and consequently becomes strongly heated by the sun; and as there are no lands south of the cape to be heated at the same time, the winds from the south-east, south, and south-west, blow toward the Cape in gales of the greatest violence.

The distribution of moisture by means of the atmosphere, has been partially explained already. The air takes moisture by evaporation from the surface of every thing moist, and it does this the more rapidly, the greater the difference of temperature between the air and the moist body. The direct rays of the sun do not assist so much in the process of evaporation as the motion of the air does; and hence we have some of our days of greatest drought cloudy, with wind. The more dense the air is, the greater is its evaporating power, and hence in times of great drought the thermometer stands high. When the moisture which has been raised by evaporation, is not intimately mixed with the atmosphere, it is let fall in the form of dew; and as the difference between the temperature of the day and night is always greatest when the sky is clear, because then the process of dissolving moisture, a process which absorbs heat, is going on in the upper regions of it, more dew falls in clear nights than in those that are cloudy. The air over fens, lakes and rivers, and also the air over thickly-inhabited cities, is more charged with moisture than that over dry and open country places, and hence a great encrease of heat produces haze, in such places, while even a small increase of cold produces fog.

When the water which the air holds in solution begins, by any means, to be formed into drops, these are very apt to be attracted by rising grounds and mountains, and if the cloud be strongly electric, it is very apt, if in the near vicinity, to move toward the sea. For the first of these reasons, there always falls more rain upon hilly countries than upon plains.

The air contains the greatest quantity of moisture when it is warmest, and also when it passes over the moistest surface: hence the winds from the Atlantic are most accompanied by rain in England; hence, also, the quantity of rain which falls in summer, is often greater than that which falls in winter, although the more rapid evaporation, by the greater heat, prevents it from making such an appearance.

When rain falls in very cold air, it is converted into snow or hail, and the pieces are small and hard in proportion to the coldness of the climate. In warm countries where no snow falls, hail sometimes falls in great masses, and in very cold countries, there never is any hail or any of that flaky snow which we meet with in England, when the frost is not very intense.

Besides the water which is directly taken to the mountain-tops by the atmosphere, the very winter's cold of those places furnishes them with a store of moisture for the summer. The snow lies undissolved till the weather becomes warm; and, because snow is one of the worst conductors of heat, it preserves vegetation from the rigours of winter, while the heat that it absorbs when melting mitigates the change from winter to summer.

4. REPRESENTATION OF THE EARTH'S SURFACE.

When the whole surface of the earth is represented, the most accurate way is by the surface of a globe, which then becomes a miniature representation of the earth. Upon this globe the seas and lands are marked, and also the equator, poles, plane of the earth's orbit, circles of longitude, and parallels of latitude, the two tropics, and the two polar circles, which mark the zones described in a former section.

A plane surface is also sometimes used; and those plane surfaces are called *maps;* but there is no possibility of representing the globular surface of the earth upon a plane without distorting it. If one looks at a globe placed at some distance, the parts toward the middle of the visible side are not much altered; but those which are toward the edges are so distorted, that they are hardly visible. When the earth is represented in this way, it is called an *orthographic projection;* but it does not answer well for geographical purposes. That which answers best is one which is contracted toward the centre, or stretched toward the outsides, just like that which would be obtained by taking half the rind of an orange, and stretching it round the edges without breaking, till it lay perfectly flat. This is called the stereographic projection; and it does for whole hemispheres, or for smaller portions, the enlargement toward the sides being less as the portion is smaller. The north is put at the top of maps, and, consequently, the south is toward the bottom, the west on the left hand, and the east on the right. The latitudes are marked along the east and west sides, and the longitudes along the top and bottom—the former being counted from the equator, and the latter (in British maps) from the meridian of Greenwich. The seas, lands, rivers, lakes, &c. are easily understood by inspecting any map.

The stereographic is the best form of map for ordinary purposes, because, though it alters the size of countries with regard to each other, it does not distort their shape.

Another form, the conical, which has all the meridians straight lines meeting in a centre, and the parallels of latitude equi-distant circles drawn from that centre, answers very well for small portions.

One of the best means of acquiring the details of geography is to construct maps of the more interesting countries.

The Terrestrial Globe. The terrestrial globe does not differ in materials or manner of construction from the celestial, and consequently does not require to be described. By means of it, the latitude and longitude of any place, the hour of the day, and other matters may be readily and easily found.

In order to find the latitude of any place, you have only to bring the place under the graduated edge of the brazen meridian; the degree of the meridian which lies immediately over the place is the latitude required.

For finding the longitude of a place, you must bring the place to the edge of the meridian, and the degree at which the meridian cuts the equator will be the longitude of the place.

If the longitude and latitude of a place are given for the purpose of finding it on the globe, you must bring the longitude to the edge of the meridian, and immediately below the latitude on the meridian, is the place required.

In order to find what the hour is at any place, you have only to bring the place, with the hour at which you are already acquainted, to the meridian, setting the index of the hour-circle to the given hour, and then to turn the globe till the other place comes under the meridian—the index will then point to the hour required.

To rectify the globe for the latitude of any place, elevate the pole above the horizon acording to the latitude of the place.

In order to find the sun's place in the ecliptic for any given time, you must first find the day of the month on the horizon wooden, and opposite to it in the adjoining circle will be found the sign and degree in which the sun is on the given day—then look for the same sign and degree in the circle of the ecliptic drawn on the globe, and bring it to the meridian, and that is the sun's place at noon for the given day.

The hour at which the sun rises and sets at any day in the year will be found by rectifying the globe for the latitude of the given place, bringing the sun's place for the particular day to the meridian, setting the index to XII, and turning the sun's place to the eastern edge of the horizon, the index will point to the hour of rising; and by bringing it to the western edge of the horizon, the index will show the time of setting.

To find the sun's place in the ecliptic, and also on the globe at any given time, you must look into the calendar on the wooden horizon for the month and day of the month proposed, and immediately opposite stands the sign and degree in which the sun is on that day—then look in the ecliptic drawn upon the globe for the same sign and degree, and that will be the place of the sun.

In order to find where the sun is vertical at a given moment of time at another place, London for example, you must find the sun's place on the globe by the last problem, and turn the globe round till that place come to the meridian, and mark the degree of the meridian just over it. Then turn the globe till the given place, what ever it may be, come to the meridian, and set the index to the given moment of time. Having done this, turn the globe till the index points to twelve at noon, and the place of the earth which stands under the before marked degree, has the sun at that moment in the zenith.

In order to find how long the sun shines without setting in any given place in the frigid zones, subtract the degrees of latitude of the given place from 90, which gives the compliment of the latitude, and count the number of this compliment upon the meridian from the equator towards the pole, marking that point of the meridian; then turn the globe round, and carefully observe what two degrees of the ecliptic pass exactly under the point marked on the meridian. Having done this, look for the same degrees of the ecliptic on the wooden horizon, and between them stand the months and days of the months corresponding, between which two days the sun never sets in that latitude.

If, again, the beginning and end of the longest night, be required, or the period of time in which the sun never rises at that place, you must count the same compliment of latitude towards the south or farthest pole, and then the rest of the work will be the same as above.

To find on what two days of the year the sun is vertical at a particular place in the torrid zone—turn the globe round, till the given place come to the meridian, and note the degree of the meridian it comes under, then turn the globe round, and note the two points of the ecliptic passing under that degree of the meridian, and lastly find by the horizon on what days the sun is in these two points of the ecliptic—on these days he will be vertical to the given place.

To find the length of the day or night, or the sun's rising or setting in any latitude on a particular day of the month, rectify the globe for the latitude of the place, bring the sun's place on the globe to the meridian, and set the index to twelve at noon, or the upper twelve, and then the globe is in the proper position for noon-day. Next, turn the globe round towards the east, till the sun's place come to the wooden horizon, and the index will point to the hour of sunrise, turn the globe as far to the west side and the index will point to the hour of sunset. These being known, double the hour of setting will be the length of the day, and double the rising will be the length of the night. And thus, also, may the length of the longest day or the shortest day be found for any latitude.

In turning round the globe, it will be perceived that the angle which the plane of the earth's orbit (the ecliptic) makes with the horizon is continually changing. When the vernal equinox is brought to the eastern side, it, in high latitudes, nearly coincides with the horizon, consequently, when the full moon is in that part (which is about the end of September) it rises for several nights nearly at the same hour, only farther and farther north every night. When this takes place it is called the harvest moon; and it is most remarkable when the moon is at full upon the 22d of September.

As the pole is raised, it will be found that the angle formed by the parallels of latitude and the horizon diminishes, and that, too, as the parallel is nearer to the pole. Hence, the twilight (which continues till the sun be about 18° below the horizon) increases with increase of latitude and also toward mid-summer and mid-winter.

5. OF THE EARTH'S SURFACE.

That forms the practical detail of geography; and cannot be acquired by any general principle, but must be studied from good maps, and the writings of actual travellers.

The first thing to be done is to study the position of the seas and lands, with their forms and boundaries; and your knowledge of this will be sufficient, if you are able, without consulting a map, to make a tolerable sketch of the outlines.

When this is done, the next thing is to trace the whole ridges of mountains, by which the land is divided into plains; and to learn how these slope, to what seas they open, and what are the means of entering them,—at the same time you may find what are their leading characters.

When the great vallies are known, turn to the rivers by which they are watered, the mountains in which these have their sources, and the seas and lakes in which they have their termination. If a river falls into a lake which has no outlet, that lake will, in general, contain salt-water; for water, in flowing through the earth always carries along with it a quantity of salt; and as, where there is no outlet, the only means by which the water is disposed of is evaporation, in which the salt is never carried off, it must remain in the lake. The saltness of the sea is explained upon the same principle.

When you are acquainted with the rivers, notice the towns upon their banks, the people by whom those towns are inhabited, their customs and the employments in which they are engaged.

After this you may proceed to trace the boundaries of the states and kingdoms, comparing their extent and fertility, and the nature of the governments to which they are subject, and the institutions that exist among them.

When you thus know the whole appearance and condition of the world, as presently existing, turn back to history, and note the scenes of all the great events, and the places of all the great men that are recorded in it, and thus your geographical knowledge will be both extensive and valuable.

CHAPTER IX.

BOTANY.

THE study of Botany comes recommended by so many substantial advantages of utility and pleasure, and these advantages so evident to every one, that it is almost needless to say a single word by way of recommending the subject. It is one too which is so peculiarly adapted for ladies, and which may at the same time be so safely and so pleasantly pursued, that the great wonder is, why it has not been more generally pursued. The other departments of natural history are undoubtedly highly interesting, and may, to a certain extent, be cultivated with pleasure and advantage; but none of them furnishes so much elegance and delight as botany, nor can any of them be so completely and thoroughly studied without experiencing disagreeable sensations, being guilty of acts of cruelty, or subjecting the student to unhealthy or dangerous experiments. In botany there is no life to be destroyed which can give rise to pain; nor any experiment to be made which is accompanied with the least danger; on the contrary, all is elegance, delight, innocence, and safety. It is a study too, which makes us acquainted with some of the most beautiful objects of nature, and many of her most curious contrivances, which will furnish occupation and food for the mind, when other materials cannot be procured, or where their possession would be cumbrous and troublesome, and which will not diminish in the smallest degree, either the time which we are anxious to devote to other pursuits, or our capacity of following them with success. On the contrary, it tends highly to sharpen the mental faculties, to render our observation and discrimination more diligent and acute, to improve our taste, and to give us more just ideas of the beauty and ingenuity of nature's contrivances. To which may be added, the inestimable advantage of

> "Looking through nature up to nature's God;"

and of acquiring just ideas of the wisdom and beneficence of that Being, who brought us into existence, and every where surrounded our path with beauty, magnificence, and pleasure.

In the accompanying sketch of botany, the object has been to give only what was really useful and necessary for studying the elements and general principles of the science. To have given a complete list of the terms used in describing the different parts of the plants, or the characters of the different genera, would have occupied the whole volume. Those who are desirous of pursuing the study of the science farther than this sketch can enable them, may have recourse to "Martyn's Language of Botany" for the terms, and "Sir James Edward Smith's English Flora" for the description of British plants. A good introduction to the science is still wanting for those who understand only English.

The directions, given at the close of the sketch, for pursuing the study of botany, and for forming an herbarium, or collection of dried plants, are the result of some experience, and will it is hoped be useful to the student.

Botany is derived from the greek word *βοτανη*, signifying an herb, or grass; and may be said to consist of three divisions, or parts. The first, denominated the physiology of plants, includes a knowledge of the structure and functions of the various parts of which plants are composed, such as the root, stem, branches, &c.: the second consists of that systematic arrangement, whether natural or artificial, which is absolutely necessary for recording and communicating our ideas respecting them; while the third, or practical part, is devoted to their uses in medicine, arts, manufactures, food, &c. Without a proper knowledge of the first branch of the subject, it is impossible either to form the arrangement or classification which constitutes the second, or to profit in any considerable degree by the knowledge and discoveries of others; while the last cannot be pursued to any considerable extent, or with any great advantage, without a thorough acquaintance with the first and second. We shall therefore consider the subject under the two first divisions; the third, being too extensive and too intimately connected with the other sciences to find more than an occasional notice in this sketch.

I. Structure and functions of the various parts of which plants are composed.

We begin by the external part, called the *cuticle*, or *epidermis*, intended to protect the plant from the injuries of the air, and at the same time to allow that degree of absorption and perspiration which is necessary to its existence. This part of plants is more or less thick, and more or less soft or hard, according to the nature of the plant, and the climate to which it belongs. On the currant tree it is perfectly smooth; on the fruit of the peach it is covered with dense wool; while in the leaf of the betony it is extended into rigid hairs or bristles. Sometimes it is composed of so hard a substance that even flint has been detected in its composition; and the Dutch rush, *equisetum hymale,* serves as a file to polish wood, ivory, and even brass.

Immediately under the *cuticle* we find a soft substance, called the *cellular integument,* generally seen in the leaves and stems, and supposed to be the seat of colour. The changes which are produced upon the sap of plants by light and air, are said to be performed through the medium of this important part.

Cutting farther into the plant, we discover the *bark,* consisting in general of several layers, according to the age of the plant. The innermost part is called the *liber,* which, according as it becomes hard, is pushed outward, and becomes in general totally useless, except as a defence against excessive cold or heat. The bark contains a great number of woody fibres, and is more or less thin or thick according to the nature of the plant. Many of the peculiar qualities and virtues of plants are found in the bark, especially that part of it called the *liber.* Its medicinal virtues are, in many instances, well known to us: the Peruvian bark is celebrated for its tonic influence; cinnamon for yielding a rich cordial; oak for tanning; alder, logwood, &c. for dyeing and other purposes. It is a remarkable fact, that when a portion of bark is removed from a tree, the remainder has the power of extending itself laterally until the blank is filled up; and that, as every new layer is formed, a new layer of wood accompanies it. From a knowledge of this circumstance, many trees which had become entirely hollow, have, in the course of a short period, been rendered externally perfectly solid and healthy.

On removing the bark, we come to that part which forms the principal bulk of the tree or plant; the *wood,* which consists of various concentric layers, one of which, it has been supposed, is formed annually. The age of a tree, therefore, may be easily ascertained, wherever the layers are sufficiently thick in substance to allow of the number of rings, of which the woody part of the tree is composed, being counted. Some have gone so far as to affirm that the occurrence of a particularly severe winter could be ascertained from the greater hardness of the ring which had been formed; while, from their being narrower on the north side, than on the south, of the tree, a means has been afforded by cutting down a tree, of ascertaining the points of the compass, and thus finding one's way in an unknown forest. The outermost part of the *wood* has been termed *alburnum.*

The inner part of the plant is called the *medulla,* or *pith.* In general, it is tolerably firm and juicy, and of a pale green colour. In many annual plants the pith becomes, when they cease growing, little more than a thin lining to the hollow of the stem; while in others, whose stems are always hollow, the pith forms a thin, smooth, and delicate coating. The nature and functions of this part are not yet thoroughly understood; some considering it the seat of life and source of vegetation; some denying to it any peculiar office in the economy of vegetables, while others look upon it as analogous to the nervous system of animals. Various experiments have been made upon plants, with the view of discovering the use and functions of this important part; but though many facts have been established in regard to it, it does not appear that they are yet sufficiently numerous to enable us to form any correct theory.

Besides these parts, which are common to almost all vegetables, there exists in every plant a great number of vessels for the propulsion and transmission of the sap through its various parts. The assemblage of the vessels is called the *vascular system.* In this part of the plant reside all those various substances, such as sugar, oil, &c. which, in many cases, constitute its only real utility. The great season of the *flowing* of the sap is the spring; it also occurs sometimes in the autumn. The subject is still involved in great obscurity, and as it is not essential to a knowledge of the parts or uses of plants, we shall proceed to the description of the completely formed vegetable. And first of the

ROOT. Its use is twofold; to fix the plant in the earth and to draw nourishment from it. It is divided into two parts, the one called the *caudex,* or the body of the root; the other the *radicula,* or fibres proceeding from it. Roots are said to be annual, biennial, or perennial, according as they live one, two or more years. In some plants, such as the turnip, carrot, &c. the *caudex,* or body of the root, is partly above ground, and has more the appearance of a stem than of a root. The *radicula,* or fibrous part of the root, is annual. During the winter roots remain in a torpid and inactive state, and may therefore be removed with safety and planted in any other spot.

The various forms of roots have been distinguished as follows:

1. The fibrous root, which is the most simple of all, consisting entirely of fibres. The roots of grasses and of the greater part of annuals are of this description.

2. The creeping root, branching off horizontally from the lower part of the stem, and throwing out fibres in every direction. Mint and couch-grass may be mentioned as excellent examples of this species of root.

3. The fusiform or spindle-shaped root, as in the carrot, parsnep, and most biennial plants.

4. The bitten or abrupt root, is similar to the former;

but on the lower part has the appearance of being bitten or broken, as in the primrose. Many plants, from having this kind of root, have obtained the whimsical name of devil's bit.

5. The tuberous or knobbed root, as in the potatoe and Jerusalem artichoke.

6. The bulbous root, as in the onion, &c. This species of root is said to be tunicated when it is composed of concentric layers, as in the onion; scaly, as in the white lily, when it consists of fleshy scales; or solid, when it forms a complete mass, as in the crocus, &c.

7. The jointed or granulated root, as in the wood sorrel, white saxifrage, &c.

THE STEM or trunk has received seven different appellations; each of which is again distinctly specified according to its peculiarities in respect to growth, branching, smoothness, roundness, &c.

1. The *caulis* or stem arising from the root and supporting the leaves and branches. Under this denomination are classed almost all trees and shrubs. It may be either simple, that is, without any division, or branched. The branched stem is again subdivided into dichotomous, trichotomous, &c. according as it forms two or more distinct divisions bearing flowers.

Stems may also be leafy, naked, upright, procumbent, ascending, creeping, prostrate, twining or voluble, pliant, trailing, &c.

In respect to shape, they may be round, triangular, quadrangular, two-edged, three-edged, five-sided, winged, &c.

In regard to surface, they may be rough or smooth, even or uneven, shining, viscid, warty, pappillose or covered with soft tubercles, bristly, hairy, downy, shaggy, woolly, hoary, striated, spotted, furrowed, or glaucous, that is, covered with a sea-green mealiness.

Internally they may be either solid, or hollow.

Some plants appear to have scarcely any stem and are therefore called stemless. A stem is said to be clustered when its several branches happen to be united longitudinally. This, however, is to be looked upon as a kind of disease incident to plants. It may be occasionally seen in the ash, holly, broom, wall-flower, toad-flax, &c. A kind of pea, called the top-knot pea, is sometimes cultivated in Norfolk with red and white flowers and an eatable pod, in which this variety of stem is regularly propagated by seed.

2. THE CULM.—This species of stem is peculiar to grasses, rushes, &c. and bears both leaves and flowers. It may be either with or without joints, solid or hollow, hairy, downy, &c. or geniculated or bent like the knee.

3. THE STALK, bearing flowers and fruit but no leaves, may be either single or many-flowered, naked, scaly, leafy, spinal, &c.

4. PEDUNCLE, or flower stalk, springing from the stem, and bearing flowers and fruit, but no leaves, is denominated cauline that is, springing immediately from the stem; ramous, when growing out of a branch; axillary, when springing from between the leaf and the stem; oppositifolious, when opposite to a leaf; gemmaceous, when growing out of a leaf-bud; lateral, terminal, solitary, clustered or aggregate, scattered, uniflorous, biflorous, &c.

The pedicel is only a partial flower-stalk, arising from a division of the peduncle. When there is no flower-stalk the flowers are said to be sessile.

5. THE PETIOLE, or leaf-stalk, supporting leaves only

may be either simple or compound, and is generally channelled or hollowed. It sometimes terminates in what is called a tendril.

6. THE FROND, uniting the stem, leaf, and fructification, is almost peculiar to the tribe of ferns and lichens;

7. The stipe, or stem of the frond, to ferns, and to the stalk of a fungus, such as the common mushroom.

THE BUD, contains the vital principle or rudiments of the future plant, or part of a plant. On this account they are essential to the trees and shrubs of cold countries, and are formed in the course of the summer in the bosoms of their leaves. In the plane-tree they are concealed in the base of the foot-stalk; and, in most instances, are protected by scales, or guarded by gum or woolliness. Hence, until they begin to vegetate, they are scarcely ever known to suffer from the influence of cold; though, when once they begin to unfold themselves, they are extremely alive to its effects. Buds may be alternate, opposite, &c. When plants are propagated by means of buds, they retain exactly the same qualities which belonged to the individual from which they were taken. The buds of some plants produce leaves only; others both leaves and flowers. Their forms and contents are various.

THE LEAF is one of the most important parts of a plant, and belongs with a few exceptions to all vegetables. Its colour is almost universally green, and its substance pulpy and filled with innumerable fine vessels.

With regard to *position*, leaves may be either radical, or springing from the root; cauline, or growing from the stem; ramous, or growing from the branches; alternate, scattered, clustered, opposite, whorled, or growing in a circle round the stem; binous, ternate, &c.

according as one or more are together; tufted as in the larch and cedar; imbricated, or overlapping one another like tiles; perpendicular, horizontal, inclining downwards; reflected, or curved backward; inflected, or bent inward; oblique, or twisted; floating on the surface of the water; immersed, or wholly under the water; emersed, or raised above water.

In respect to *insertion,* or the mode in which they are connected with other parts of the plants, they may be petiolated, or growing on foot-stalks; peltate, or growing out of the foot-stalk like a shield; sessile, or without any foot-stalk; embracing the stem; vaginate, or forming a sheath to the stem; decurrent, or running down the stem; floriferous, or bearing flowers.

With regard to *form*, they may be either simple as in grasses, lilies, &c. or compound as in umbelliferous plants. Simple leaves may be entire or undivided, or divided into lobes. Their form is of great importance in distinguishing the species, and may be orbiculate, or circular; roundish; ovate, or egg-shaped; elliptic, or oval; oblong, spatulate, wedge-shaped, lanceolate, linear, needle-shaped, triangular, quadrangular, trowel-shaped, heart-shaped, kidney-shaped, arrow-shaped, halberd-shaped; runcinate, or lion-shaped; lyrate-lobed, palmate; pinnatified, or cut into parallel segments; bi-pinnatified, or doubly pinnatified; pectinate, or like the teeth of a comb, &c. &c.

In respect of *termination,* leaves may be either abrupt, or having the extremity cut off; emarginate, or nicked; obtuse, sharp, acuminate, or pointed like a needle; sharp-pointed, or tipped with a rigid spine; cirrose, or ending in a tendril.

In respect of *margin,* leaves may be entire; spinous, or thorny; dentate, or toothed; serrated, or having teeth like a saw; notched, or round toothed; jagged, or irregularly notched; wavy, revolute, involute, folded, &c.

In respect to *surface*, they may, like the stems, be rough, smooth, &c.; dotted, veined, concave, ribbed, curled, three ribbed, coloured, variegated, naked, &c.

Finally, in regard to *substance* and *configuration*, they may be cylindrical, semi-cylindrical, tubular, fleshy, channelled, sword-edged, three-edged, &c. tongue-shaped, membranous, leathery, evergreen, deciduous, &c.

All these terms may again be combined, diminished or increased, in their effect, according as the case may re-require. Thus ovate, *sub*-ovate or nearly egg-shaped; *sub*-petiolated, &c.

Leaves are said to be compound when two or more of them are connected by a common foot-stalk. They may be articulate or jointed; digitate, or finger-shaped; binate, ternate, quinate, pinnate, cirrous, auricled, conjugate or yoked; which terms may again be modified by subjoining to them the terms, opposite, alternately, decurrently, &c.

The leaves of plants are no less useful to their existence and health than they are highly ornamental to their external appearance. Various experiments have been made by the most celebrated botanists for the purpose of ascertaining their functions, which have terminated much more satisfactorily than in many other branches of the subject. It is now perfectly ascertained that the leaves of plants are not only a protection against excessive heat or cold, but that they imbibe and give out substances of various kinds; and that if this natural process were checked, the plant would die or become unhealthy. The perspiration of aquatic plants by means of the leaves is particularly copious; and their absorption equally great. They appear in fact to perform the same office to the plant which lungs do to animals; and imbibe and expire air in the same manner. Light produces very powerful effects upon them, (particularly on those of pinnated leguminous plants,) and if admitted through glasses of different prismatic colours, renders them paler in proportion as the glass approaches to violet. It acts beneficially on the upper, and hurtfully on the lower surface of leaves. The upper is in consequence always turned toward the light in whatever situation the plant may be placed. The same thing may be observed in regard to flowers, as in the sun-flower, daisy, &c. The duration of leaves is for the most part annual, but in some trees and shrubs they survive two or more seasons: such plants are denominated evergreens.

The leaf of the plant is so important an organ in many respects, and presents such a variety of interesting parts, that it deserves to be considered more at length. Light, as we have mentioned, acts as a wholesome stimulus to leaves when in their natural position, and it appears certain that they require occasional repose from its action on their upper surface—a fact which is proved by plants closing their leaves and folding them together, as if in a state of relaxation when the light is withdrawn, and spreading them forth again on its return. This is particularly the case with pinnate leaves, such as those of the pea kind. Those of the white acacia have been observed to be over excited by a very hot sun, and to fold their upper sides together, in a manner directly contrary to their nocturnal posture. Anatomical investigations of plants have demonstrated that the nutritious juices which they imbibe from the earth become sap, and are carried by appropriate vessels into the substance of the leaves, from which they are again returned, not into the wood, but into the bark. The sap is thus carried into the leaves for the purpose of being acted upon by air and light, which, with the aid of heat and moisture, work a very material change on its component parts and qualities;—differing of course according to the difference of the plants in which it is matured. Thus the resinous, oily, mucilaginous, saccharine, bitter, acid, and alkaline secretions of plants are elaborated. The flavour and qualities of leaves, which depend on the operation of the leaf itself, and not on the sap which is common to, and nearly similar in all plants, are also materially different. Their green colour is owing to the action of light, as is clearly proved by the pale and sickly hue of those which have been removed from its influence, and by their resuming their natural colour on being again exposed to it.

The irritability of leaves is a remarkable feature in the vegetable economy. The sensitive plant, when touched by any extraneous body, folds up its leaves one after another, while its footstalks droop, as if dying. The plant known by the name of Venus' fly-trap, has on each of its leaves a pair of toothed lobes, which, when touched at the base, fold themselves together, and imprison any insect which may have approached near enough to be caught by them. To account for this curious phenomenon, it has been supposed that the air evolved by the dead body of the insect is wholesome to the plant; leaves being known to purify air which is impregnated with carbonic acid gas, by the breathing of animals, or the burning of a candle. The *sarracenia* also bears tubular leaves, which retain water, and imprison insects; and analogy leads us to suppose, that the air inhaled by the putrefaction of their bodies is, in some way or other, serviceable to the constitution of the vegetable.

THE APPENDAGES or fulcra are those parts which are not essential, or universally found in all plants. Linnæus has distinguished them into seven kinds:

1. Stipula, or leafy appendage to the leaves properly so called, or to their foot-stalks, is generally situated at the base of the latter, and is differently shaped in different plants. The stipulas are generally found in pairs, and in most instances last as long as the leaves. Their presence or absence is an indication that the plants belong to the same natural order, and sometimes even to the same genus.

2. The bracte, or floral leaf, is an appendage to the flower or its stalk, and has a variety of forms. It is sometimes green, and sometimes coloured.

3. The thorn, proceeding immediately from the wood, is either terminal or lateral, and, in some cases, disappears on the plant being removed from its natural state, and subjected to culture.

4. The prickles, proceeding from the bark, and having no connexion with the wood.

5. The tendril, intended to support plants which have weak and climbing stems, upon others of greater strength. When young, they frequently come out in a perfectly straight direction, and afterwards become spiral. The vine, the whole of the pea-tree, &c. may be mentioned as examples of plants with spiral tendrils.

6. The gland is defined by Linnæus to be a small tumor discharging a fluid, and is to be found indiscriminately on the stalks and calyxes of different plants.

7. The hair is an excretory duct of a bristle-shaped form, such as that found in the nettle. It varies greatly in consequence of differences of soil and climate; but is of great use in enabling us to distinguish between different species.

The term INFLORESCENCE, or mode of flowering, is used by Linnæus to denominate the particular manner in which flowers are situated on a plant. Its different kinds are distinguished in the following manner, and by the following terms:

1. The verticil or whorl, is that mode of flowering which is seen in the dead nettle, &c. where the flowers surround the stem in a sort of ring.

2. The raceme or cluster, is a knot of flowers rather distant from one another, each on a distinct stalk, and all connected by one common stalk, as in a bunch of currants, &c. It may be simple or compound.

3. The spike consists of numerous flowers situated on one common stalk, without any partial stalks, as in the spiked speedwell, &c. The flowers are successive; those nearest the root coming out first, and falling off before those nearest the top are fairly blown. It may be simple, compound, whorled, or unilateral.

4. The corymb is a spike, of which the flower-stalks are longer or shorter according as they stand higher or lower on the common stalk;—the lower being longest, and rising nearly to a level with those situated near the top. Instances of it occur in the cabbage and wall-flower.

5. The frascide, is a term applied to flowers which are variously inserted and subdivided, and collected into a close bundle level at the top, as in the sweet william, &c.

6. The tuft consists of flowers which are sessile, and have a globular shape, as in the globe amaranthus.

7. The umbel consists of several flower-stalks, or rays which are nearly equal in length, spread from the same centre, and at the summit form a level, globular, or concave surface. It may be either simple, that is, each ray simple, and single flowered; or compound, that is, each ray or stalk bearing a small umbel. The first species is exemplified in the ivy; the second in the carrot, parsnep, &c.

8. The cyme resembles the umbel, but differs from it in

having the stalk variously and alternately subdivided. The inflorescence of the elder may be given as an example.

9. The panicle is applied to flowers which grow in loose bunches or clusters, without any regular order or subdivision, as in the common oat, &c. It may be diffuse, crowded, divaricated, &c.

10. The thyrse or bunch, is a species of panicle extremely close and dense, of an ovate figure, as in lilac, butterbur, &c.

Of the Fructification.

Having now examined the root, the stem, the bud, the leaf, the appendages, and mode of inflorescence of plants, and mentioned the terms by which they are described, we come next to the most important, and at the same time the most transitory, part of the plant—the flower and fruit. By means of these, the various plants which cover the surface of the earth are renewed from year to year, and may be so without limit or intermission. A plant may want any one of all those parts which we have described, and yet be able to perform its functions; but if it be destitute of those which we are now to describe, it is utterly impossible that its species can be propagated. In some plants, the parts of fructification may not be so apparent to the common observer as in others; but the botanist is fully aware, that they are, and must be present, in all under some form or other. An individual plant may be preserved for some time by other modes of propagation—but it is only for a time, and that time of no very long duration.

The parts of fructification enumerated by Linnæus, are seven in number; some of them essential to the very nature of a flower or fruit, others not indispensably necessary.

1. The calyx, or flower-cup, generally of a green colour, of the same texture as the leaf, and surrounding the flower. This part is frequently absent.

2. The corolla, or internal leaf of a flower, variously shaped and divided in different plants, and not indispensably necessary.

3. The stamen or stamens, ranged within the corolla, and of a thread-like form, terminating in a knob or cellular body. The stamen or stamens are the male part of the plant, and are indispensably necessary.

4. The pistil or pistils in the centre of the flower, containing the rudiments of the future plant, and having one or more organs attached to them. This is the female part of the plant, and is essential.

5. The pericarp, or seed-vessel, containing the seeds, and of various texture, being sometimes leathery, sometimes woody, and sometimes soft and pulpy. It is not essential.

6. The seed, to the production and perfection of which all the other parts contribute, and on which the propagation of the species must ultimately depend, is of course essentially necessary.

7. The receptacle or basis, with which all the parts of fructification are connected, is always present in some shape or other.

These seven parts have received different appellations, or been divided into different kinds, according to their figure, &c. in the same manner as those already mentioned.

I. The Calyx is denominated a

1. Perianthium, when it is contiguous to and makes a part of the flower. The green leaves encircling the rose may be given as an example of this species of calyx, or flower-cup. The tulip and many others have none,

and are said to be naked; in some it is found double, and even triple.

2. The involucre, at a distance from the plant, and scarcely distinguishable from a bracte. It may be seen in some species of anemone, and in umbelliferous plants.

3. The catkin consists of a common receptacle, of a cylindrical form, set with numerous scales, and accompanied by one or more stamens or pistils;—the whole forming one complete flower. The willow and fir tribe are good examples.

4. The sheath, more or less distant from the flower, and bursting in a longitudinal direction, as in the snowdrop, narcissus, &c.

5. The husk, of a chaffy nature, and peculiar to grassy and grass-like plants, to which an awn is generally, though not always, attached. Examples of this species of calyx are familiar to every one.

6. The scaly sheath, embracing the fertile flower, and base of the fruit stalk in some mosses.

7. The volve or wrapper of the fungus tribe, membranous in its texture and concealing the parts of fructification, bursting in due time, and forming a ring upon the stalk,—as in the common mushroom.

The general name of calyx is derived from a Greek verb, signifying to cover, from its serving to protect the flower from external injuries. It probably performs other functions to the plant, but these are not as yet ascertained with any degree of certainty.

II. Corolla, or leaves of the flower, is principally distinguishable from a calyx, where one of them is wanting, by its being of finer texture and coloured. In the rose it is red, in the violet purple, in the primrose yellow. It includes two parts, one of which is denominated the petal, the other the nectary. It serves principally as a protection to the more tender and essential parts, denominated the stamens and pistils; and as it presents itself in a very remarkable manner to the sun-beams, it may possibly be of great use to the plant in respect of light and air. The corolla is in general of very short duration, falling off, or at all events, fading in most cases before the fruit is perfected. The nectary contains and secretes a kind of honey, and is the great source of attraction to myriads of insects. It is found in almost all plants, in some form or other.

The corolla is either simple or compound. A simple corolla is said to be monopetalous, or of one petal, as in the primrose; a compound one polypetalous, or having several petals, as in the rose.

A monopetalous corolla consists of two parts: the tube or cylindrical part inclosed in the calyx, and the limb or spreading part. The same parts in polypetalous corollas, are denominated the claw and border. The primrose and rose furnish examples of both.

The corolla is different in point of figure, in different genera; and is said to be regular or irregular, according as its general form happens to be uniform or otherwise; and equal, or unequal, according as its divisions are the same, or different in point of size. The terms used for distinguishing the various forms of the monopetalous corolla, are much more applicable, and consequently much more easily comprehended than those of the other parts. They may be bell-shaped, funnel-shaped, salver-shaped, wheel-shaped, ringent, or gaping like the mouth of an animal, and personate or masked by a kind of palate.

Polypetalous corollas may be cruciform, or shaped like a cross; rosaceous, or spreading like a rose; papilionaceous, or spreading like a butterfly; and incomplete, that is, wanting some part which we should have expected to find.

The papilionaceous corolla consists of three separate parts, distinguished by the terms, standard, wings, and keel.

III. The Stamens consist of two parts, the one of of which supports the other; the first being denominated the filament, and the other the anther. The filament is generally slender and smooth, resembling a thread, and is occasionally bearded, branched, and forked. The anther is the essential part; has generally two cells, sometimes four, and contains the fecundating pollen or dust, which is thrown out in warm weather by the bursting of the cells. The pollen or dust, is composed of several small bags, which burst on the application of moisture, and discharge a subtle vapour; but they are too small to be seen without the aid of a microscope.

The stamens, in the case of double flowers, are changed into petals, and rendered useless.

IV. The Pistil or Pistils constitute the female part of the plant, and are equally essential with the stamens to the continuation of the species. They stand in the centre of the flower, surrounded by the stamens, except when the male and female parts happen to be situated in different parts.

The pistil consists of three distinct parts: the germen, or rudiment of the young fruit or seed; the style, answering to the filament in the stamens, varying in length and thickness, and sometimes altogether wanting; and the stigma, or head, answering to the anther in the male part. The germen and stigma are essential to the continuation of the species; the style is not indispensable.

The stigma is very various in point of shape, and is always moist with a species of viscid fluid, designed for the reception of the pollen,—which explodes on meeting with it.

In regard to the germen, the principal distinction to be kept in mind is, whether it be situated above the leaves of the calyx and corolla, in which case it is said to be superior; or whether its position is below them, when it is said to be inferior. The strawberry is an example of the former, the pear of the latter.

Pistils, like stamens, are sometimes changed into petals or leaves.

V. The Pericarp, or seed-vessel, is formed of the enlarged germen, and is not essential, as the seeds are frequently found in a naked state, destitute of any covering except the calyx. Its use, where it exists, is to preserve the seed till brought to maturity, and then, by its splitting, to scatter it in various directions.

The pericarp receives various denominations, according to its shape, &c.

1. It is called a capsule, when it is of a dry, woody, coriaceous or membranous texture, and splits into several valves; the parts separating the cells being termed dissepiments or partitions, and the central column to which the seeds are attached, the columella. Capsules have been also divided into various kinds, which it is not necessary to mention.

2. A silique or pod, when it is a long solitary seed-vessel, consisting of two valves, along the edges of which the seeds are alternately ranged, as in the class tetradynamia. The silique or pouch differs from the silique only in being of a shorter and more rounded figure.

3. A legume differs from the former in being formed of two oblong valves, without any longitudinal partition, and bearing the seeds along one of its margins. The tamarind furnishes an example of the legume.

4. A drupe or stone-fruit, when it has a fleshy coat, not separating into valves, and containing a single, hard, and bony nut, such as the plum, cherry, peach, &c. The nut sometimes contains several seeds.

5. An apple, when it contains a capsule, or capsules, with several seeds, as in the common apple.

6. A berry is sometimes scarcely distinguishable from the preceding, but differs from it in being without valves, and having the seeds enveloped in pulp, It may be simple or compound. The compound berry consists of several single ones united together, as in the raspberry, the orange, the lemon, &c.

7. A cone is a catkin, hardened and enlarged, as in the fir tribe. The scales in general form a shelter for the seeds.

VI. The SEEDS have been already defined as being that particular part of fructification of the plant to which all the others are subservient, and which is destined to continue the species. A seed consists of several different parts: the embryo, the cotyledons, the albumen, the yolk, &c. which we shall now mention in order.

1. The embryo, or germ, is that part of the seed which contains the living principle of the future plant. It is particularly conspicuous in the whole of the pea, bean, and lupine tribes. Internally it consists of a medullary substance, which when excited by being placed in the earth or in water, expands and developes parts and appearances which no one could have imagined to exist in it.

2. Attached to the embryo are the cotyledons or seed lobes, commonly two in number, but sometimes more, and generally producing leaves, for the purpose of sheltering the springing embryo.

3. The albumen, or white, is a farinacious substance,

destined for the nourishment of the embryo, and not springing into leaves like the cotyledons. Grasses, corn, &c. are examples in point. This or a similar substance must be present in all plants, though it is sometimes not very easily distinguished.

4. The yolk is not so generally to be found as the other parts of the seed. Like the albumen it never rises out of the ground, and is likewise destined for the nourishment of the embryo. Some have considered it as a kind of subterraneous cotyledon.

5. The skin, containing all the parts of the seed now mentioned, and differing in thickness, shape, and other quantities, according to the nature of the plant, and the office which it may have to perform. It is sometimes single, and sometimes double; the inner coat or skin being always of the softest and finest texture. It bursts on the swelling of the embryo.

6. The scar is the point by which the seed is attached to the seed-vessel, or receptacle, through which nourishment is transmitted to the embryo. It may be said to form the base or connecting point of the seed; all the other parts resting upon it, and being intimately united with it.

Besides these, there are various other parts, or appendages, occasionally belonging to seeds, which it is only necessary to enumerate: such as the pellicle or outside covering, closely adhering to seeds; the tunic, fixed to the base, and inclosing it more loosely than the pellicle; the seed-down in seeds having no pericarp; the tail, an elongated appendage; the beak, as in the tribe of geraniums; spines, hooks, crests, &c.

In all those appendages which are observed in the seeds of different plants, the wisdom and providence of the Almighty are particularly conspicuous. Those of them which are extremely light are furnished with a species of fine down, by means of which they are wafted and dispersed in different directions by the wind. Others are inclosed in pulpy substances, which serve for food to various animals, who deposit their seed in a condition peculiarly fit to call the vital power into action. Even the ocean itself frequently serves as the channel of communication and conveyance. In all cases, the seed presents that external appearance which is most fit for enabling it to answer the end of its existence—the continuation of the species.

VII. The receptacle has been already sufficiently defined. Its figure is various, being sometimes conical, sometimes flat, and sometimes concave. In some it is naked, in others scaly, downy, or hairy.

Before proceeding to speak more particularly of the functions of the essential parts of fructification, it may not be improper to state, that flowers are divided into various kinds: complete, when they consist of a calyx and corolla; incomplete, when the corolla is wanting; naked, when the calyx is absent; simple, when only one set of stamens or pistils is contained within them; compound, when there are several sets inclosed in different florets or small flowers,—as in the daisy, thistle, &c.; and aggregate, when they exist in a common undivided receptacle, with separate anthers united at the base, and the florets standing on stalks, and encircled by a single or double calyx. These again have been subdivided by Linnæus; but as the divisions are more perplexing than important, and may easily be learned by a little practice, it is thought better to omit them.

The peculiar functions discharged by the stamens and pistils have been already hinted at. Though long considered of great importance in perfecting the fruit, their real use was not ascertained till the time of Linnæus, who established it beyond the possibility of a doubt. In 1749, it was still further confirmed by an experiment upon a palm tree at Berlin; which, for want of pollen or dust, had never brought any fruit to perfection. A branch of flowers, of the male kind, having been brought from Leipsic and shaken over its pistils, fruit was produced and young plants raised from the seeds.

The contrivances of nature to bring the anthers and stigmas together are curious and remarkable. In some plants the style is bent so as to allow the fecundating dust to fall with more certainty on the pistil; in others a part of the stamens lean over the stigma, and after having shed their pollen, withdraw and make way for others. Some are furnished with elastic stamens, which, when touched by any insect or extraneous body, contract and strike their anthers against the stigma; some are furnished with a curved germen, which releases itself by a spring from the heel of the flower, and thus accomplishes the same end. The contrivances of nature in this respect are endless.

Again, to protect themselves from injuries, many flowers fold their petals together on the approach of rain or heavy dew; many droop and close their petals at night; and all of them expand and turn towards the sun. The nymphæa lotus rises out of the water and expands its flowers at sunrise; at night it closes them and sinks so far under the water as to be out of the reach of the hand.

Many other examples might be given equally curious and interesting, in regard to the fecundation, sensibility, diseases, and sleep of plants; but these in a short sketch, like the present, would occupy too much space.

II. SYSTEMATICAL ARRANGEMENT OF PLANTS.

Whoever reflects for a moment on the immense variety of plants which adorn the face of the earth—whether as trees, shrubs, or herbs, must feel that some arrangement or method of classing them is absolutely necessary, both for the purpose of recording our own observations with brevity and simplicity, and for enabling others to profit by them. Various schemes have been adopted for this purpose, some of them natural, others artificial. Of the former kind is the arrangement of plants according to their qualities, as graminous, bulbous, medicinal, eatable, &c. or according to the structure of their flower, as rosaceous, papilionaceous, campanulate, &c. All of these natural methods have their uses and advantages; and some of them, particularly that of Jussieu, of which we shall give an outline, may be consulted with advantage, as exhibiting the relationship and affinity af plants; but all of them have failed in enabling the student of botany to ascertain, with any degree of ease and facility, the particular plant which he has thought proper to examine. The artificial method of Linnæus, founded on the parts of fructification, is the only one which combines facility of reference with some degree of natural arrangement, or collocation. It divides all plants into classes, orders, genera, species, and varieties. The classes and orders comprehend a certain number of plants, agreeing in the number of stamens, and pistils, or some other circumstance equally intelligible,—the genera, those which, besides that agreement, have also in common some other part of the fructification,—the species being merely the individual plants constituting the genus,—and the varieties, merely indicating some trifling and occasional discrepancy in the species.

According to these principles, the whole vegetable kingdom has been divided by Linnæus into twenty-four classes; each class comprehending so many orders; each order so many genera; each genus so many species; and many of those species being occasionally marked by a considerable number of varieties.

Class I. Monandria, or one stamen, has only two orders; Monogynia, having one style, and Digynia, having two styles. Both of these orders comprise many beautiful and useful plants, as the cardamoms, ginger, turmeric, &c.; but few of them are found in Britain.

Class II. Diandria, or two stamens, has three orders; Monogynia, Digynia, Trigynia. The first is numerous, and, among other plants remarkable for their beauty, comprehends the jasmine, the lilac, &c.; the other two are less so.

Class III. Triandria, or three stamens, has also three orders, Monogynia, &c. This class comprehends in its second order the greater number of those useful plants known by the familiar name of grasses. Only one poisonous plant is found among them, and all of them, owing to their being strictly adapted to their particular climates, are very difficult of transplantation.

Class IV. Tetrandria, or four stamens, includes also three orders, Monogynia, Digynia, and Tetragynia, or four styles. The first order is extremely numerous, and contains some splendid and beautiful plants; the other two are less so.

Class V. Pentandria, or five stamens, has six orders. Order 1. Monogynia is one of the most extensive and important in the whole system. It comprises those rough-leaved plants, which have a monopetalous and inferior corolla, with four naked seeds, which are wheel or bell-shaped in the corolla; and also those so dangerous from their powerful narcotic qualities,—as the tobacco, solanum tribe, &c.

Order 2. Digynia contains a number of plants, some of which are included in the former, having oblique or twisted corollas, known by name of *contortæ;* also, the numerous family of the *umbelliferæ,* or plants having their flowers in umbels. Those of them which grow on dry ground are highly aromatic; those which appear in water are deadly poisons. They are extremely difficult of examination, owing to the smallness of their parts.

Orders 3 and 4, though they contain many beautiful, and some useful plants, present nothing remarkable.

Orders 5 and 6, Pentagynia and Polygynia, contain numerous succulent, alpine, and rosaceous plants.

Class VI. Hexandria, or six stamens, contains six orders. The first, Monogynia, is most numerous, and is distinguished by comprehending the beautiful tribe of lilies, hence called Liliaceous; a tribe considered by Linnæus as the noblest of the vegetable kingdom—an idea supposed to allude not merely to their beauty and splendour, but also to the text, "Consider the lilies of the field how they grow; they toil not, neither do they spin." Digynia has but few genera: Trigynia, Tetragynia, Rexagynia, and Polygynia present, nothing remarkable.

Class VII. Heptandria, or seven stamens, has four orders, Monogynia, Digynia, Tetragynia, and Heptagynia, neither of which are numerous.

Class. VIII. Octandria, or eight stamens, has also four orders.

Order 1. Monogynia contains the beautiful plant, Tropæolum, used in decorating bowers; the tribe of heaths, the maple, and many other beautiful genera.

Orders 2, 3, 4. Digynia, Trigynia, and Tetragynia, are not very numerous.

Class IX. Enneandria, or 9 stamens, has three orders.

The first, Monogynia, contains several noble and highly useful plants, such as, the cinnamon, the sassafras, the camphor, &c.

To the second, trigynia, belongs the rheum or rhubarb; it is not numerous; neither is the third, hexagynia.

Class X. Decandria, or 10 stamens, has five orders.

The first, monogynia, contains a great number of papilionaceous and leguminous plants, Venus' fly-trap and other beautiful and curious plants.

Order 2. Digynia is remarkable for containing a great number of the most beautiful plants in the whole vegetable kingdom, such as, the saxifrage, the pink, and the caryophyllous tribe.

Order 3. Trigynia has also several beautiful plants; some of them belonging to the caryophyllous, others to the maple family, &c.

Orders 4 and 5. Pentagynia and Decagynia are not particularly numerous and contain no plants of the same splendour or beauty as the foregoing orders.

Class XI. Dodecandria, containing from 12 to 19 stamens has six orders; monogynia, digynia, trigynia, tetragynia, pentagynia, dodecagynia, which contain nothing remarkable, except the heliocarpus a very rare American tree having a beautifully radiated fruit.

The classes hitherto mentioned have been entirely founded upon the number of the stamens; in those which follow, it will be observed, that their insertion, proportion, and connection are to be considered. Of the preceding classes, the characteristic marks of the fourth, fifth, and sixth, are those most liable to be mistaken for those of succeeding ones.

Class 12. Icosandria having 20 or more stamens inserted in the calyx. This mode of insertion always indi cates eatable and wholesome fruit. The class comprehends three orders.

The first, Monogynia, contains a great number of fine trees having generally stone fruits; such as, the peach, the plum, the cherry, &c.: also, the myrtle tribe, which is extremely numerous, especially in New Holland.

The second, Pentagynia, includes the apple and pear tribes.

The third, Polygynia, is almost entirely composed of a natural family of rosaceous plants; all extremely elegant in their appearance and structure, and agreeing in various qualities. Nearly all of them are eatable, perfectly innoxious, and astringent in their roots, bark, and foliage. Sir James Edward Smith remarks, that a student of Botany cannot do better than study this order, and the genera which it contains, as an introduction to the knowledge of those which are more obscure and less familiar to the eye.

Class XIII. Polyandria, having numerous stamens inserted in the receptacle, contains 7 orders. It is very distinct in point of qualities and character from the preceding class; and the plants which it contains are mostly poisonous.

Order 1. Monogynia contains a great number of plants, but many of them of dangerous or suspicious qualities; such as, the poppy, &c.; some of them are particularly splendid, such as the genera Cistus and Nymphæa.

Orders 2, 3, 4, 5, 6. Digynia, trigynia, tetragynia, pentagynia, hexagynia, contain nothing remarkable beyond the uncertain number of their pistils. It has been remarked by a celebrated botanist, that they ought to be comprehended in one order; the present division only serving to keep natural genera asunder.

Order 7. Polygynia is almost a natural one; and besides the ranunculi, clematis, &c. boasts of the tulip tree and the splendid magnolia.

Class XIV. Didynamia, having 2 long and 2 short stamens, has two orders extremely natural; and containing those plants which have labiate, ringent, or personate flowers.

The first, Gymnospermia, having the seeds naked in the bottom of the calyx, contains the mints, the lavender, and various other genera, all distinctly marked, and having their flowers diversified with the most beautiful colours.

The second, Angiospermia, having the seeds in a seed-vessel, contains a number of plants very closely allied with those which occur in pentandria monogynia. The plant named after Linnæus, also vervain are included in it.

Class XV. Tetradynamia, or 4 long stamens and 2 short, has two orders perfectly natural.

The first, the siliquilose, having cruciform flowers and a roundish pod or pouch, contains several curious plants, generally supposed to be anti-scorbutic, and emitting a very fetid smell.

The second, the siliquose having its fruit in a long pod, contains some useful plants.

Class XVI. Monadelphia, or the stamens united by figaments *into one tube*, contains eight orders, whose distinction is founded in the number of their stamen. This is the first class in which the connection of the filaments is taken into consideration.

Order 1. Triandria, is not so numerous.

Order 2. Pentandria contains several plants more or less connected with the geranium tribe.

Order 3. Heptandria is distinguished by comprising most of the Cape geraniums.

Order 4. Octandria contains no plant of importance.

Order 5. Decandria comprises the geranium tribe properly so called, and several papilionaceous plants.

Order 6. Endecandria is distinguished by the South American genus Brownea, whose stamens differ in number in different individuals.

Orders 7, 8. Contain some of the most splendid plants principally of the Malvaceous or Mallow family, any where to be found; to which may be added the tea-tree, and the carolinea, which bears what are termed Brazil nuts.

Class XVII. Diadelphia, or the stamens united by their filaments *into two parcels* which are occasionally though not always connected at their base, contains four orders, distinguished by the number of their stamens.

These orders are pentandria, hexandria, octandria, decandria, all of them containing papilionaceous plants; and the last the family of the pea, vetch, broom, &c. called the leguminous or papilionaceous, and so closely allied that it is extremely difficult to distinguish the genera of which it is composed from one another. The one, accordingly, distinguished by such marks as these—having the stigma downy, the stamens all united, &c. They are all perfectly innoxious, and many of them highly useful.

Class XVIII. Polydelphia, or the stamens divided by their filaments into *more than two parcels*, contains three orders distinguished by the number or insertion of their stamens.

Different attempts have been made to define more perspicuously the orders of this 18th class, but as yet without the requisite success. Sir J. E. Smith arranges them in the following manner.

Order 1. Dodecandria, having the stamens, or rather anthers, from 12 to 20 or 25. and their *filaments uncon-*

nected with the calyx. The orange and lemon properly belong to this order.

Order 2. Icosandria, having numerous stamens and their filaments *inserted* (in several parcels) *into the calyx.*

Order 3. Polyandria, having very numerous stamens *unconnected with the calyx.*

Class XIX. Syngenesia, having the anthers united into a tube, and the flowers compound, contains five orders, all of them so closely and naturally united, as by a glance to be easily known as belonging to this class. The minuteness of the parts of fructification in some of them renders it sometimes difficult for a beginner to distinguish the different genera.

Order 1. Polygamia æqualis, or each floret perfect in itself, having stamens and pistils and bearing seed.

Order 2. Polygamia superflua, or the flowrets of the disk perfect, and those of the margin having pistils only, but all bearing perfect seed.

Order 3. Polygamia frustanea, or the flowrets of the disk perfect and united, those of the margin destitute of pistils and stamens.

Order 4. Polygamia successaria, or the flowrets of the disk furnished with stamens only; those of the margin with pistils, rendering the one indispensably necessary to the other.

Order 5. Polygamia synegata, or several flowers simple or compound, with united tubular anthers, and having a partial calyx,—the whole included in one general calyx.

Class XX. Gynandria, or the stamens inserted either upon the style or germen, though originally containing nine orders, has now been reduced to seven. Great care must be taken, in examining plants belonging to this class, to observe that the stamens actually grow out of the germen or style, and not out of any part that supports it.

The orders now retained are,

1. Monandria, with only one stamen or sessile anther, and comprising the beautiful orchis tribe, distinguished by the glutinous nature of their pollen.

Diandria, triandria, petrandria, pentandria, hexandria, and octandria, present nothing remarkable.

Class XXI. Monœcia, or the stamens and pistils in separate flowers *on the same plant,* contains nine or ten orders, monandria, diandria, triandia, tetrandria, pentandria, hexandria, polyandria, monadelphia, polydelphia, and gynandria,—all of which terms have been already ex-explained.

Class XXII. Diœcia, or the stamens or pistils in separate flowers and on separate plants, contains eight orders: monandria, diandria, priandria, petrandria, pentandria, hexandria, polyandria, and monadelphia.

Class XXIII. Polygamia, or the stamens and pistils separate in some flowers and united in others, either on the same plants, or on two or three distinct ones, contains three orders: monœcia, diœcia, and triœcia. Several eminent botanists have been of opinion that this class might safely be abolished.

Class XXIV. Cryptogamia, or having the stamens and pistils not well ascertained, or so concealed as not to be numbered with any certainty, contains five natural orders; the ferns of which the parts of fructification grow on the back summit or base of the frand, the mosses, the liverworts, the flags, and the mushrooms. The ferns form a beautiful natural order, and the mosses, though diminutive in size, are highly elegant, extremely tenacious of life—growing in the hottest as well as the coldest climates, and flourishing most in the damp wintry months. Under the flags is included the vast family of lichens,—the hardiest of all vegetables, and which is found in the coldest and most inhospitable climates, upon the naked rock, the barren heath, or the desolate trunk of a tree. A particular species of them furnishes food for the rein-deer in winter; while others have been found highly serviceable in medicine and dyeing. The mushrooms are fleshy in substance, of quick growth, and short duration. Some of them are eatable, and some poisonous. Though this class contains many beautiful and highly interesting plants, it is extremely difficult of examination, and ought not to be attempted until the other classes have been fairly mastered.

To these classes have been added as a sort of appendix, the Palm tribe which have, in general, six stamens, with three, or six, petals, and one, or three, styles. Their fruit is what we have designated as a drupe or stone-fruit. They are nearly allied to the libaceous tribe, and are the noblest plants in the whole vegetable kingdom. They ought to be included in the ninth class.

Palms have been denominated by Linnæus the princes of the vegetable kingdom. They grow to an amazing height, bear a great abundance of fruit, and have their stems crowded with evergreen leaves. Some of them are highly valuable as articles of food, such as the date, the cocoa nut, &c.; while others supply whole nations with oil from their fruits, wine from the juices of their stem, or cordage from their fibres.

Having now given such an outline of the Linnæan system as may enable the student of botany to acquire a thorough knowledge of its distinguishing characters, and also, we trust, of many of the most important points in the science, we proceed to sketch as briefly as possible the natural system published by Jussieu, an eminent French botanist, and generally adopted by his countrymen.

The grand divisions of this system are founded upon the structure of the seed. Thence arises the distinction of plants into *acotyledones*, destitute of a cotyledon, monocotyledones, having one cotyledon, and dicotyledones, having two cotyledons. It ought to be observed, that many of the plants of which the division monocotyledones is composed, are now known to have no cotyledon at all, and that what has been denominated a *cotyledon* in others, is more properly *an albumen*, while that of the dicotyledones includes several genera that have numerous cotyledons, as the Pine, and its relative tribes.

The whole system is again subdivided into fifteen classes, comprising in all an hundred orders. The classes are distinguished, not by distinct names, but by numbers, which are accompanied by a short definition of their essential character; while the orders, except those of the first class, are named for the most part after some considerable genus belonging to them.

Class I. Acotyledones. The orders of this class are in a great measure the same as those of the twenty-fourth class of the Linnæan system. 1. Fungi, or mushrooms. 2. Algæ, or flags. 3, Hepaticæ, or liverworts. 4. Musci, or mosses. 5. Filices, or ferns, to which has been added a sixth, called Naiades, or Water plants.

Class. II. Monocotyledones, having the stamens inserted beneath the germen, or, as Linnæus expresses it, having the germen *superior*. Its orders are four: 7. Aroideæ: 8. Typhæ: 9. Cyperoideæ: and 10. Gramineæ, or grasses.

Class III. Monocotyledones, having the stamens inserted round the pistil, that is, on the calyx or corolla.

The orders are eight; 11. Palmæ, already described: 12. Asparagi: 13. Junci: 14. Lilia: 15. Bromeliæ, as the pine-apple and agave: 16. Asphodeli, as the aloe, hyacinth: 17. Narcissi: 18. Irides, as the iris, crocus, &c.

Class IV. Monocotyledones, having the stamens inserted on the germens or style, that is, having the germen *inferior.*

The orders are four: 19. Musæ, as the plantain-tree: 20. Cannæ: 21. Orchideæ: 22. Hydrocharides.

Class V. Dicotyledones, without petals, and having the stamens the same as in the last class.

It contains only one order: 23. Aristolochiæ.

Class VI. Dicotyledones without petals, and having the stamens inserted into the calyx.

It contains six orders: 24. Elœaginæ: 25. Thymeleæ: 26. Proteæ: 27. Lauri: 28. Polygoneæ: 29. Atriplices.

Class VII. Dicotyledones, without petals, and having the stamens inferior to the germen.

The orders are four: 30. Amaranthi: 31. Plantagines: 32. Nyctagines: 33. Plumbagines.

Class VIII. Dicotyledones, having one petal, which is inserted under the germen.

The orders are fifteen: 34. Lysimachiæ: 35. Pediculares: 36. Acanthi: 37. Jasmineæ: 38. Vitices, or vines: 39. Labiatæ: 40. Scrophulariæ: 41. Solaneæ, or potatoe tribe: 42. Boragineæ: 43. Convolvul: 44. Palemonia: 45. Bignoniæ: 46. Gentianæ, a tribe of bitter plants: 47. Apocinæ: 48. Sapotæ.

Class IX. Dicotyledones, having one petal inserted into the calyx.

It contains four orders: 49. Guiacanæ: 50. Rhodo dendra: 51. Ericæ, or heaths: 52. Campanulaceæ, or corollas bell-shaped.

Class X. Dicotyledones, having one petal crowning the germen, the anthers united into a tube, and the flowers compound.

The orders are three, and include the plants arranged under the Linnæan class Syngenesia: 53. Cichoraceæ: 54. Cinarocephalæ: 55. Corymbiferæ.

Class XI. Dicotyledones, of one petal, crowning the germen, and having the anthers distinct.

It contains three orders: 56. Dipsaceæ: 57. Rubiaceæ: 58. Caprifolia.

Class XII. Dicotyledones, with several petals, and having the stamens inserted upon the germen.

It contains two orders: 59. Araliæ: 60. Umbelliferæ, an extensive natural order, and very difficult of examination.

Class XIII. Dicotyledones, having several petals or stamens inserted under the germen.

It contains twenty-two orders: 61. Ranunculaceæ: 62. Papaveraceæ: 63. Cruciferæ: 64. Capparides: 65. Sapindi: 66. Acera: 67. Malpighiæ: 68. Hyperica: 69. Guttiferæ: 70. Aurantia: 71. Meliæ: 72. Vites: 73. Gerania: 74. Malvaceæ: 75. Magnoliæ: 76. Anonæ: 77. Menisperma: 78. Barberides: 79. Filiaceæ: 80. Cisti: 81. Rutaceæ: 82. Caryophyleæ.

Class XIV. Dicotyledones, having several petals, and the stamens inserted into the calyx or corolla.

It contains thirteen orders: 83. Sempervivæ, a succulent tribe: 84. Saxifragæ: 85. Cacti: 86. Portulaceæ: 87. Ficoideæ: 88. Onagræ: 89. Myrti: 90. Melastomæ: 91. Salicariæ: 92. Rosaceæ, nearly the same as the Linnæan class, Icosandria: 93. Leguminosæ, a very extensive natural order, and much more advantageously arranged under this system than under that of Linnæus: 94. Terebintaceæ: 95. Rhamni.

Class. XV. Dicotyledones, having stamens in separate flowers from the pistils, contains five orders: 96. Euphorbiæ, mostly acrid and milky plants: 97. Cucurbitaceæ, a tribe of gourds: 98. Urticæ: 99. Amentaceæ, containing the elm, the poplar, the oak, &c.: 100. Coniferæ, a beautiful order, including the cypress, casuarina, &c.

Such is an outline of the system of Jussieu, to which he has annexed a considerable number of genera, under the denomination of *Plantæ incertæ sedis,* or plants not referable to any of the foregoing orders. This is undoubtedly an additional defect in the system; and a defect which must adhere to every natural system, while any plants remain to be discovered, or those which have been already discovered are imperfectly known. The system is, however, extremely useful in many respects, and consequently deserves the attention of those who are desirous of being thoroughly acquainted with the vegetable kingdom.

The great attention which was paid, during the last century, to the arrangement and classification of plants, has had the effect of throwing considerably into the shade the really useful and practical part of the science—the qualities and virtues of the various plants which have been described. The necessities and wants of man, along with those accidents to which discoveries in science are much more frequently owing than to his genius and talents, have undoubtedly made us acquainted with many of those valuable qualities which belong to plants; but much, undoubtedly, still remains to be known, and the botanist ought ever to bear in mind, that, however well versed he may be in systems of Botany, and however skilful in the examination and description of plants, these acquirements are merely means for the promotion of a certain great and valuable end—the knowledge of their uses and qualities—and acquirements which, if not employed for the promotion of that end, are of no more real utility, than a knowledge of the rules and characters of the Chinese language to one who never intends to convert that knowledge to speaking or writing it.

By way of assisting the student to some portion of this knowledge, we shall mention a few of the characteristic qualities of certain classes and orders of plants.

The plants in the order Diandria, of the Linnæan class Didynamia Gymnospermia, are innocent and wholesome; those of Angiospermia are fetid, narcotic, and highly dangerous; a large part of those in Pentandria Monogynia, are poisonous. The class Tetradynamia is wholesome. Plants having the stamens growing out of the calyx, as in Icosandria, are wholesome and nutritious. The papilionaceous corolla is likewise indicative of innocent or nutritious plants when roasted or boiled, with the exception of the seeds of the *laburnum,* which, when unripe, are violently emetic, and, when eaten, have produced very dangerous consequences. Plants having their nectary distinct from the petals, are always to be suspected. So also are milky plants, whose flowers are not compound, and even some of those which have that characteristic are highly dangerous.

Umbelliferous plants, which grow on low, marshy, or watery places, are among the most virulent poisons; those, on the contrary, which are found in dry or elevated soils, are wholesome, and highly aromatic. The mallow tribe are all emollient, and abound with mucillage, which is frequently of great use in medicine, for removing internal irritation. The Liliaceous tribe is also dangerous, especially its roots, from which savages are said to obtain a poison for their darts. The Gramineous tribe is almost entirely wholesome. The *œnanthe crocata* poisons by its scent, if confined; and the *cicuta virosa,* if eaten under water by cattle, destroys them in a very short time. The berries of the deadly nightshade, are known to every one as a powerful poison.

All these observations must be understood with reference to our own species, and to those animals which most nearly resemble us in organization and structure; for it is not only highly probable that many of those plants which are noxious to man, are wholesome to animals differently constituted, but it is even beyond doubt, that they are so in several instances. Plants may also be freed from their poisonous or noxious qualities by the art of cookery, &c. Our knowledge, however, of the qualities of plants, and of the changes which may be produced upon them by art, is yet in its infancy; and those who despair of improving the systematic arrangement of the vegetable tribes, have here left for their research a wide and almost unexplored field.

As we have now sketched the various parts of which plants are composed, as well as the classes and orders both natural and artificial, into which they have been divided, and mentioned generally the principles of that division, and a few of the characteristic qualities of some of the different classes and orders, it may be useful, before proceeding to give any directions for collecting or preserving plants, to point out the proper method of studying this beautiful and highly interesting science.

Nothing is more common in this, as in other matters, than to see students of botany endeavouring to load their memories with the various terms used in botanical studies, and at the same time to neglect their application to the plants themselves; the necessary consequence of which is, that they never have any distinct idea either of those marks which distinguish different genera and species, or of those more prominent ones by which these are arranged into classes and orders. All this may be avoided, not only without any trouble, but with much pleasure and satisfaction to the student. As a first and indispensable step in the study, the pupil should be made so thoroughly acquainted, by inspection of the plants themselves, with all those parts which serve to distinguish them into classes, as that she can pronounce with certainty, on the slightest examination, to which of these the plant in question properly belongs. When this point has been mastered, let her next proceed to the study of the different orders; each lesson being exemplified by a selection of plants growing wild; that is in their natural, not in their cultivated state, which is sometimes very different from the other. The less glaring characteristics of the genera of the different classes and orders ought then to be pointed out in the same way, and several plants under each, whose distinctive marks are plain and easy, given for the examination and solution of the pupil. This part of the study ought to be persevered in until she is thoroughly acquainted with the principal genera in each class and order, and can tell the family to which they naturally belong, on the slightest inspection. As a knowledge of the species or individuals is the ultimate point to which all the preceding part of the examination tends, and depends on characteristics of a less obvious nature, it ought to be the last to which the attention of the pupil should be directed; and may either be preceded by, or carried on in conjunction with, an exemplification of the various kinds of stems, leaves, &c. on which it depends.

In this manner the technical and artificial part of the science may be mastered in the course of a few weeks, and the pupil so fully and thoroughly instructed in its elements, as to be able to prosecute it, not only without any assistance, but with safety, profit, and pleasure. It must be borne in mind however, that this object cannot be accomplished if any one of these intermediate steps are glossed over for the sake of arriving at another; and that the consequence of pursuing such a plan would inevitably be the attainment of a mere knowledge of the names of a few individual plants, and a total ignorance of the principles on which all the others are arranged under their different classes, orders, and genera.

The Linnæan system of classification is undoubtedly the best for reference, and is of the same use and advantage to the botanist, as a dictionary is to one who is learning the language of which it contains the various words. It ought, however, always to be looked upon as a mere dictionary, which, while it necessarily brings together, like a dictionary of words, many plants which are closely allied, also necessarily separates others which are no less intimately connected. The unavoidable consequence, therefore, of studying plants, merely with reference to this system, is that the student of botany never has any distinct idea of the vegetable kingdom, or its division into families—a divison which exists as certainly and as distinctly among the various plants which adorn our globe, and are the sources of so much pleasure, utility, and satisfaction to the various tribes of animals which inhabit it, as among the different nations by which it is peopled. To remedy this defect in the Linnæan system, the method of classification adopted by Jussieu, and already detailed ought to be in part studied, that is to say, studied with the view, not of using it for the purpose of finding out the names which have been given to different plants, but of being able to form an idea of the characteristic marks of the various grand assemblages or families into which the vegetable kingdom is divided. No work can be perused on this subject with greater advantage than "Rousseau's Letters on Botany," translated by Martyn.

The formation of an herbarium, or collection of dried plants, is of the greatest use in imprinting on the mind of the student the names and characteristics of the various plants which she may have examined, and is attended with so little care and trouble compared with the pleasure which is derived from its possession, that it ought never to be neglected. The process is exceedingly simple. A few sheets of brown paper, either loose or slightly sowed together, are all that is necessary for accomplishing the purpose of drying the plants intended for preservation, provided the room in which they are placed be free from damp or moisture. If allowed to remain for a sufficient length of time in these, there will, with the exception of a few very succulent and juicy plants, be no necessity for changing them more than once. A very slight degree of pressure ought to be applied to the papers in which they are contained, and those parts carefully exposed, which it is wished to render most visible. When thoroughly dry, they may be transferred to the herbarium, (which ought to be divided into as many parts or small volumes as there are classes,) and fixed in it, either by means of a little carpenter's glue, or by cutting two slits in the lower part of the leaf, for the purpose of passing a part of the stem or root through it. The name of the plant, or the order to which it belongs, ought to be written on a slip of paper, or in the bottom of the leaf containing the plant, along with any remarks which it may be important to record. If possible, the genera of each class and order, and the species of each genus ought to be brought together.

Some prefer arranging their plants in an herbarium, according to the natural method of Jussieu, which, in this respect, has undoubtedly many advantages, and when the student is thoroughly acquainted with both systems, may be advantageously adopted.

Many botanists are in the practice of applying a hot smoothing iron to the plants which they intend for their herbarium; but this method of drying them has only one advantage—expedition—and generally renders them unfit for subsequent examination, which is the great end aimed at in making an herbarium.

To prevent the attacks of insects on the herbarium, which are frequently very annoying, a solution of corrosive sublimate of mercury in rectified spirits of wine (about two drachms to a pint) along with a little camphor, may be applied with a fine hair pencil, when the specimens are perfectly dry.

CHAPTER X.

SKETCH OF ZOOLOGY, OR THE NATURAL HISTORY OF ANIMALS.

The science of zoology comprehends a knowledge of the geographical distribution of animals, of their habits, instincts, and organization. The great number and variety of them which are found in different parts of the earth have rendered it necessary to class and arrange them in the same way as the productions of the vegetable kingdom. The systems which have been constructed for this purpose are some of them natural, and some of them artificial. The first division of the animal kingdom which deserves our notice is that of Aristotle, into viviparous and oviparous animals; that is to say, into such as produce living and perfectly formed young, and such as produce eggs, from which the young are afterwards excluded. This division, though exceedingly imperfect, remained in use until the time of the celebrated Ray, whose extensive knowledge of the animal kingdom enabled him to form a new and more complete classification, founded principally on the structure and nature of the heart and lungs in the different tribes. The principles of this mode of classification was partly followed by Linnæus, particularly with respect to quadrupeds. The whole animal kingdom was distinguished by that great naturalist into three grand divisions: the first consisting of such animals as have warm red blood, and a heart divided into two cavities or ventricles, the second of those having red blood of a lower temperature, usually denominated cold, and having only a single cavity or ventricle; and the third of those supposed to have a heart with a single cavity and cold, colourless, or whitish blood. The first division included quadrupeds and birds; the second amphibious animals, such as frogs, lizards, &c. and the third insects and worms.

To these systems have succeeded a great number of others, none of which, however, with the exception of that of Cuvier, have come into general use. That celebrated naturalist divides the whole animal world into two grand classes; vertebrated, and invertebrated, animals; that is, into such as are furnished with a back-bone divided into joints called vertebræ, containing the spinal marrow, and into such as are destitute of this process. The first class, vertebrated animals, is subdivided into such as have warm blood and a heart with two cavities or ventricles, and into such as have blood comparatively cold and a heart with one ventricle; the former comprising quadrupeds and birds, the latter amphibious animals and fishes. The second class, invertebrated animals, is naturally enough divided into such as have a system of vessels for the circulation of the blood, and such as have none: the former comprising the mollusca and crustacea, and the second insects and zoophytes.

I have been the more particular in mentioning these divisions of the animal kingdom, because they tend to throw considerable light on the general structure of animals, and will enable the reader to appreciate properly the system which is adopted in the following sketch. Cuvier has shown a much more intimate acquaintance with the animal kingdom than any other naturalist, and his arrangement of it displays the highest anatomical knowledge; but its air of precision and its complicated appearance have prevented it from coming into general use. Those, however, who wish to acquire a thorough knowledge of the structure of the various tribes of animals which inhabit the different parts of the earth, cannot do better than apply themselves to the study of Cuvier.

I shall now proceed to detail the system of classification adopted by Linnæus. After distributing the various tribes of animals into the three grand divisions already mentioned, he proceeds to subdivide them into classes, orders, genera, and species, in the same manner as in his system of vegetables. His classes are in number 15 and comprehend 33 orders.

Class I. MAMMALIA, or those animals which nourish their young by means of lactiferous teats, contains seven orders, which are characterized by lungs that respire alternately, jaws incumbent and covered, teeth usually within, teats yielding a milky fluid, four feet or supporters, except in the case of those living in the water, organs of sense, and by walking and emitting distinct sounds. The greater part of the animals belonging to this class are quadrupeds, and bear a very strong resemblance to man in their internal structure.

The division of this class into orders proceeds upon the number, situation, and structure of the teeth.

Order 1. PRIMATES, so styled from the animals composing it being the chiefs of the creation, is distinguished by having four fore or cutting teeth above and below, and one canine or sharpened tooth on each side of these. The feet bear a strong resemblance to the human hand, and are furnished with nails of a more or less oval shape. This order comprehends four genera, the first of which is man, the second the ape or monkey tribe, the third the macauco, and the fourth the bat.

The chief of the ape tribe, (which includes several species all very closely allied to man in their general structure,) the oran otan, was not many years ago very studiously held up as merely a variety of the genus man in a wild state. A more particular examination of the animal has, however, shown, that though it can maintain for a time the same erect posture as man, its structure is that of an animal intended for walking on all fours. Two distinct species are known; the one black and a native of Africa, the other reddish or chesnut coloured and a native of the East Indies. In height the ape tribe is inferior to man, seldom exceeding two feet, gentle in their manners, and excellent imitators of human actions. They have no tail.

Many of the monkey tribe are distinguished by a prehensive tail, possessing the power of coiling round any object at pleasure, and answering, in some measure, the same purpose as a fifth hand.

The genus macauco, comprises a number of animals very nearly allied to the monkey tribe, but of a much more elegant and attractive appearance. They feed principally on vegetables, and are distinguished from monkeys by having the lower front teeth stretched outwards, and the index or second finger of the hind feet being furnished with a sharp lengthened claw. Some species are carnivorous, and one of them, the flying lemur, is furnished with expanded lateral membranes, measuring nearly three feet, covered with a furry skin, which enable it to fly from one place to another. This species has by some naturalists been considered as forming a distinct genus.

The genus bat does not certainly appear at first sight to constitute one of the chiefs of the creation, and Linnæus has been much censured for classing it among the Primates. The slightest attention to its structure, however, will show the propriety of placing it under this order. It is characterized by upright sharpened teeth, and has the fingers or divisions of the fore-feet stretched out to an amazing length and connected by a thin naked membrane which gives it the power of flight. The common bats of this country, bear no proportion in point of size to those which inhabit India, Africa, or South America. The most curious of the whole genus, is that species which has been denominated the vampyre bat, which preys chiefly on insects and fruits, and is said to have the power of inserting the tip of its tongue so dexterously into the vein of a sleeping person as to draw away a large quantity of blood without awakening the person. Its structure seems to be peculiarly adapted to this purpose, the tongue being furnished with a number of sharp prickles. The appearance of the animal is hideous and disgusting in the extreme; they lie torpid during the winter months in any confined cavity, and are sometimes found hanging together in clusters. The whole of them are remarkable, even when their eyes are put out, for finding their way with ease and safety in dark and dusky places. Spallanzani instituted various experiments for the purpose of showing that they must necessarily be in possession of some additional sense, which enabled them to avoid obstacles which might be in their way, which they never failed to do, even after being deprived of their organs of vision.

Order 2. Bruta, or Brutes, is distinguished from the preceding by having no fore-teeth in either jaw. The feet are furnished with strong hoof-like nails; the motion of the animals is in general slow, and their food, vegetables. The order comprehends nine genera; the bradypus, or sloth; the armadillo, the pangolin, the ant-eater, the ornythoryncus, or duck-bill; the rhinoceros, the elephant, the walrus, and sakotyro.

The whole of the animals constituting this order deserve the greatest attention, from the peculiarity of their structure and conformation. The *sloth* is a native of the warmest regions of South America, and is remarkable for the slowness of its motions and its habitual inactivity. Its general appearance is extremely repulsive; its size about that of a small dog; the fore legs long, the hind short, and armed with powerful sharp-pointed claws. Its common colour is a greyish brown.

A very curious skeleton of an animal more nearly resembling the sloth than any other, though also considerably different from it, was dug up some years ago in South America to which Cuvier has given the title of *megatherium*. It measures twelve feet in length and six in height.

The genus *armadillo* is easily distinguished from all others, from its being furnished with a suit of bony armour of the most curious and admirable structure. The whole of the species of this genus are natives of South America, reside in dry and rocky places, and have the power of burrowing in the ground. The general colour of these animals is brown. When attacked by other animals they roll themselves up in the form of a ball, by contracting their body and limbs, and are thus enabled to bid defiance to any common violence. They are perfectly harmless and inoffensive.

The genus *pangolin* is also furnished with a coat of armour, like the preceding, which covers every part of its body except the belly, and enables it, when rolled up, to despise the most ferocious enemy. Its mouth is lengthened into a species of tubular snout and contains a long worm-shaped tongue, which it can lengthen or contract at pleasure. It is thus enabled to thrust it dexterously into ant-heaps for the purpose of supplying itself with food.

The genus *myrmecophega*, or ant-eater, resembles the preceding in several respects, and is furnished with a similar apparatus for feeding itself. All the species, however, with the exception of two lately discovered, are covered with hair. The most extraordinary species is that lately discovered in New Holland, which differs from all others in being furnished with spines like the porcupine. It is of a black or very dark brown colour on the limbs or lower parts, and has the fore and hind feet furnished with very strong claws, by means of which it can, in the course of a few minutes, conceal itself underground in the hardest soil. It coils itself up when attacked like the pangolin, lives on ants, and is eaten by the natives.

The genus *platypus*, or *ornythoryncus*, consists of only one species; which, like the aculeated or porcupine-ant-eater is also found in New Holland; and is, without exception, the most singular animal which has as yet been discovered. It is furnished with a bill resembling that of a duck, and with fine short strong claws on the feet, which are more or less webbed; while the body is covered with a beautiful, soft, glossy hair, generally of a black colour. It inhabits the fresh water lakes, and is supposed to feed on worms. Its size varies from twelve to sixteen inches. It is supposed to be oviparous.

The genus *elephas*, or *elephant*, is so well known as to require no description. Its amazing strength, docility, and intelligence have been the theme of naturalists in all ages. It drinks by means of its trunk, with which it sucks up the water and then conveys it into its mouth. In some parts of North America several immense bones have been dug out of the earth, bearing a general resemblance to the elephant. The appellation of *mammoth* has been given to the skeleton which was discovered some years ago. It differs from the elephant in having the teeth deeply lobbed on the top, like those of carnivorous animals. Some have supposed it to be an extinct species of elephant, others have imagined it to be a marine animal.

The genus *rhinoceros* is distinguished by a horn or process situated above the nose, from which it derives its name. Its usual height is about eight feet; its skin hard and strong; its feet divided into three large hoofs, all standing forwards. The horn on the nose is said occasionally to exceed three feet in length. It is a native of Asia and Africa, and feeds on the shoots of young trees.

The genus sakotyro is distinguished by a horn on each side near the eyes, and contains only one species. It is represented as equal in size to a large ox, and as possessing the snout of a hog, with long rough ears and a thick bushy tail. It is a native of Java, and feeds on herbage. Some have doubted the existence of this animal.

The genus *trichecus*, or walrus, is characterized by having no foreteeth, and by a large tusk on each side pointing downwards. The skin is thick in the northern walrus, and covered with short dusky hair. It attains sometimes to the enormous size of eighteen feet, is of a gregarious disposition, and feeds principally on sea-plants and shell animals. Great numbers of this tribe are occasionally seen in the northern seas on masses of floating ice. There are several species.

The importance and remarkable structure of the animals composing these two orders has rendered it necessary to enter more at length into an account of the genera included under them, than it is necessary to do in regard to the others. In the remaining classes and orders a description will only be given of the general characters of the tribes of which they are composed, along with such particulars, in regard to the more curious individuals or species, as may be deemed most worthy of attention.

Order 3. FERÆ, or predacious quadrupeds, is characterized by having the fore-teeth conic, commonly six in each jaw; the tusks longer; the grinders with conic projections; the feet armed with annulate claws. It comprises ten genera; the dog, the opossum, the hedgehog, the cat, the weazel, the seal, the shrew, the mole, the bear, the kangaroo.

The first genus, the dog tribe, consists of the whole of the varieties of the dog, the hyæna, the fox, and the jackal, the cat tribe, and of all those animals resembling the common cat, and includes the lion, the tiger, the panther, and the leopard; of all which there are a great number of species and varieties. The common cat is occasionally found in a wild state and of much larger size than when it is domesticated. The whole tribe is furnished with what are termed retractile claws; that is, they are so constituted as to be withdrawn into a species of sheath when not in use. They never unite for mutual defence, but pursue their prey with solitary energy. They all spring upon their prey with the suddenness of lightning, and generally suck its blood before devouring the carcass. They will occasionally feed on vegetables; and though differing greatly in point of size and colour, resemble one another strongly in form, structure, and disposition. There are twenty-three species.

The *weasel* tribe is distinguished by a certain slenderness of body, a sharpened visage, and rather long tail. The ichneumon, so highly valued by the Egyptians on account of its destroying serpents and other noxious animals, belongs to this tribe; some of which are remarkable for emitting such an intolerably fetid smell when disturbed or pursued, as even to make the pursuers relinquish their prey.

The *opossum* tribe comprehends a great variety of very curiously formed animals, which are principally characterized by a cavity or pouch, in which the parent places the young immediately after their birth, and preserves them till they are able to defend themselves. Six or eight teats are situated inside the pouch.

The genus *kangaroo* contains several varieties, all of which are found in New Holland. They are of various sizes, from a foot to three feet in length. The fore-feet are much shorter than the hind, and are seldom used by it in walking. Its tail is of an immense size, and appears to be of great use in assisting it to move forward. It is also furnished with a pouch.

Order 4. GLIRES, or sleepers, is characterized by having a pair of strong lengthened teeth, placed close together in the front of both jaws. They have no canine teeth, and are furnished with grinders on each side. This order comprehends the porcupine tribe, the beaver, the whole of those animals in the mouse and rat tribe, the marmot, the hare, the squirrel, the dormouse, the jerboa, and the hyrax; all of which contain several species and varieties.

The most curious of all these animals is the *beaver*, so well known for the fur and castor oil which is procured from it. Large numbers of this genus assemble in the neighbourhood of woody and watery situations, form a species of community, and build arched mansions, curiously lined and plastered with clay, in which they pass the coldest winter months; taking care, before they arrive, to fill their dwellings with a large quantity of the twigs and branches of the softer trees, such as willows and poplars, for winter consumption.

Of the European rats, the most remarkable is the *hamster*, which is furnished with a large membranous pouch or bag on each side of the mouth, which it uses for carrying off large supplies of grain, for consumption during the autumn months. On the approach of winter, the hamster conceals himself in a deep cell, well lined with grass and moss, and falls into such a state of torpidity, that it might be cut into a thousand pieces without exhibiting the least appearance of sensibility. When taken out of its burrow and exposed to the air, it gradually revives.

The jerboa is also furnished with a pouch.

Order 5. Pecora, or cattle, is characterized by having no fore-teeth in the upper-jaw, but several in the lower; the feet hoofed and cloven; four stomachs for macerating, receiving, digesting and preventing their food from putrefying, and by the power of bringing it back again to be chewed. It comprehends eight genera; the antelope, the ox, the camel, the camelopardalis, the goat, the deer, the musk, the sheep, with their several species and varieties. All of them ruminate and feed on vegetables; many of them are highly useful; and others are remarkable for their elegance.

The most singular of the whole tribe is the *camelopardalis*, a native of Africa, often measuring seventeen feet in height, and distinguished by its long and lofty neck, which gives to its fore parts an appearance of greater height than the hinder. Its existence was considered extremely problematical, till La Vaillant brought one home from Africa, which is now deposited in the national museum at Paris.

Of the *deer* tribe, which is characterized by having branched horns, which fall off and are renewed annually, the elk is the largest. There are several species, all well marked, such as the stag; the rein deer, constituting the wealth of the Laplander, and the fallow deer, common in every nobleman's park in this country, &c.

The *camel* tribe contains the camel and dromedary, so well known and so useful to the inhabitants of Asia and

Africa, the lama, the vicuna, &c. The *musk* is celebrated for yielding the substance known by the name of musk, which is contained in a small pouch, about the size of an egg, situated under the body.

The *antelope* is well known to be one of the handsomest animals, and at the same time one of the swiftest. It is a gregarious animal, and contains several species.

The goat and sheep tribe require no description. The original of the latter is supposed to be Argali, found in the mountainous parts of the East, and covered with a species of hair instead of wool.

Order 6. BELLUÆ is distinguished by having the fore-teeth obtuse, the feet hoofed, the motion rather heavy, and feeding entirely on vegetable substances. It comprises four genera; the horse, the hippopotamus, the hog and the tapir.

Under the genus *horse,* which comprises several species, are included the ass, the zebra, and the cloven-footed horse of Chili, lately discovered. The ass in its native region is remarkable for its spirit, swiftness, and handsome appearance; but it is surpassed in all these qualities by the zebra, so distinguished for its beauty and variegated coat.

Of the genus *hippopotamus* there is only one species. It is nearly equal in size to the rhinoceros, and lives partly in water and partly on land. Its general appearance is uncouth; its skin is smooth and covered with short hairs, and its tusks are much esteemed as a species of ivory.

The genus *tapir* contains a single species. It is also uncouth in its appearance, but it is perfectly harmless and inoffensive.

The *hog* is easily known from all other animals by the peculiar form of its head and snout.

Order 7. CETE, or WHALE TRIBE, is distinguished by having one or more spiracles or spout-holes, situated on the fore part of the skull, through which the water is discharged which has been taken in at the mouth, pectoral fins without nails, a horizontal tail, and being destitute of feet. The whole of this order, though living in the water, and bearing external resemblance to fish, are much more closely allied to quadrupeds than could at first sight be supposed. They are provided with lungs, intestines, and other internal organs, formed on the same principle as those of quadrupeds, and produce and nourish their young in the same manner. The order comprehends four genera, the narval, the whale, the cachalot, and the dolphin.

The *whale*, of which there are several species, is distinguished by a total want of teeth, instead of which the upper part of the mouth is furnished with a great number of long, broad, horny plates, familiarly known in the country by the name of whalebone. The principal species is the *northern whale*, the largest of all animals; having, in former times, been found of an hundred, and even an hundred and fifty, feet in length. The head is immensely large, and constitutes nearly a third part of the animal; the mouth is of a prodigious width, the tongue measuring eighteen or twenty feet in length; while the eyes are seldom more than two inches either way. The throat is remarkably narrow, which obliges it to feed on the smaller medusæ, or sea-blubbers. The vertebræ of the back-bone are several feet in length and circumference; while the jaw-bones are sufficiently large to form gateways. Its strength is incalculable, its motion rapid, and the period of its life supposed to be very long. The female produces only one at a birth. The substances known by the name of spermaceti and ambergris are obtained from two species of the genus cachalot, of the whale tribe. The latter is a part of the natural contents of the animal's intestines hardened by disease.

The *dolphin* tribe is characterized by numerous teeth in both jaws; an elongated shape, a sharpened snout, and thick pointed fin, situated about the middle of the back. Its appearance is considered by seamen as the forerunner of a storm. The common dolphin, the porpoise, formerly used at table as an elegant dish, and the grampus, belong to this genus.

The *narwal* is distinguished by a large, long, spirally twisted tooth or horn, which projects from its upper jaw. Two of these teeth, or horns, are sometimes found parallel to each other. This animal is sometimes called the sea-unicorn.

Before proceeding to the next grand class of the animal kingdom, it may be proper to observe, that though cetaceous animals live in the water, and feed on small marine animals, they bear no other resemblance to fishes, and are considered as a sort of connecting link between herbivorous and carnivorous animals.

CLASS II. AVES, OR BIRDS.

This class is sufficiently distinguished from all other tribes of animals, by those which compose it having the body covered with feathers and down, the jaws long and naked, and the body being furnished with two wings and two feet. Their whole structure indicates the element in which they are intended to move; the body being shaped like a wedge, to enable them to fly with ease and celerity, the bill sharp, and the head comparatively small. The whole frame is of a lighter nature than in quadrupeds; the spine immovable—the breast bone large, and formed for the attachment of strong muscles. The disposition of the lungs along the back-bone, and their communication with the different bones of the wings, thighs, &c. increase their buoyancy, by admitting the air, and enable them to exist for a much longer time without breathing, which must frequently be suspended during rapid flights.

The internal structure of birds differs likewise in other respects from that of other animals. The throat, after passing to a certain distance downward, becomes dilated, and forms a membranaceous bag, usually called the crop, similar to the stomach of quadrupeds, which softens the food taken into it before it passes into another receptacle, denominated the gizzard. This stomach is more powerful than the former, and consists of two very strong muscles, lined with a strong tendinous coat, and furrowed on the inside.

The eyes of birds are more or less convex in different tribes, and their sight particularly acute. Though they have no external ear, the internal is formed on the same principle as in quadrupeds. They are all oviparous.

The orders belonging to this class are six.

Order 1. Accipitres, or predacious birds, comprehending the vulture, the falcon, the owl, and the shrike, is distinguished by having the bill bent downwards, the upper mandible dilated on both sides and armed with a tooth-like process, the nostrils wide, the feet strong and short, and composed of four toes, one of which is bent backwards, the other three forwards, and all furnished with sharp hooked claws. All the birds belonging to this class live in pairs, build their nests in lofty situations, and subsist principally by preying on other animals. The female is always larger, and more powerful than the male.

The *vulture* tribe, which is extremely numerous and highly useful in warm climates, from its preying on dead animals, is distinguished by comprising the condor of South America, the largest and most powerful of all the winged tribe. Its wings are said to extend to fourteen or fifteen feet from tip to tip; and itself to be sufficiently powerful to carry off a boy of nine or ten years of age.

The genus *falcon* comprises all the tribe of hawks and eagles, amounting to upwards of a hundred. The most celebrated is the golden eagle, measuring about three feet in length, and known among the ancients as the bird of Jupiter. It is occasionally found in Britain.

The eyes of the *owl* tribe are so very sensible to the smallest ray of light, that they prefer hunting their prey in the dusk, or when it is altogether dark.

Order 2. PICÆ, or PIES, is characterized by a sharp-edged bill, convex above, and strong short legs formed for walking, perching, or climbing. They live in pairs, feed on the most filthy substances, and build their nests in trees. The genera comprehended in this order are twenty-six, and are subdivided according as the birds composing them are formed for perching, for walking, or for climbing. Among them are to be found the buceros bird, the toucan, the parrot tribe amounting to upwards of a hundred and seventy, the woodpecker, the bird of paradise, the king-fisher, the cuckoo, and the humming-bird; all of which, independently of generic distinctions, are marked by considerable peculiarities.

The *buceros* tribe is distinguished by the immense size of its beak, and sometimes by a large prominence on the upper mandible. The same disproportion is likewise seen in the *toucan*, the bill being frequently nearly as large as the body of the bird. The tongue consists of a horny substance, divided into a great number of notches, and so strongly resembling a feather, that it was long considered by naturalists as such. In the tribe of *woodpeckers*, the tongue can be extended to the full length of the body, and is tipped with a sharp horny point, for the purpose of enabling them to seize and transfix the insects on which they feed. The paradise birds are natives of the Philippine, and other Indian, islands, and are celebrated for the beauty of their plumage. The genus *cuckoo* is characterized by the striking peculiarity of usurping the nests of other birds, and depositing its eggs in them for the purpose of being hatched by the birds to which they belong. The *humming-birds* belong to the warmest regions of America, and have long been admired for their swiftness, their vivacity, their singular appearance, and brilliant colours. The tongue in these birds consists of a long double tube, fringed on each side with horny hairs, by means of which they are enabled to absorb the nectar in the bottom of flowers.

Order 3. ANSERES, or the SWAN and GOOSE tribe, is distinguished by a smooth bill, covered with a soft skin, and somewhat dilated at the tip; the toes of the feet webbed, or palmate, and evidently adapted for swimming; the body fat and downy, and the legs short. The food of this tribe, which contains thirteen genera, consists of grass, aquatic plants, sand, worms, &c. which they pick up in the neighbourhood of marshes or running water, &c. A few of them are occasionally found on lofty rocks, but their usual residence is in the neighbourhood of the element in which they principally live. A great quantity of oil is secreted by set of glands near the tail, which when rubbed over their bodies by means of their bills, enables them to remain in the water without being in the least degree wet. Some of them are exceedingly expert in catching fish, and have occasionally been tamed for that purpose.

The genera composing this order are divided into two sections; the one comprehending those having bills with, and the other, those having bills without, teeth.

The genus *swan* includes all those birds known by that name, and also geese and ducks. The most remarkable of this family, is the black swan, found in Van Dieman's Land, and lately brought over to this country. It is the only one of the whole family that is in the smallest degree musical—all the others uttering the harshest and most discordant sounds.

The *tropic bird* belongs to this tribe; also, the *albatross*, so famed for its distant flights; the *pelican*, distinguished by a loose ditable skin below the lower mandible; the family of *penguins*, which seem from their facility in diving and swimming, and their utter incapability of walking, to form a kind of connecting link between birds and fishes; the *petrel*, the *darter*, the *gull*, &c.

Order IV. GRALLÆ, or CRANE kind, so called from the extraordinary length of their legs, includes the herons, storks, bitterns, cranes, snipes, plovers, the ibis, &c. and is characterized principally by the great length of the leg, and its being in general completely naked above the knee. This tribe lives principally in watery situations, and feeds partly on aquatic animals, and partly on vegetable substances.

Of the birds comprised in this order, one of the most singular is the *jabinu* of South America, of which the beak is slightly turned up, instead of descending as in other birds. The family of herons is remarkable for a long pointed bill, frequently marked on each side by a longitudinal furrow. They are remarkably expert fishers, and are occasionally seen to pounce from a great height and seize their prey. The *giant heron*, a native of Bengal, and of immense size, is the principal bird of this tribe.

Its stomach is sufficiently large to contain a full grown cat, which an eminent traveller relates to have been once found in it, along with a land tortoise in its craw. The *bitterns* differ only from the herons in being thicker and shorter, and in having a great fulness of feathers on the breast. The common bittern is remarkable for emitting in certain states of the weather a loud mugient kind of noise, about which there has been much disputing. Such has also been the case with the *ibis*, which was held sacred among the Egyptians on account of its killing a species of serpents with which the country was infested. The question as to the particular bird indicated under the name of Ibis does not yet appear to be set at rest. The *curlew* only differs from the ibis in not having a naked front. The *Iacana* is remarkable for being easily domesticated, and for guarding poultry which may have been committed to its trust in the same way as a certain species of dog defends sheep. The *spoon-bill* is easily distinguished from all others of the same order, by its long, flattened, and spoon-like bill. The far-famed *flamingo*, whose tongue was esteemed one of the greatest dainties by the epicures of Rome, closes the list of genera in this order. It is nearly four feet in length, and when of proper size, is all over of the deepest and most beautiful scarlet. They are an extremely shy race of birds, and when assembled in flocks, regularly place a sentinel at some distance to give warning of any approaching danger. They are extremely susceptible of cold, and cannot be reared and preserved without great difficulty.

Order 5. GALLINÆ, or poultry kind, comprises the whole tribe of pheasants, turkies, partridges, quails, bustards, cassowaries, and the dodo. The birds of this order being intended rather for walking than for flight, are are much more heavy in their structure than those belonging to the same class. Their wings are short, and their toes connected at the base by a strong membrane, reaching as far as the first joint. The upper mandible overtops the edges of the lower, and the toes are furnished with broad claws, fitted for scratching up the ground in search of food. The whole tribe feeds on grains, insects, and sand, and is the only kind considered pure under the Mosaic law.

The common fowl is of East Indian extraction. The *pheasant* tribe of birds is one of the most beautiful, (particularly those species found in New Holland,) which have yet been discovered; and the tails of a particular species are used as ornaments for the head. Of the *partridge*, there are a great variety of species. The *ostrich*, the *bustard*, and the *quail*, which is found in all climates from the Cape of Good Hope to the snows and frosts of Iceland, belong to this tribe. The singular kind, the *dodo*, has become so exceedingly rare, that no specimen of it has been seen for the last two hundred years. It is principally distinguished by having the bill strongly wrinkled and indented in the middle, which gives it a very curious appearance. The pride of this order of birds is the *peacock*, particularly the crested species so well known to every one. It is a native of India.

Order 6. PASSERES, or sparrow tribe, is distinguished by a conical and pointed bill, by pervious, oval, and naked nostrils, by legs peculiarly adapted for hopping, and toes divided, and remarkably slender. The nests of this tribe are formed with great art, and many of them are extremely vocal. The flesh of those which feed on insects is considered impure, and unfit for food; that of those which feed on grain extremely fine and pure.

This order comprises seventeen genera, of which five have thick bills, three have the upper mandible hooked at the point,—four have it notched near the end, and five have it simple, straight, and tapering. The whole tribe of sparrows, larks, thrushes, doves, swallows, nightingales, the taylor bird, the titmouse, the water-wagtail, &c.; almost all of which are known to the British ornithologist. The *taylor* bird is distinguished by forming its nest of one or two leaves, which it sews together for that purpose, and fills up with cotton or feathers. It should also be remarked, that the so much admired song of the nightingale proceeds from the male bird who endeavours in this way to soothe his mate during the period of incubation. This order contains in general all the smaller kinds of birds, many of which are remarkable for the beauty of their plumage.

Class III. Amphibia, *or Animals living partly on Land, and partly on Water.*

This class is one of the most curious in the whole animal kingdom, and though differing so much from the preceding class in external structure, is very nearly allied to it in some parts of its internal organization. All the animals belonging to this tribe, possess the power of suspending respiration at pleasure, and can support a change of element without the least inconvenience. They are distinguished by having the heart uni-locular, or possessed of only one ventricle or cavity, and by their lungs being formed of a pair of large bladders, or membranaceous receptacles parted into more or fewer subdivisions, among which are the pulmonary blood-vessels. The vascular system, in all the animals composing this tribe is much smaller than the vesicular. Their blood is always colder than that of quadrupeds and birds, and its particles oval instead of round as in viviparous quadrupeds. Many of them are what is termed reproductive; that is, they have the faculty of supplying themselves with those parts of which they may have been deprived. Some of them are remarkable for their beauty; others for their ugliness, and all are particularly tenacious of life, and will continue to move, and to exhibit symptoms of life after being deprived of what we should consider the most essential parts. Some of them are extremely long lived, particularly the tortoise, frog, and serpent tribe. They pass the winter in a torpid state, and are found to exist under a very high degree of cold. All of them are oviparous, and either deposit eggs covered with a calcareous shell, or soft eggs in the form of spawn. In the viper tribe, the eggs are hatched internally. The young of those which deposit hard eggs only differ from the parent in size, while those which are produced from soft eggs or spawn, appear for some time under a kind of tadpole shape.

The whole of this class is divided into four different sets; tortoises, frogs, lizards, and serpents; or into reptiles or footed amphibia, and serpents or footless amphibia.

The reptile tribe is characterized by breathing through the mouth, by possessing feet, and flat naked ears without auricles.

Of these, the first genus, the *tortoise,* of which there are three kinds,—the sea, the land, and fresh-water—is easily distinguished by the hard, bony covering in which it is cased, by the mouth being destitute of teeth, and the upper jaw over lapping the edges of the lower. The toes of the land tortoises are furnished with claws; while the feet of those which are found in fresh water are webbed. The most common of the former kind is the Greek tortoise, which has the power of abstaining from any species of food for a considerable part of the year, and has been known to live upwards of a century. It is remarkably indolent, slow in all its motions, and particularly sensible to damp or rainy weather. When full grown, a loaded cart might pass over it without doing it the smallest injury. It buries itself under ground from November to April, and sleeps away a great part of the summer. Several disgusting experiments have been tried upon it to show its tenacity of the vital principle, such as cutting off the head, scooping out the brains, &c. after which cruel and inhuman treatment it was found to live for several months.

There are a great number of the species of land and sea tortoise, all of which are more or less characterized by the above general character, with the exception of the fierce tortoise of North America, which darts with great fury upon any one who may happen to assail it, and is distinguished by rather a swift motion. The *hawk's-bill turtle* is the species which affords the substance known by the name of tortoise-shell which is used in so many different ways.

The *frog* tribe includes all those animals known under the name of frogs and toads, all of which retire under water during the heats of summer and frosts of winter. During the latter season they remain in a torpid state till the warmth of summer revives them again. In the month of March the frog deposits its eggs in large groups, each egg containing the rudiment of the future animal. In a short time the egg or globe changes into the form of a tadpole, apparently consisting of a mere head and tail bordered by a finny-like margin. The hind-legs make their appearance in about five weeks, the fore-legs soon afterwards, and finally the tail disappears altogether. The animal arrives at maturity in about five years, and is supposed to live for ten more.

The same observations apply to the *toad* tribe, with this exception, that they lay their eggs in double strings like so many necklaces. Those of them which belong to this country are, notwithstanding the general prejudice against them, perfectly innoxious; some of those which are exotic exude a highly acrimonious and offensive moisture.

The *lizard* tribe is exceedingly numerous, and includes animals of the largest and the smallest size, from the crocodile and alligator down to the common water-newt. The species are all sufficiently distinct from one another in external structure, and may be generally characterized as having the body four-footed, tailed, naked, long, and the legs equal. The *crocodiles* have very large and strong scales; the guanas are furnished with a serrated process along the back, the *cordyles* with serrated or toothed scales, while the lizards, properly so called, are quite smooth. The common crocodile is a very formidable animal, and not unfrequently measures 20 feet in length; as is also the Gangetic, the American, and the Ceylonese.

Under the lizard tribe are comprehended the salamanders, the *chameleons*, and the water-newts. The vulgar idea of the *chameleon* changing colour is now found to be without foundation, as is also that concerning the *salamander* being able to live in the midst of fire. To these genera may be added the *siren* of Carolina, distinguished by a pair of breathing organs on each side of the neck, and the flying dragon, which is furnished with a wide expanded skin on each side of the body, which enables it to fly and flutter.

The *serpent* tribe is readily distinguished from all others of this class by its total want of feet. The distinction of the species is particularly difficult in some genera;

while it has been found absolutely impossible to point out by any certain marks, those which are poisonous from those which are not. Actual inspection of the teeth of the animal is the only criterion in this respect. The teeth f those which are poisonous are always tubular, and have a glandular reservoir of poison connected with them, which communicate with the fang on each side of the head; while those which are harmless have no tubular teeth. These tubular teeth or fangs are situated in the upper jaw, and are frequently accompanied by smaller ones ready to grow up and supply their place, if the larger ones should happen to be lost or destroyed by accident. Poisonous serpents have in general much larger heads than those which are not venomous.

In cold and temperate climates serpents conceal themselves during winter, and remain almost in a state of torpidity. Some of them are viviparous, such as the rattlesnake, the viper, &c., others oviparous and perfectly innoxious. All of them cast their skins, even to the outer film of the eyes.

The largest, perhaps, of the whole tribe is the *rattlesnake,* which is sufficiently distinguished from the other genera, by having its tail terminated by a species of rattle. Its power of fascination is now generally attributed to the effect of fear. The *boa,* particularly the species denominated *constrictor,* is also very powerful, and will crush in its folds, and afterwards devour at a single meal, the largest tiger. It is distinguished by broad scaly transverse plates, both beneath the body and tail, and grows sometimes to the length of 35 feet. The cobra capella, so well known in India, is also highly poisonous. Besides these, there are four other genera, the species of which are partly poisonous and partly harmless.

Class IV.—Pisces, or Fishes.

This class of the animal kingdom is described as having a heart with one auricle and one ventricle, cold red blood, incumbent jaws, eggs destitute of white, organs of sense, fins for support, imbricated scales for a covering, and capable of swimming in the water. It is so different in every respect from those already described, that it will be proper to give some account of its various functions rather more at length than in the others. Of these, the most important is respiration, which is performed by means of gills, which extract the proper quantity of air from the water which is taken in at the mouth, and then allow it to pass through them. The respiration goes on while the animal is asleep and is repeated about 25 times in a minute. Its suspension, by keeping the gills of the fish perfectly close together, would cause the death of the animal in a few minutes.

Fishes are particularly alive to sound, as well as to every thing which affects their organs of smelling; their organs of taste and touch being considered much less perfect. The eyes of fishes are admirably adapted to the element in which they move, and are defended from the various injuries to which they are exposed by a firm pellucid membrane. They are always open and are not provided with palpebræ.

The motion of fishes is in general remarkably rapid, for which their shape, fins, tail, and back-bone are all admirably contrived. A large fish will easily overtake a ship in full sail, and play round and round it as if in mockery of its attempt to leave it behind. The air-bladder with which fishes are provided, enables them to rise or sink in the water at pleasure by increasing or diminishing their specific gravity. The tail acts as a species of rudder; the pectoral fins help to push the animal forward, the ventrical fins to raise or depress the body, and the dorsal fin acts as a kind of poiser.

Fishes are all carnivorous; the larger preying on the smaller, and obliging them to fly for safety to places which they are unable to approach. A difference of sex is easily remarked in most of them, and it has been observed, though possibly without sufficient grounds, that the number of males is nearly double that of females. A few are viviparous, the eggs being fecundated by the male after deposition. They have different seasons for spawning; some choosing the winter months, others those of summer. The quantity of spawn in some species is almost incredible. The cod produces upwards of 9,000,000 of eggs, the flounder more than a million; the mackarel above 500,000, the herring 10,000, &c. A great portion of these eggs, however, are destroyed by the lesser fish as well as by aquatic birds, while much must also remain unfecundated.

Various divisions of this class of animals have been proposed by Ray, Artidi, and others; that of Linnæus has, with some improvements, been received into most general use, and proceeds upon the situation, presence, or absence of the ventral fins. The first order or division consists of those which are destitute of these fins, and are termed apodal or footless fishes; the second, of those which have ventral fins placed under the throat, and are termed jugular; the third, of those, whose ventral fins are placed immediately under the breast, and are called thoracic; and the fourth of those whose ventral fins are situate on the abdomen, and are denominated abdominal. In addition to these, he has given another tribe denominated cartilaginous, from their skeleton being cartilaginous instead of bony.

The genera, which are comprised under these orders, are determined by the number of rays in the branchiostegous membrane, the condition of the teeth, the figure of the body, and other remarkable parts, each of which has received its appropriate name; while the characters of the species are in general determined by the number of rays in the fins. The great variety and number of this tribe of the animal kingdom, renders it impossible to give more than a cursory notice of the most remarkable genus belonging to each order.

Of the apodal, or footless fishes, the *eel* may be mentioned as a principal and well known genus. They are distinguished by soft smooth bodies surmounted by a shallow back fin, which unites with the tail and forms a species of border. A particular species of it was esteemed a great delicacy among the Romans. There is also a genus of the apodal kind, known by the name of the electric eel, from its possessing a high degree of natural electricity. It communicates a very powerful shock, on the slightest touch, to any animal that may incautiously approach it—frequently kills the smaller kinds of fish by it, and afterwards devours them. It is a very ugly animal.

Of the jugular order of fishes are the *cod* fish, the haddock, the ling, the turbot, and a great variety of others, well known on the British coasts. The chief resort of the *cod* is on the banks of Newfoundland, where they are found in immense shoals, and perform various migrations at stated seasons of the year. They are caught by means of the hook and line; the former being baited with pieces of herring, shell fish, sea fowl, &c. As soon as they are taken, the sound or air bladder is perforated by a needle, in order to let out the air contained in it, and to insure their arrival at the place of sale in a perfectly fresh state.

The thoracic tribe is numerous, containing upwards of twenty genera, some of which measure six and ten feet in length. Of these the gymnetrus, or the king of the herrings, is one of the most remarkable, to which may be added the comet-fish and the dolphin, remarkable for the beautiful colours which it successively exhibits when expiring. The remora, which also belongs to this division, is remarkable for the curious structure of its head, and from its adhering to the sides of ships, sharks, and the larger fishes. It is a native of the Mediterranean sea. All these must, however, yield in peculiarity of structure to the genus *pleuronectis*, which includes the different species of flounders, turbots, soles, and other fishes of a similar kind. The eyes are here placed on one side only, while the animal itself swims sideways. To these may be added, as examples of this order, the different kinds of mullet, perches, gurnards, &c.

The abdominal order contains the whole of the salmon or trout race, the pike, the silurus, the flying fish, the carp tribe, including the gold fish, &c. The salmon is an inhabitant of the northern regions, and is well known; so also is the pike, of which there are many species. The *silurus* appears to be furnished with a complete suit of armour, equally fitted for offence or defence, and supplies the naturalist with many interesting points of speculation and inquiry. The carp tribe are said to live upwards of a century.

Of the cartilaginous order, the lamprey, the skate, the shark, the sturgeon, the sterlet, the trunk-fish, the sun-fish, &c. are examples. The lamprey is celebrated as an article of food; so also is the skate. The lamprey is viviparous. The skate grows sometimes to such a size as to weigh upwards of two hundred pounds. All the genera of this order are remarkably well marked, and easily distinguished from one another.

Class V. INSECTS.

This class is distinguished from those preceding it by the animals of which it is composed having their blood vessels filled with a transparent lymph instead of red blood. They are destitute of internal bones, and have no spine formed of regular vertebræ; but are furnished with a hard external covering to which the muscles are attached, and which they throw off once every year. They have always six legs, and frequently more; but are not furnished with a distinct heart, composed of auricles and venticles. They possess organs of sense, such as vision, hearing, smell, touch, and probably taste also. The greater number have two eyes; some have three, four, six, &c. and others eight, almost all of which are in general immovable. The food of insects is various, and consists of leaves, flowers, fruit, animal bodies dead and alive, &c. Most of them appear to be furnished with a species of instinct, which leads them to deposit their eggs in situations where the larvæ may, as soon as they are hatched, find that kind of food which is best adapted to their nature. All of them appear to be provided with lungs, and these frequently of a very large size in proportion to their bodies, by means of which they respire, not through the mouth or nostrils, as in the tribes of quadrupeds, birds, and amphibia, but through a number of spiracles, situated on the sides. With the exception of the bee, the ant, &c. all of them are either male or female. Their species is propagated by means of eggs, from which, after they have been deposited for a considerable time, the young insect comes forth generally full formed.

Insects are perhaps the most numerous division of the whole animal kingdom, and are certainly the most curious in variety of structure, and singularity of appearance. Gmelin described upwards of eleven thousand, and it is highly probable that double that number yet remain to be discovered; many of them being so minute as to escape common observation, and others so shy and flighty as to be caught with great difficulty. The woods of India, of New Holland, of Java, and South America swarm with the most beautiful species of insects, a thirtieth part of which has not yet been described. They are to be found in every situation; in water, in air, and in the bowels of the earth. Many superior animals, such as fishes, reptiles and birds, are almost entirely supported by preying on them; while they, by consuming decayed vegetable and animal matter which would otherwise taint the atmosphere, help to preserve the air pure for the respiration of man and other animals.

Many insects are highly useful, such as the bee, the crab, the silk-worm, the cochineal insect, &c. The propagation of their species, and the various transformations which they undergo, furnish the naturalist with many interesting points of observation and speculation. The majority of insects are short lived; a year being in general the utmost extent of their existence, and several of them apparently surviving only a few hours. In the caterpillar state they are particularly voracious, but when full formed, scarcely appear to feed at all.

In investigating the different parts of insects, we find that they have a head distinctly separated from the breast, and the breast again from the body; that they are provided with a mouth for gnawing or breaking their food; with a stomach, intestines, brain, eyes, muscles, &c.

Linnæus has distributed them into seven orders; the coleopterous, or sheath-winged; the hemipterous, or half-winged; the lepidepterous, or scaly-winged; the neuropterous, or fibre-winged; the hymenopterous, or membrane-winged; the dipterous, or two-winged; and the apterous, or wingless.

Of these different orders, a few examples shall be given.

The first order, the caleopterous, comprises the family of beetles, the goat chaffer, the weevils, &c. several of which are highly curious.

Of the hemipterous order, the cockroach, the locust frequently so very destructive, the lantern-fly, &c.

Of the third, or lepidepterous order, the butterfly, the sphinx, and the moth, are the grand divisions; all of them proceeding from caterpillars, which afterwards change into a chrysalis, and finally form the complete insect. These comprise many beautiful and highly interesting species.

The fourth, or nerve-winged order, is exemplified in the dragon flies, May flies, &c.

The fifth, or fibre-winged order, comprises the wasp and bee tribe, the ichneumous, &c.

The sixth, or two-winged order, consists of flies properly so càlled, gnats, &c. The common gnat and gadfly are examples.

The seventh, or wingless order, contains the crab and lobster tribe, spiders, scorpions, centipedes, mites, &c. of these the crab tribe possess the extraordinary faculty of throwing off any limb or part which may have been maimed, and of renewing it in a short time by means of another. Several of the scorpion and spider tribes are furnished with poisonous stings, or fangs. The mite tribe comprises the smallest of all known insects, and when viewed through a magnifying glass, presents a very curious structure.

Class VI. VERMES, OR WORMS.

This class contains not only those animals known by the name of worms, but also those which have the general character of being "slow in motion, soft in substance, tenacious of life, capable of reproducing such parts of their body as may be taken away or destroyed, and inhabiting watery and moist places." The orders comprehended under this class are five:

Order 1. INTESTINA, or those found within other animals; they are described as naked animals without limbs, and are divided into two sections; those found within other animals, and those not found in them. The number of genera at present described exceeds twenty. The tape-worm and hair-worm are examples of this order.

Order 2. MOLLUSEA, or soft bodied animals, are characterized as being naked, furnished with arms, generally inhabitants of the sea, and communicating to it in the dark, a luminous appearance. Of these there are twenty-eight genera, which are classed according to the situation of the mouth, feelers, &c. This order comprises many highly curious animals, of which the English *cuttle-fish* is not the least remarkable. Besides its general structure, which is extremely worthy of attention, it is furnished with an internal pouch filled with a dark fluid which it discharges when pursued through a tubular orifice situated at the base of the breast, and is thus enabled to elude the attacks of its assailants. In the body of another species, is found an oblong calcareous bone, which forms an article of commerce, and is highly useful in various ways. The most striking peculiarity, however, is the circumstance of its being furnished with three hearts, which are situated in the form of a triangle. When once it has fastened itself on any animal by means of its arms, there is scarcely any possibility of its being liberated, except by breaking them or cutting them off. The black liquor which it emits, forms, when dried, what is known in this country by the name of Indian ink. The *eight armed cuttle-fish* is the most powerful of this genus, and will defend itself for a long period against the strongest mastiff. Its arms have been known to measure from three to four feet in length, and are supposed to be possessed of something of an electric or galvanic nature. Some accounts have been given by Pennant and others of a large species found in the Indian seas, and measuring between ten and eleven fathoms in length; but these do not appear to be sufficiently authenticated.

The genus *Medusa* is easily distinguished from all others of the same order, by its being composed of a soft, gelatinous, semi-transparent substance, and of a rounded and flattened shape, furnished with numerous arms. Many of the species of this genus are highly phosphoric; all of them are of predacious habits, and are popularly known by the name of sea-blubbers. They are to be seen on the coasts of Italy and of the Indian islands in great numbers.

The genus *Actinia*, or sea-anemone as it is called, from its flower-like appearance, is remarkably beautiful, and is characterized by having an oblong expanse body. It adheres to rocks and marine substances, and is an extremely voracious animal—preying on all sorts of sea-animals, and even swallowing univalve shell-fish. They are nearly allied to the tribe of polypi, and are highly reproductive.

In addition to these, the *star-fish*, of which there are a great number of species, and the *sea-urchin* may be mentioned as illustrations of the order.

Order 3. TESTACEA, or soft animals covered with calcareous shells, contains thirty-six genera, which are divided according to the number of valves of which the shell is composed, and to the regularity or irregularity of the spine.

Of the univalve genera, the most remarkable is the *argonaut*, which has two arms furnished towards the tip with a large oval membrane, by means of which it is enabled to sail along the surface of the sea when calm, and to sub-merge itself, by contracting them, on the least appearance of danger. The shell of the paper nautilus, a species of this genus, is well known to shell collectors; the animal itself has been but rarely found, and is represented as bearing a strong resemblance to the eight armed cuttle-fish. It is an inhabitant of the Mediterranean and Atlantic seas.

Of the bivalve genera, the *mytilus* is most deserving of attention, as furnishing the substance known by the name of mother-of-pearl, of which many beautiful articles are formed. The *pearl muscle,* also, is a product of this shell, and is found in greatest abundance in the neighbourhood of the East Indian islands, Ceylon, &c. where regular pearl fisheries are established. The animal inhabiting the shell is popularly called the pearl oyster, but has not the least resemblance to that genus of animals. The pearls are found in the soft and pulpy part of the animal's body; their manner of production is yet unknown. Their general colour, like that of the shell, is silvery; some, however, have been found of a deep red, and others of a pink colour. It is said, that between two and three hundred of them have been found within a single muscle. The largest ever known, is that which Cleopatra is said to have dissolved in vinegar, and afterwards swallowed. A manufacture of artificial pearls, little inferior to genuine ones, is carried on at Paris.

Of the multivalve shell tribe there are several genera, none of which, however, present any thing particularly remarkable.

All the testaceous tribe are produced from eggs, which in some species are gelatinous, and in others covered with a calcareous shell. The young emerge with the shells on their backs, and may be seen to move several days before they are hatched.

Order 4. ZOOPHYTES, or animals having the appearance of plants. Most of these take root, and grow up into stems, multiplying life in their branches and deciduous buds. They differ from plants in being possessed of sensation and organs of spontaneous motion. Some of them are soft and naked, others covered with a hard shell. The order contains fifteen genera, all of which present striking peculiarities; while the immense works which they raise, are sufficient to excite the greatest admiration and astonishment. The greater part of naturalists have considered the coral reefs which surround the islands of the Indian Archipelago, and particularly New Holland, as simply so many masses of shells to which the animals are fixed. Ocular inspection and observation, has, however, convinced others, that these reefs bear no closer relation to the zoophyte, than the comb does to the bee, and that both the one and the other are formed in a similar way, and with a similar view. The subject has as yet been but little investigated, and cannot be entered into in an elementary treatise.

Order 5. INFUSORIA, or animalcules.

This tribe, which is the last of the Linnæan orders, can scarcely be distinguished from the Mollusca and Intestina, except by the minuteness of its parts. They are generally found to be in fluids, and on inspection by the microscope, are found to be as regularly formed and adapted to their mode of life, as the largest of the animal kingdom. The manner in which they are originally produced is totally unknown. There are in the whole fifteen genera, which it is quite needless to particularise. Several of them propagate their numbers, by dividing spontaneously into two or more parts. They are not found in inflammable spirits.

Such is the Linnæan division of the animal kingdom; but though this sketch may serve to convey some general notions of it, the subject must be studied more at length, before it can be productive of the great ends of all knowledge—utility and pleasure. The French naturalists are as yet our masters in this department of science; but if it is pursued with the same zeal which has characterized our countrymen in other branches of knowledge, that superiority must soon cease. The study is inviting, and the means of pursuing it ample and accessible.

CHAPTER XI.

ACCOMPLISHMENTS.

THE branches of female education, which are severally comprehended under this title, are different from those which have been treated of in the preceding chapters; and though, to a certain extent at least, they be not less essential than those, they are not so capable of being explained in writing. The grand difference is, that the subjects which have been treated of consist chiefly in *knowing*, while *doing* is the essential part of the accomplishments; and though knowledge may be communicated by precept, action is best acquired by example.

No doubt the whole of the accomplishments have some general principles, some connexion with one or other of the branches of philosophical knowledge; but this forms but a small part of them; and though it were ever so fully described, and the description ever so carefully studied, one would be no nearer than ever to the performing of the operations. Thus in the case of dancing, for instance, no volumes, however carefully written, and no lectures, however long or carefully repeated and attended to, could enable one to assume the attitudes, and perform the motions that might be acquired by an hour or two of practice, in imitation of a teacher who could assume the one, and perform the other, gracefully. The reason seems to be, that the body can of itself find out the balances which impart firmness, yet lightness and grace, to the attitudes and movements, much better than they could be found out by the most careful observation, and the nicest calculations of the mechanical philosopher.

Music has a good deal more of science in it than dancing, because it combines the principles of mechanics and acoustics; but still it may very fairly be doubted, whether all the writing that could be written, or all the lectures that could be delivered, could enable a person who had not practised to modulate a single note, or bring any thing like melody or harmony out of the best constructed instrument.

Those two arts, and indeed all the arts by which the voice, the carriage, and the hand can be improved, must be tried and tried again, before they can be acquired. No doubt, after a certain progress has been made, the principles may be studied, and they will be the better understood that the pupil has been instructed in general knowledge; but to begin with them, would be to begin at the wrong end; and we should just as soon expect a country peasant to make an elegant porcelain vase, by our reading him a lecture upon aluminary action, turning lathes, colours, and enamels, or a man who was blind to write us a treatise on the nature of colours, and unassisted by others, to perform what he taught, as to communicate to the understanding any thing which depended originally or solely upon the management of the limbs, the ears, the tongue, or the fingers.

Those accomplishments, whether their object be to give elegance to the body when in a state of repose, grace and spirit to it in walking or in dancing, dignity and safety when riding on horseback; or whether their object be to teach the tongue and the instrument to charm by the sweetness, the melody, and the variety of sounds; or whether, again, they are intended to make the labour of the hands conducive to elegance and utility, must all be acquired from the example of others, and may all be acquired by one who is unable to understand one principle of knowledge, or even to read one line of a book. Every person, learned or unlearned, may by practice make some progress in all of them; but, before it can with certainty be foretold that any one shall become eminent in any one of them, there are certain conformations that must be evinced; and though many have written "about it, and about it," no one has been able, apart from seeing the actual performance, to tell what are the requisites upon which a graceful figure, and movement, or an enchanting musician depend.

In consequence of the impossibility of treating those parts of the subject in such a manner as that the acquisition of them would be forwarded by it, it is not intended to make the attempt. All that the pupil requires in addition to the personal directions and example of the teacher, may be found in the ordinary books; and though there be a sort of philosophy in them, that philosophy does not, like the philosophy of manner, guide us in the first instance to the practical application

To compensate this defect, however, nature herself appears to have made ample provision; for, young people have a natural fondness for those exercises and accomplishments, which few of them evince for those studies, which, while they are a far more severe exercise to the mind, leave the body comparatively at its ease; and thus perhaps, the best general rule is to gratify those natural tendencies as far as may be consistent with the circumstances and other studies of the pupil. Those exercises, especially, which by exercising the body, give firmness to the constitution, at the same time that they give elegance to the form, ought not to be neglected; and perhaps, if a few tens of thousands of hours, during which little girls, whether they be fond of the business, and successful at it or not, are condemned to sit erect on three-footed stools, and fret and hammer any thing but music out of the various instruments in fashion, were devoted to graceful and active exercises which would give occupation to the whole figure, neither the graces nor the fascinations of ladies would be diminished. By this it is not meant to be alleged, that music is not a good thing;—when properly performed, it is one of the most innocent and delightful of all human pleasures; what is complained of is, that in very many cases, a great deal of time is wasted, while that which is acquired at so much expence, is to all who may thereafter be visited with it, an infliction, and not a pleasure. If it can be had good, by all means have it at its fair cost in time; but if it be impossible to communicate the real accomplishment, do not sacrifice other matters for that which is painful in the acquisition, and more painful in the use.

Some may be disposed to ask, how the time of those unsuccessful hunters after the wind is otherwise to be filled up?—to which there is this ready and obvious answer: Let them do *any* thing else which has no tendency toward vulgarity, idleness, or vice, and they are sure to be better employed. To reason people out of their absurdity upon this subject is just as hopeless, however, as the communication of the practice of the art by reasoning is impossible.

There is one accomplishment, however, which depends less upon positive conformation, and more upon general principles than those which have been now enumerated; and therefore the few remaining pages of this volume shall be devoted to a notice of it. The art alluded to is Drawing, which though it be not so popular as music, because it is less calculated for temporary show, and also perhaps because perfection in it requires more general knowledge, is yet far more applicable to the common occupations of life, and far more intimately connected with that portion of education which is mental. In so far indeed, as drawing consists in the mere use of the eye and the fingers, it comes within the class of mere arts; and it would be just as difficult to enable one to make a picture by a lecture upon light and colours, as it would be to play a piece of music by a lecture upon vibrating chords and thorough bass; but still there is more of science—or if you will, a reference to more sciences in the one than in the other, and, therefore, a few words upon it may not be wholly useless.

These shall be divided into two very short sections; one upon the principles of *perspective*, and the other upon the practice of *drawing*.

I.—PERSPECTIVE.

A brief definition of perspective was given in the section upon optics. Perspective consists of two branches, the perspective of lines and the perspective of colours. The former can be reduced to rules, which are strictly geometrical; the other depends upon observation.

The thing required to be done in the perspective of lines, is to give the surfaces such a shape as that they shall represent the true form or picture of that solid of which they are the surfaces, and of which the magnitude, figure, distance, and position are supposed to be known.

Every body, except a globe, changes its apparent shape as we change our position with regard to it, and yet under all these changes, we are always sure that it is the same body. When a globe is at a very great distance from us, we cannot find out whether it be a globe, or merely a flat circular surface of the same diameter, but if we come near to it, or view it in a different position, we find out which of them it is. Take an orange and a piece of paper of the same diameter and coloured exactly like the orange, and if you place them right opposite to you at the other end of the garden, you shall not be able to distinguish them; go near them, and you shall find that if the light falls side-ways upon them, the orange will have a light side and a dark, while the light upon the paper will be uniform. Take one upon the palm of each hand and raise them gradually up, and you will find that while the form of the orange changes not, that of the paper becomes an oval, which gradually narrows till it be at the same height with your eye, and then you see the edge of it as a straight line; or hold the orange before you and turn it round, if it be a complete globe it does not alter, but in the course of a complete turning, the paper will pass from a circle to a straight line, and back again to a circle.

Hence, a surface always narrows in the direction in which it is oblique to the eye.

The room is perfectly square: stand in one corner, look toward the opposite one across the centre of the floor, and mark the shape and position of the floor, the ceiling, and the walls. The floor will appear to rise up, and the ceiling to sink down, as they recede from you, and the two walls will in consequence appear shortened, both at top and bottom, at the opposite corner. Go to that corner, make a mark, and then return to your former place; and you will find that all horizontal or level lines below the mark and upon the two walls will slope upwards as they recede, and that all level lines above the mark will appear to slope downwards. Thus you have another practical lesson in perspective.

Stand opposite the middle of one wall of the room and look to the middle of the opposite one, you will find that the floor appears to ascend and the ceiling to descend, as before, but that, while the other two walls are diminished both at top and at bottom as they recede, the one opposite to you will appear of its proper shape, but smaller according as it is more distant. Look at the point immediately opposite to you, and you will find that all level lines, on the walls that recede, can be traced straight forward so as to meet at that point. Move to the one side or to the other, and you will find that the point will move along with you, that the wall toward which you approach will shorten and the other will lengthen. This is almost the whole doctrine of the perspective of lines.

The point before you, and precisely of the same height with your eyes, is called the centre of the picture, and all lines which recede, and are below the eye, rise upward, while all that are above the eye sink downward; and if you carefully attend to those simple principles, you will soon acquire as much expertness in perspective as will prevent you from falling into those errors which some of the best painters have not been able to avoid.

The aerial perspective must be studied by a careful examination of nature.

II.—PRACTICAL DRAWING.

Drawing is, properly speaking, the art of exhibiting with accuracy the outlines or boundaries of objects, real or imaginary, on plain superficies. From its great utility in making us acquainted with the forms of those objects which we have no opportunity of seeing and observing, and in preserving those lines for the information of others long after the originals have perished or been entirely changed, it has been highly esteemed in every civilized country, and partially cultivated in the rudest and most barbarous. It is an art, too, which may be cultivated so as to be eminently useful, by those possessed of the most moderate degree of talent, in every situation whatever, and with the aid of materials which cost almost nothing.

Practical drawing admits of various methods of division, according to the nature of the materials used, the manner in which they are used, the objects represented, and the way in which they are represented. The most simple division is into *outline* and *shading*.

The *outline* is the foundation of excellence in all the other parts of the drawing, and ought therefore to be the primary subject of attention. To be able to draw it expertly and readily requires not only a certain correctness of eye and dexterity of hand, but also some acqaintance with geometry, anatomy, and perspective, in order to enable us to give to the objects represented their just proportions, forms, and appearances.

The materials used in drawing outlines, are paper, lead, chalk, charcoal, Indian rubber, a case of mathematical instruments, a drawing-board, a Gunter's scale, and a T square.

The best black-lead pencils are neither too hard nor too soft, and may be known by being easily cut, and at the same time possessing such solidity and firmness as to bear considerable pressure without breaking. They possess this advantage over chalk or charcoal, that the lines which are made by them may be completely effaced, and of course renewed until they are rendered sufficiently correct.

Indian rubber, composed of the gum of trees, which grow in India and South America, is used for effacing any line which may have been improperly drawn and for removing stains from the drawing.

The paper which is best adapted for drawing outlines, is thick, strong, and rather rough, and if the outline is not to be finely shaded afterwards, cartridge-paper may be used in preference to any other, as being cheaper and capable of undergoing more fatigue.

The drawing-board is used for stretching the paper and preventing it from being creased during the execution of the drawing. Previously, however, to this operation, the paper should be slightly spunged with water, laid between some folds of blotting-paper and then thoroughly smoothed with the hand. Its edges may then be fastened to the board by glue.

The mathematical instruments are absolutely necessary in drawing plans, maps, &c.; but in other cases, where exact admeasurement is not required, they ought not to be used, as they prevent the student from measuring by the eye, and acquiring that degree of confidence in it which is necessary to ease and facility.

The T square is used for drawing perpendicular and horizontal lines.

Besides the black-lead pencil, chalks, charcoal, Indian ink, &c. may be used in drawing outlines, but as they are also used in shading, it is better to defer mentioning them till we come to treat of that subject.

Outlines.—In beginning to make outlines, the simplest subjects ought always to be preferred, and those with which the student is best acquainted; but before proceeding to this, a certain portion of time ought to be devoted to the drawing of lines of various kinds, for the purpose of acquiring correctness, facility, and expedition.

Straight lines are the best to begin with; and should be drawn perpendicularly, horizontally, and sloping to the right or left, till they can be easily made of any length, and in any position. Perpendicular lines being the most difficult, should be most frequently practised. Circles and ovals, either erect or flat, ought next to be attempted, and continued till they can be correctly formed. The best way of drawing a circle is to make dots at the top and bottom of the line which would pass perpendicularly through it, and then to draw first, the semicircle to-towards the left hand, and lastly the one toward the right.

When the pupil has practised sufficiently to be able to draw all sorts of lines and circles with ease and correctness, she may then proceed to copy objects, first from drawn or engraved outlines, next from shaded copies, then from statues or casts in plaster, and lastly from nature.

In copying objects from drawn, engraved, or shaded outlines, those which are simplest and on the largest scale, ought to be chosen first, and great care should be taken that the subject of the copy be one that has been correctly delineated. The copy ought to be well studied, and every part of it perfectly familiar to the eye, before it is attempted to be copied. By way of assisting the pupil in this process, a few dots marking the principal points and boundaries in the outline to be sketched may be set down. The outline ought to be lightly touched, and then examined at such a distance as to enable the pupil to see the whole before finishing any part of it. After this has been done, it should be carefully compared with the copy in all its details, and amended wherever it is found to be erroneous.

As the practice of copying, however, is apt, if continued for any great length of time, to make the pupil a servile imitator of others, and to make her resort to all those artificial and pernicious means which have been adopted for abridging the labour and rendering the copy more correct; she ought, as soon as possible, to copy from nature,—using the black lead pencil, both on account of its being more easily managed, and of the facility with which its lines may be effaced. And here, as in copying from drawings or engravings those subjects should be chosen which are least complicated in their details, and of which the grand outlines can be most easily executed on account of their simplicity, clearness, and distinctness. Arches, leaves, trees not particularly branching, gates, rustic implements, &c. and all single objects should be carefully practised for a considerable time, in order to gain an acquaintance with their forms and parts; otherwise, when the pupil proceeds to more difficult and extensive subjects, her eye will wander over them without any proper discrimination, and she will find herself embarrassed and confused with the execution of what would otherwise have proved both plain and easy.

Animals may next be attempted, and considerable time ought to be devoted to making correct representations of them, because one or other of them, and frequently several, occur in every landscape. The human figure may then become the subject of the pupil's attention, and rendered in every respect familiar to the mind; first, by the study of drawings, or engravings, representing it in every possible position and state; and, secondly, by comparing these carefully with the figure as it exists. In pursuing this study there are three principal things to be attended to; form, attitude, and expression. By form is meant the distinction of age, sex, profession, dispositions, character, and the just proportion of the several parts; all of which have considerable influence upon the human figure. Thus, for example, the head and trunk of a child are larger in proportion to the other parts of the body than those of an adult; the feet and hands of a female are smaller, and the limbs shorter, in respect to the body, than those of a male. Persons inured to labour, and those who are totally unoccupied; those who live freely, and those who are temperate, &c. present very different appearances, and must not be confounded. The country too, to which they belong, exercises a similar influence. A striking difference, in fact, will be perceived, not only between natives of the same quarter of the globe, but even between those belonging to different districts of the same country.

No proportions can be given which will hold good in every case; and the pupil ought, therefore, to study nature, the only true and infallible guide, wherever any of her productions are to be represented. The following may, however, be of some use till familiar acquaintance with nature has been attained. The distance from the tips of the fingers of each hand extended horizontally, is equal to the height of the figure from head to foot; the whole figure is equal to ten faces in length, and the face is divided into three equal parts; from the hair to the insertion of the nose; from the insertion of the nose to its extremity; from its extremity to the bottom of the chin; from the chin to the collar bone is twice the length of the nose; from the collar bone to the lowest part of the breast is one face; from that to the navel another, to the groin another; to the upper part of the knee two; the knee is a half a face in length, from the lower part of which to the ancle is two faces, and thence to the side of the foot is one half. These proportions might be continued to any extent; but as they will never enable any one to draw tastefully or well, and are besides not easily remembered without actual admeasurement, it is not deemed necessary to multiply them.

In regard to attitude, or the placing of the body in a proper position, and giving its different members that situation which is required by the figure, it is only necessary to observe, that the whole of the figure must harmonize; and that it must not be represented as in a situation which in nature it would not admit of.

Expression is the most difficult part of the art, and cannot be attained without long practice and close observation of nature. When perfect, not only does the countenance represent the emotion of the mind, but the arms, limbs, and every part of the frame.

When some degree of proficiency has been attained in these preliminaries, the pupil may proceed to draw landscapes from nature.

A landscape is a representation of some portion of the earth, with the several objects on its surface, and the sky over it; it may be either real or imaginary. When a portion of the sea forms a principal feature in the landscape, it is called a sea view, or sea piece, and when the interior of a city is the subject, it is called a street view.

In sketching landscapes from nature, some precise determination must be formed, previously to sketching any part of it, as to what the drawing is to include; so that it may neither be confused from the multiplicity of objects, nor any part of it be out of proportion to the rest. The simplest method of accomplishing this object is, to take the edge of the paper or sketch-book, hold it level, and, raising a hand at each extremity of it, move the whole till the space intended to be sketched be bounded at the bottom by the edge of the book or paper, and on the sides by the hands;—carefully observing during the time of doing this, what proportion each object within the inclosure occupies both as to height and depth. In the delineation, those objects which occupy the foreground, as it is called, or bottom of the landscape, ought to be first sketched; beginning at the left hand and sketching towards the right, so as to have the whole that is done under the eye, and never, in any case, from the two sides on account of the difficulty of filling up the intermediate space with proper accuracy. Having sketched the objects in the foreground boldly and carefully, those in the next field may then be proceeded with, rendering the lines gradually fainter as the distance increases. In regard to the sky, unless the sketch is intended to be the foundation of a coloured drawing, it is not necessary to take any particular notice of it.

Views may be taken at all seasons; but the autumn, when the sky is most transparent, and the flying clouds afford the finest contrasts by their lights and shades; and the leaves of the trees become interspersed with every variety of colour is the most proper, both for exhibiting the skill of the artist and affording the finest views. The sun should be on one side, and toward the left hand, if possible; but the pupil ought to accustom herself to sketch in all lights.

Various contrivances have been invented and resorted to for the purpose of sketching landscapes; but though several of them are of great use to those who cannot or wish not otherwise to succeed, their tendency is pernicious and hurtful to the main object of the pupil, viz. to draw readily and correctly by the sole aid of the hand

and eye. Those therefore who wish to become proficients in the delightful art ought never to resort to them.

The correct delineation of trees, being one of the most difficult parts of landscape drawing, ought to be studied with the greatest attention and care; until those which occur most frequently, such as the pine, the oak, the elm, the beech, the fir, the birch, the poplar, &c. be perfectly familiar in all their parts, and can be executed with ease and accuracy.

When the pupil has acquired proficiency in making outlines, she may then proceed to copy the pencil sketches in chalk, and to shade and finish them.

Shading.—By the shading of objects is meant, giving to the representation of them the appearance of reality, by an imitation of the natural effects of light. This can only be done by one who is acquainted with the principles of optics; or, in other words, who knows the effects which light produces when it falls directly or obliquely on objects, and the changes which it undergoes in passing through such as are transparent. Light may be either direct, that is immediately from the sun or some other luminous body; or reflected, that is, thrown back from a polished surface upon other objects. Reflected light is always colder and fainter than direct light, and in general falls in a direction opposite to it. Natural and artificial lights ought never to be mixed up in the same piece. Artificial light may, however, be frequently used with great advantage where natural light could not, especially when it is wished to represent the interior or under part of an object.

One light may be made to fall on a drawing in three different ways; from before, behind, and parallel. The front light is the most brilliant and most easily represented; that from behind, the most gloomy and striking; those coming directly from before or behind being the worst, because in the one there is no shade and in the other no light. Lights and shades should always be most distinct in those objects and points of objects which are nearest.

All the different methods of shading may be reduced to two, according to the materials used; shading with dry and shading with moist colours. Both have their advantages and disadvantages; but in the case of a beginner, proficiency should be attained with the several kinds of dry colours, before attempting to use the moist. Black lead should be employed first; and the proper manner of proceeding is to lay on the broad masses of shadow in parallel lines, crossing them, if necessary, with other lines in a slanting direction, and marking out the details afterwards. The effect may be considerably softened by rubbing them with the finger, or with a piece of pointed cork, a leather stump, &c. The disagreeable glaze of the lead may in some measure be taken off by laying the drawing for a few seconds on the surface of creamed milk.

Chalks are of several kinds. Black chalk is the kind most frequently used, from its admitting of greater depth and producing a much finer contrast with the ground of the white paper than any other. It is sometimes employed in conjunction with the white chalk, but the effect is seldom good. Red chalk may also be applied to a white ground, and used along with the white chalk for such a ground as would be produced by the mixture of equal portions of red and white; but black and red chalks can never be used in the same drawing, unless there is at the same time a mixture of browns, yellows, and greens.

Crayons are also employed in shading, either on crayon paper, or on common paper prepared by a dead colour, and may be very advantageously used in landscapes, especially of wild mountain scenery, or in representations of animals, human figures, and likenesses. The principal objection to the use of crayons arises from their incapability of representing sharp angles or small objects with sufficient force and distinctness, and from the drawings, which are executed by them, being liable to be spoiled by any damp. The latter disadvantage may in some measure be overcome, and the colours fastened, if the drawings be made on paper without size, by laying the drawing on its back in a hot solution of isinglass, until it appears slightly wet through.

Moist colours differ from dry, in requiring some preparation before being used.

Besides the colours, (of which hereafter,) a marble or porcelain slab or an ivory pallet are necessary, for the purpose of rubbing them down, along with hair pencils for laying them on, and a sponge.

Hair pencils should be as large as can well be managed, and may be known to be good by coming to a firm point when wetted, and by springing straight again when bent, without any separation of the hairs. Six of different sizes, and one as large as one's finger, are sufficient for shading with a single colour. A pallet knife, made of ivory, is also occasionally necessary, for grinding and mixing the colours. Only a small portion of gum should be mixed with them, otherwise they are apt to crack and fall off.

Shading in moist colours may be performed in three different ways; in a single colour, in water colours, and in body colours or distemper. Shading in a single colour ought to be first learned, because it gives the pupil the best idea of light and shade.

Single colour.—The colours most commonly used for this purpose are Indian ink, sepia, and bistre.

Of these, Indian ink is the most durable and the easiest to work. When good, it is light in proportion to its bulk, and feels smooth whilst rubbed against the teeth: when bad, it is hard and gritty. It is made available for use by rubbing it gently on the slab with a little water, till the necessary quantity has been melted down; and care ought to be taken that that quantity be sufficient for the purpose to which it is to be applied, before the shading is commenced, because it is difficult to make more of exactly the same tint, and because the shade would run the risk of being spoiled by the interruption.

Three or four different kinds of shades may be laid on with Indian ink, plain tints, or shades of one colour, shades softened on one or both sides, and shades softened all round. The plain tints are used for objects whose surfaces are flat; the second for those which form small portions of circles, as cornices, &c.; the third for cylindrical bodies; and the fourth for globes, or globular hollows.

In plain tints the pupil should begin at the upper corner of the shade towards his left hand, and proceed regularly downwards, wetting the paper equally and taking care that no part of it should be missed, or a drop left upon it. If the surface be very large, it should be moistened with a sponge; but not much, otherwise the tint would be apt to run into clouds.

In laying in a shade softened to one side, it is necessary to have a pencil on each side of the stick, one for the tint and the other for water; both of which should be filled before the shade is begun. If the shade be narrow, an equal line of colour should be drawn along the dark side; the pencil should then be turned, and that which has the water in it should be borne along half on the line of colour and half on the paper, until the edge of the tint be made to vanish smoothly and gradually. Where one stroke is not sufficient to complete the shade, care must be taken that blots be not made at the joinings.

In laying on a shade softened both ways, it may be done without moistening the paper, first on the one side and then on the other; but in one which has to be softened all round, the ground should be moistened, and the shade laid on to its full depth, or not, according as circumstances may require. The more frequently a shade is worked over, it is softer, more beautiful, and more durable.

The lights in a drawing shaded with Indian ink must always be formed of the paper, and must in general be left out. In some instances, and these very rare, they may be stopped up by the application of the yolk of eggs, white lead mixed with oil, and varnish and pipe-clay, formed into a paste with water. The lights may also be struck out with a clean pencil, while the shade is wet, and if they are small and faint, after it is dry.

Sepia is an intermediate colour between Indian ink and brown, and is used in the same manner as the former; and has this advantage over it, that it may be glazed or washed lightly and carefully over with a very faint tint of any warm orange brown; such as, a weak infusion of tobacco, a solution of liquorice, terra di sienna, &c. varying it of course with the tone of the drawing.

Bistre is a warmer brown than sepia, and is used in the same manner as the other two, but does not work so easily nor adhere so well to the paper. The ground should be brown both for bistre and sepia.

Any other colour may be used singly as well as these, making the ground a faint wash of the colour itself; but with the exception of indigo and Prussian blue, there are few which have the proper depth.

There are several kinds of water colours; but they may all be arranged under the general heads of red, blue, yellow, green, brown, and black. In shading with water colours, both lights and shadows have colour on them; the colours are transparent, and the lights are produced by the paper appearing through the colour. A colour is called transparent, when the other colours laid on the paper shine through it; and opaque, when it has not that quality. These colours are either animal, vegetable, metallic, or composed of earthy substances; and may almost all be mixed with each other, except metallic colours. They are prepared by being ground in the first place to a fine powder, and afterwards in gum water. They may, however, and generally are, purchased in cakes, which are melted in the same way as Indian ink. The shadows on every colour should consist partly of the colour itself, and partly of a dead colour or neutral tint, which should vary with the tint on which it is laid, and also with the distance. The proper shadow for any colour may be discovered, by placing the colour in a strong light, and then interposing some object that may cast a shadow on it. In this way, red will be perceived to have purple or blue; blue green, brown black, and yellows and oranges brown.

The shadow must vary with the distance of the object: those which are very distant, whatever their natural colour may be, should have their shades blue or grey, formed of Indigo or Prussian blue and a little light red. As they approach nearer, the shadows should have more red, with a small tinge of black; and when very near, more black, and burnt amber may be added. In near objects, however, the natural colours must be more or less attended to.

This variation of colours is called ærial perspective.

There are two ways of shading in water colours; working in a neutral tint, and working in colours. In a neutral tint, all the shades and shadows are laid on with some one colour, in the same way as a drawing with Indian ink, and then finishing the several objects with their proper colours after it is dry. The best colours for this purpose are grey, blue, red and black.

In working in colours, the lights and shades are laid in of their proper colours at once. In the latter case, the colours are more brilliant, but less durable and soft in appearance than in the former.

Before laying on dead colours and tints, the pencil lines in the drawing should be obliterated with Indian rubber; and the whole afterwards smartly wiped with a wet cloth, to take off the loose colour.

Water colours may be preserved by copal or any other transparent varnish, after being secured by isinglass or parchment glue. This mode of preserving them is, however, objectionable, in so far as the varnishing becomes discoloured in the course of time, gives considerable harshness to the effect, and at the same time takes away the solidity of the colours.

Shading in body colours is altogether distinct from the preceding methods, and properly speaking, forms a part of painting; the whole of the ground, whatever it may be, being concealed, and the lights and shadows formed entirely of colouring matter. The best paper for this purpose is soft, somewhat rough and spongy. Two or three sheets of cartridge paper, well damped and glued together, and stretched on the drawing board, will be found to answer remarkably well. The colours must all be opaque, and if not so naturally, must be rendered such by the addition of other colours. In finishing, however, the tints may be made both deeper and richer by glazing them over with transparent colours; taking care that the body colour be completely dry before this operation is commenced.

Body colours should be prepared in a size of isinglass, parchment scraps, or fine glue, made of such strength as to be just fluid, and no more, on a moderately warm summer's day.

Drawing in body colours is best adapted for the representation of buildings, and other subjects which have a hard and sharp outline, or which require a bold relief; but it may be blended with water-colour shading, and even with painting in oil, so as to produce a much more brilliant effect than would be produced by any of them singly. It is also the best suited for the decoration of rooms, and for such objects as are to be viewed chiefly by candle light.

Body colours may be preserved by white spirit, or any other transparent warmth, but unless great care is taken in securing them with size and passing the varnish lightly, the lights are very apt to be injured.

It is not easy to give any directions for the colouring of landscapes which would be useful. Due attention to nature, and to the works of the best masters are the proper instructors in this department. In general, however, the lights and shadows should be grouped in masses, and one general tone of colour given, according to the character of the landscape. If the lights of the sky, for example, be red or orange, the lights on the ground should be warm and rather dusky; if the lights of the sky be clear, those on the earth should be transparent, &c. If the landscape be one of mountain scenery, the air should be clear and transparent, and the lights never hazy unless through the intervention of mist, and on the other hand, if it be one of low lands, containing towns and cities, there should always be a certain degree of haze and smoke.

In colouring the greatest attention must be paid to chiaro-scuro, that is, to the distribution of lights and darks in a picture, so as to give proper relief to the figures, the best effect to the whole composition, and the greatest delight to the eye. No one can become a good artist without a thorough knowledge of the chiaro-scuro—as it is by its proper application that he is enabled to make the various objects in his picture project or recede, according to their relative situations or distances.

Painting in oil does not differ in principle from painting in water colours. In the former case, however, the colours are longer in drying, and may, consequently, be laid on in much greater quantity at a time than water-colours; while, from their being less liable to be affected by air and damp, they are much more permanent. This branch of the subject must, however, like the preceding, be studied at greater length than it is possible to treat them here, by those who are desirous of acquiring proficiency in the art.

Some mention already has been made of varnishing. Its principal use is in forming a defence against the action of the air, and giving a lustrous and shining appearance to the body to which it is applied. Resins are the bases of all varnishes, and are prepared for the purpose by being dissolved by fixed oil, volatile oil, or alcohol. The essential varnishes are those used for painting.

THE END.