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A

POPULAR GUIDE

TO THE

OBSERVATION OF NATURE;

OR,

HINTS OF INDUCEMENT

TO THE

STUDY OF NATURAL PRODUCTIONS AND APPEARANCES, IN THEIR CONNEXIONS AND RELATIONS.

BY ROBERT MUDIE,

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NEW YORK·

HARPER & BROTHERS,

NO. 82 CLIFF-STREET.

1836.

PREFATORY NOTICE.

PERHAPS it may be more candid than wise in an author to express doubts respecting his own book; but the public deserves candour from every author, and gratitude from one who has been previously heard with attention and kindness.

On the present occasion, I feel an embarrassment, which I have not previously felt upon ushering any of my little publications into the world. Hitherto, whatever of strength or weakness I have possessed, I have stood alone in it; so that whatever of censure I may have merited could only fall upon myself. Now, however, I am merely making a little addition to a series containing the labours of many authors; and that may suggest comparisons, the test of which I may be ill able to abide.

There is one other comparison respecting which I feel that I am "under the yoke," and that is the comparison of what I have written with the title, "A popular Guide to the Observation of Nature." These words taken literally are presumptive; and therefore I may be permitted to add my interpretation of them. A "Guide to Nature," taken literally, would be arrogant, because it would be assuming a knowledge of the whole of that of which the most diligent inquirer can in the longest life know but little. But a guide to "Observation," taken unexplained, is even worse; for unless it be in the use of instruments and apparatus, I know not how one man can guide another to observe. Means may certainly be taken to tempt a person into the fields: but if he will not use his own senses when he is once there, his case is hopeless. "Hints of Inducement to the Observation of Nature," is, therefore, what I have been reduced to in the execution of the volume, and, consequently, that should be taken as the fair interpretation of the title.

Even that is no easy task. Anybody could write a panegyric on nature; and so could any one who had access to the printed books, and a talent or turn that way, compile a manual of the outlines of Natural History, or of the details of any, or all, of the departments of it. But the first of these would not have accomplished the object which I had in view; and the second would have defeated that object. Mere panegyric does not put anybody in the way of knowing what it lauds; and as for writing on Natural History, the quantity of that is already out of all measure compared with the observation. There is not an apartment in the densest part of the British metropolis in which it would not be possible to "grow" a naturalist, who should utterly confound the sharpest eyed and clearest headed man who ever looked at real nature, and reflected on what he saw. That is merely a fashion, however; and, like all fashions, it affords no pleasure, except when it is so worn as to attract public notice. Now, I have no wish to set up

₃ tailor or the milliner; and 'ainly not willingly do any 'atural History a matter of

...ı who observes nature is not to be supposed to collect an audience every time that he looks abroad upon the earth or upward to the sky, and though he be ever so zealous a member of any of the societies which have for their object the advancement of his favourite study, it is but rarely that he can have any thing worth communicating even there. So that a man's contemplation of nature is, like his religion, a subject of personal pleasure to himself; and, as is apt to be the case with religion, if he makes too much parade of it before the world he runs some danger of losing it. Besides, although there are few occupations more pleasant than rational conversations on Natural History with friends, especially with young friends, when one can instruct them without appearing to act the schoolmaster; yet still the sweetest hours of a man's converse with nature are those during which he has it all to himself. It is then that the career of thought runs free and far as the light of heaven; and vanity is subdued, and bitterness is sweetened, and hope is elevated, by the comparison of one's own little acquirements and cares, with the mighty expanse around, and of the perfect nothingness of this life in respect to that which then rises clearly and convincingly in the anticipation.

That is the feeling of natural objects which I have wished to excite and encourage: if that end could be seen and kept in view, the observation of the facts would be a very easy matter; and, as every person must *begin* observation in his own way, or else lose all the pleasure of it, the less of detail which was mingled with the attempt to excite the feeling, it seemed to me the better. Following my own judgment on a subject which is so perfectly original that, so far as I know, there is not a book or even a page expressly on it, I may be wrong, and may have failed; but even in that case, I shall not feel so much humbled by absolute failure in an original attempt, as I should have done at inferiority in an imitation.

The plan which I have adopted has been to throw momentary glances on those portions of nature which struck me as capable of reflecting the greatest breadth and brilliancy of light; and such as I thought the most likely to induce the reader (and more especially the young reader) to return again to the subjects, and work out the details for himself. I have studiously avoided system, because it is to be wished that every one should enter upon the observation of nature unfettered; and I have also been anxious to steer as clear as possible, not only of hypotheses, but of theories.

In some places I have called in the aid of numbers, to estimate causes of action which are not generally estimated in that way; but immense as some of these numbers may seem, they are all under what the legitimate deductions from the data can bear. At page 76, it is stated that the hand—that is, the muscular feeling—can divide space to greater nicety than the eye; and as that is not in accordance with the common belief, I shall here state my authority. Mr. James Gardner, the geographer, can rule, blindfolded or in the dark, with the natural angle of a diamond on hard white metal, fifty-one lines in the fiftieth part of an inch, and cross them at the same distances, with an additional line each way to complete the number of squares. There are thus 2550 spaces, or 2551 lines in the inch in length; and there are 6,502,500 squares between the lines in the inch. These too are more regular in their sizes than the majority of people could draw lines by the eye at, say the fortieth or even the twentieth of an inch. Small as that tactual, or rather muscular, division is, the limit of it is in the instruments and not in the feeling; for if it were possible to obtain any cutting substance sufficiently fine, there seems no reason why each of those little spaces should not be equally divided into any number of parts; so that, if the eye could see the work after it is done, it is probable that the muscular feeling could discriminate down to the primary atom.

A glance at the table of contents will show the leading subjects, and the order in which they are placed; but as the book is intended to be one of excitement, and not of reference, the reader must not be surprised if upon any, or all, of the subjects, the impression left on his mind is merely the desire of knowing more. Having said thus much, I leave the volume to its fate, anxious to meet with commendation, but not unprepared to bear censure, if that shall be the way in which the *chances* turn.

ROBERT MUDIE.

Grove Cottage, King's Road, Chelsea,
November, 1832.

ANALYSIS

OF

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A

POPULAR GUIDE

TO THE

OBSERVATION OF NATURE.

SECTION I.

The Necessity and Use of Observing.

So natural is observation to us, that we in common language allude to it in cases where there is really nothing to observe. When we are perplexed and in difficulty about the absent or the future, and take counsel together in order that, by our union, we may overcome the difficulty, our words of mutual encouragement are, "Let us see;" and when we have exercised our thoughts rightly, and the difficulty is overcome to our mind, our expression of triumph is, "Now we see our way." Also, whenever we fail in that which we attempt, or err in the performance of it, the cause of the failure or the error is, that "We do not see our way." To see our way, and to see it clearly, ought therefore, in all matters, to be our very first object. Indeed, the only difference between the ignorant and the intelligent is, that the former grope, as it were, in the dark, and the latter see the end of matters, as if the road were open and straight, and the noon-day sun shining upon it.

This seeing with the mind—this light of the understanding, is far more valuable to us than the common light of day. It is our own—a light within us—nothing can cloud it; darkness itself cannot hide it, if it is once kindled in the proper manner, and to the proper extent. But though its illuminating influence be within, we must at first light it up from without; and though it be the candle of the mind, it can only be lighted by knowledge obtained through the medium of those senses with which our all-bountiful Creator has furnished us. The exercise of those senses is OBSERVATION; and that is the fountain of all knowledge, and the original source of all pleasure, whether that which we immediately know or enjoy be or be not present to the senses. What we thus obtain is unalienably vested in us for the whole period of our lives. That which we have in our coffers may decay through time, or be destroyed by accident; or it may be taken from us, or we from it; and that which is told to us by others may be false, or we may forget it because of the weakness of the impression that it made; but that which we see with our own eyes, or otherwise perceive with our own senses, is proof against accidents, against time, and against forgetfulness.

In the case of old people, even after their powers of observation are decayed, and when themselves are, as we would say, in their dotage, we find that they enjoy themselves and are happy in the memory of their young years. Not only so; but when, insensible, as it were, to the present, they glance back for pleasure to the days that they have lived, the earlier in life the occurrence is, they remember it the better. And past events, and past objects, get more shadowy, not as they are more remote, as is the case with views in space, but as they are nearer to the present time. The man of fourscore may forget that he was a man of threescore and ten; but he never forgets that he was a boy; and one of the reasons why very old people are so fond of the society of children is, that the recollections of age, and even manhood, are comparatively faint on their memories, and they actually remember, and think, and enjoy themselves as children, after they cease to find pleasure as men.

We call those years of extreme age—those lingerings by the grave's brink, "a second childhood;" and the thoughtless among us regard the appellation as one of pity, if not of derision. But it partakes of that sound philosophy and perfect wisdom which are contained in all proverbs and by-words which pass current among men, and are sanctioned by the general voice. Why, indeed, is it that any expression becomes a proverb or by-word? Is it not just because the truth of it is so plain and so striking, that everybody, learned or unlearned, assents to it at once; and that it cleaves to the memory as if it were a fact of which our own senses have been the immediate evidence?

There is something very delightful, as well as something very instructive, in this revival of the memory of youth in the very extreme of old age. It is delightful to think that the mind is independent of time, and not affected by that decay which wastes the body, and in the end brings it to the dust. Were there no other proof of the mind's immortality—no other hope of a life beyond the grave, that alone would be a demonstration of it, as clear and satisfactory as we can obtain of any truth whatever.

But the lesson is more to our present purpose: Why is it that, when we come near to the end of life, and look back upon it, the events of our young years are the most fresh to our memory? It is not the mere youth; for there is a period younger still, of which we can remember nothing. Nobody remembers being born, and there are few that remember being carried in the nurse's arms. But if it is not the mere fact of our being younger that makes us remember better, so neither is it that our minds have more power. The power of the mind has nothing at all to do with goodness or badness of memory, or with the simple fact of remembering. Persons of weak judgment have often the best memories; and have them just because their judgment is weak. Those who have been much employed in educating young people, and have attended to the subject, and been capable of understanding it, know very well that those pupils who can, without effort, learn every thing by rote, are with difficulty made to understand any thing; and grown-up persons, that can quote "day and date" for every trifling occurrence, can seldom give a sound or valuable opinion upon any matter of importance. I knew a fool, who was placed under the charge of a clergyman in the country, as being utterly incapable of conducting himself in ordinary matters (he was a young man of fortune, and did not need to work, except for his amusement), and yet he could repeat every word of the clergyman's sermon, tell how many people were in the church, how any one that sat in a pew named to him was dressed, or who did or did not contribute to the poor. He could do that for any Sunday, if you gave him any hint of it; last week, or last year, was all the same to him. His memory was, in short, as perfect as memory could be; but then he had no judgment in the using of it; and so, when in company, it often made him seem, and not unfrequently made other people feel, very ridiculous.

It would not be fair to mention names on such a subject; but the fact is beyond question, and it bears so closely and forcibly upon the object of this section, and indeed upon the whole purpose of this little volume, that I shall mention one other instance. Some time ago, there was employed, as a reporter to one of the morning newspapers, a gentleman of the most amiable character and the most upright conduct; but one who never made a profound or even an original observation in his life, unless the uncouth juxtaposition of two matters of memory, between which there is no congruity or connexion, can be regarded as a sort of ludicrous originality. He had been long a faithful labourer on the establishment, and so he attended the Upper House, where the every-day duty was then easier than that in the Commons. He took no notes whatever, and yet, if an unexpected debate sprang up, and he was left for hours before any one went to relieve him, he could write out the whole verbatim. While listening, he was literally "held by the ear," so as not only to be incapable of thought, but almost of the use of all his other senses. In the office, too, he was the oracle of facts and dates; and, as he had read the newspapers diligently for many years, he knew almost every parliamentary sentence, and could tell by whom it was spoken, on what evening, what was the subject of the debate, and who were the principal speakers. His memory was chiefly a memory of sounds, and probably that was the reason, at least one of the reasons, why his judgment, weak as it was for the opportunities he had had, was so very much superior to that of the young man previously mentioned.

Those two instances, the one of which would be, in common language, called a "natural," and the other a "very soft-headed man," are not given with the smallest intention of undervaluing the fact, or, as it is usually called, the faculty of memory. Far from it, the fact of memory is the foundation without which there can be no structure of knowledge. Those are merely instances in which there was plenty of foundation, but very little structure; and the perfection of the matter consists in the two agreeing with and being worthy of each other. It would be easy to give other instances; but some will occur to every observant reader; and indeed those mentioned are decisive of the point.

It is not from the mere fact of our being young when they happened, that the events of our youth return to us in our old age, while those of the more energetic, and therefore more valuable period of our manhood, which, in respect of time, are more recent, are forgotten, and "will not come when we do call them," call with what earnestness we may. As little is it that our judgment is in youth more acute; for we have seen that the most perfect memory—a memory probably more perfect, and certainly more minute, than that of any person of superior intelligence—can exist with very little judgment, or with none at all. Is it the novelty then? No; not altogether, and probably not at all; for in that case, we would surely best remember the greatest novelty; and that unquestionably is the first sight we get of the world.

The reason why we remember cannot be explained by the individual things that we remember; and as little can it be owing to any act of the mind, considered as such. Where then shall we seek for it? We shall best answer that question by putting another, and pausing to weigh it well before we answer it. How came we by all that we think and know, or by all that we can think? The answer to that question, if the right one, will show us where the mine of knowledge is, and how that mine can be worked; and if we know these, no matter how small our present stock of knowledge may be, we shall soon and easily obtain more—as much more as we please.

That is a very simple question,—a question the answer to which requires no philosophy, no learning, no reading, nay not even the faculty of speech; and yet that question is the seal upon all the possible knowledge of which we are not in possession; and many of us live long and go down to our graves in ignorance merely because we do not see, or, seeing, will not take the trouble to break that seal. That truth is so very important that we must dwell a little upon it. Some may think it would be better to give the knowledge itself than merely point out the sources from whence it may be derived. Many persons would, no doubt, consider that gift more advantageous, or, at any rate, more amusing, just as schoolboys sometimes like their play better than they like their lessons,—or, to come nearer to the point, just as lazy folks like better to have things given them, than to make them for themselves, or to be told how to make them. But then we should have some difficulties. Some readers would know the subject better than we do; others might not understand us, not from any want of ability (for anybody may understand any thing, if the explanation of it be plain and clear enough); and people's tastes are so very different that perhaps not one in ten of those to whom the information was novel and intelligible would care about it. Besides, why should the man who writes a book treat all his readers as if they were beggars? It is disgraceful to beg any thing, if we be able to get it by any other means; and there are few names that offend a man of spirit more than to call him "a beggar." It appears to be more humiliating, too, to beg knowledge than to beg any thing else; for few men are satisfied with their wealth, but most are satisfied with their understanding; and, insulting as the word "beggar" is, it is not half so insulting as the word "fool."

The only ground upon which begging can be justified is that of inability to work on account of weakness, disease, or decay. Indolence is too often the real cause; but it admits of no proper excuse; and shame, or even the whip, rather than alms, should be given. But there is no disease or decay of the mind; and therefore the man who begs for knowledge can have no plea but idleness, and shame or the whip ought to be more especially *his* reward. There is no harm in pointing out to him where the knowledge is to be got, and how he is to get it; but there the lesson of the schoolmaster ends; and if the scholar be still backward, "lay on the birch."

In getting any thing, all that we need to know is where it is to be got, and how it is to be got. The "how" is always "how it was got before;" and the "where" is also "where it was got before," if the store then be not exhausted, or in the possession of another. But knowledge is inexhaustible; and nobody can make a property of it any more than of the light of the sun. No man, be his power what it may, can make an exclusive property of that. Men may be deprived of it by shutting them up in dungeons; and it is the same with knowledge. You can hinder from it only those whom you have the power and the means of shutting up; and then the knowledge is not one jot more your property than it was before. The way and the means by which we got the knowledge which we do possess, are therefore the way and the means, and the only way and the only means by which we can get more; and if we use them rightly and diligently, the getting is a matter, not of doubt, but of absolute certainty.

Let us consider those means: Do we gain knowledge of a subject by thinking about it? We do not. By thinking, we may arrange our knowledge, put it into new shapes, and make it the means of letting us see what further knowledge we want, and what service that future knowledge is to be to us, just in the same manner that a tradesman, by examining his stock, can so arrange his goods, as that he can at once put his hand upon what he wants, and also know what additions it is most necessary and proper to make; but just as a tradesman cannot, by any examinations and arrangements add one tittle to the *quantity* of his goods, so neither can we, by any thinking in which we may engage, add any thing new to the stock of our knowledge. By thinking, we can arrange what we do know, so that we can more readily use it, and we make room for other knowledge; but, *we cannot think ourselves into an acquaintance with even the simplest thing that we do not know by some other means.* It is the belief that we can; that thought will do what thought never did, can do, or was intended to do,—which lies as a stumbling-block in our path, and hinders us from knowing a great many things that would be very useful as well as very pleasant to us.

Then, how do we come by our knowledge? A simple case will show that better than many words about it: It is a lovely summer morning, the sun shines brightly, the air is perfumed by the scent of the roses; and the songs of the birds are very delightful music. Be it so. How do we know that the sun shines? "We see it with our eyes." Very true: we see the light, and we see the sun; and as we never see that kind of light without seeing the sun, and never see the sun without seeing that kind of light, we in our thoughts associate the two together, and can no more help saying that the sun shines than we can doubt that we see it.

But how do we know as regards the perfume of the roses? "We smell it:" and as we have never seen the flowers which we call roses without smelling what we call the perfume of roses; and never, unless we be able to account for it in some other way (as by the exposure of rose-water or oil of roses to the atmosphere), smell that perfume except where roses were near us, whether within our sight or not, we have learned by the judgment of our minds to associate the smell with the flowers; and can no more refrain from thinking it the smell of roses, than we can from perceiving the perfume.

In the case of the songs of the birds, there is another organ affected, but the process is the same: the ear never hears such sounds unless there are birds in the case, or some substitute for birds, which is explainable in some other way; and, therefore, we no more doubt that that song is the song of the birds than we can doubt that we are hearing a song.

So also, if we lay our hand upon any substance, as a piece of woollen cloth or a piece of iron, or taste any substance, as a bit of bread or of sugar, if we have been formerly acquainted with that substance, and have been accustomed to call it by that name, we can no more deny that it is the substance than we can deny our own existence.

These matters may seem to be so simple, and so self-evident, that it is a waste of time to write them down, or to read them after they are written. But that is an error; and it is *the error* which keeps very many of us in ignorance, and makes us listless, and even vicious, when we otherwise might be occupied, happy, and doing right. That which we already know is the instrument, and the only instrument, with which we can "work out" more knowledge, and turn it to account; and our *senses*, or organs of OBSERVATION, are the only means through which that instrument can work.

Those organs of observation will not cease from making their revelations to us, if the circumstances under which we are placed will at all admit of their acting. We cannot mark their beginnings; and, as we have no positive knowledge but where we have had experience, we cannot even imagine what our knowledge or our enjoyment may be when we are "out of the body;" but what we receive through them, and the arrangement of it after it has been received, are all our occupation and all our enjoyment in this world, and the immediate purpose of these remarks extends no further.

To observe is, indeed, the very constitution of our nature; and though our own memories do not reach back to that period, and those who are very near it cannot inform us, yet we have every reason to believe that life and observation begin at the same instant, and hold on their course, and close together;

and that there is nothing that we can know, or believe, or deny, for which we are not immediately indebted to observation, or of which the foundation may not be traced to something that we have observed, however removed it may seem to be from the ordinary exercise of the senses. When we call a man of intelligent mind "a man of sense," we do not therefore speak falsely, or even figuratively. We speak the literal truth, for we mean a man who has used his senses to good purpose—a man of observation.

From want of knowing what led us to make the first observation, and how that observation was made, we are unable directly to school or instruct each other in the process of observing. But after we have observed and profited by it, we can retrace the process backwards, which is teaching by example—the best, and in most instances the only, method of instruction!

The inference—the belief, or perhaps rather the conviction according to which we judge or act, is quite a different matter. It is not an immediate exercise of the senses, but an act of the mind—something which follows, after the senses have brought in their information; though, as the mind, having no material substance to move through space, requires no time to act, the act of the mind often follows so close on the process of sensation that we are not able to distinguish between the one and the other. The distinction is, however, a very important one: for the two *are* different, and very different; and if we confound them, we understand neither, lose the government of ourselves, remain ignorant, and fall into error in judgment and in conduct.

But though the act of the mind is different from observation by the senses, that act never takes place unless observation has gone before it; and there cannot be the least exercise of the mind without a reference to observation, either immediate or remote. It has been already said that we can have no knowledge of what the state of the mind may or may not be when apart and separated from the body; but of this there can be no doubt, that if we had been wholly without sensation, we never could by possibility have known any thing about the material world—about that creation which is the source of so much knowledge, and the fountain of so many enjoyments.

Try to recollect or call to memory any thought, whether that thought related to the departed past, or to the future which did not then or does not yet exist; and you cannot help feeling as if you were present bodily on the spot, and saw all the parties—all the subjects of that thought, whoever, whatever, or wherever they may be. No matter whether the thought is real, that is, of realities, or not; no matter whether it is even possible: still it comes as if it were both real and present. What Shakspeare says of "the poet's eye" is partly true of "the mind's eye," in the most unpoetical man that lives: that always gives to the "airy nothing" of thought "a local habitation;" and there wants only the power of expression in order to give it "a name." To give that name is, however, no necessary part of the thought. It is another and a separate operation, and may be inferior in men who think well, or superior in those who think but indifferently. But thought stands nearly in the same relation to expression, that the exercise of the senses does to thought; where there is no thought there can be no expression; and if both faculties have their proper exercise, the man who thinks most correctly always expresses himself in the clearest and most agreeable manner; and if he had the hand of a painter, he could easily and correctly make a picture of any subject of his thoughts. However long the process of thinking may be, the subjects are present, as if they were before the eyes all the time; and one can alter their relations to each other, just as if one were moving them about by mechanical force, and yet they preserve their identity, or are the very same parties amid all their changes of relation, just as the mind itself remains the same amid all its changes of thought.

This changing of the relations of subjects of thought, to which we give the name of "invention" or "contrivance," is very valuable. It is done in very little time, and with no labour, for there is no weight to be moved, and no resistance to be overcome. A skilful architect will, in his own mind, rear a palace, before a brickmaker can mould and burn a single brick, a mason fetch a stone from the quarry, or a woodman fell a tree; and he will feel none of the fatigue and exhaustion which they feel. We are, indeed, accustomed to say that the mind is fatigued; and when we long continue thinking on the same subjects, especially if there is any thing dispiriting in them, we do feel a sort of languor, and pass into a revery, or dreamy state, in which we not only lose the command of our bodies, as we do during slumber, but in the end lose the memory of our thoughts, just as we do in profound sleep, during which we have no dreams. Everybody must recollect instances of having thought upon subjects till the memory of all the particulars was gone; and, when an author writes an original book upon any subject that requires close and profound thinking, the chance is that he shall know less of what is in the book after he has just finished the writing of it, than an intelligent reader after he has glanced it over. "Don't ask me about that, for I have written upon it," was an habitual saying with a veteran both in science and literature; and Abernethy's constant referring of his patients to "My book" had philosophy in it, whether he understood that philosophy or not.

This fact, that we not only can, but actually and often do, think ourselves out of thought and the power of thinking, is a very important matter, and one which shows, perhaps more strikingly than any other, the value and necessity of observation, not only for making us ready and successful in action, but for making us ready and profound in thought. It is therefore worthy of a little consideration; and it is the more so that it is not much, if at all, noticed in the common books, which profess to school us in the most useful of all arts—the art of making the best use of our faculties.

Why do we lose the memory of our thoughts in sleep? The common answer is, "Because we are asleep;" but though in most instances that satisfies us, it does not satisfy the question. It is an identical proposition, the two parts of which have the same meaning, though the words are different; and such propositions give us no knowledge, though they deceive us with the appearance of it. If the question were, "How does a man get on his journey by walking?" and the answer were, "Just because he walks," that would be just as much (that is, as little) to the purpose as the former.

But when we consider that we lose the memory of our thoughts when we are awake, not only occasionally, but (perhaps in all men) more frequently than we retain it; and that we can pass through the day-dream of revery into a state of as utter forgetfulness both of sensation and of thought, while we are to appearance wide awake and walking on our feet, as when we are in the most profound and unbroken sleep; we cannot believe that sleep is the cause of forgetfulness. Sleep-walking is so very like profound revery during a day-walk, that one can hardly tell the one from the other. Indeed the revery may be the more "oblivious" state of the two; because in it the motions of the limbs are purposeless, and the "absent man," as we not improperly call him, falls into ditches, and runs his head against posts; whereas the sleep-walker keeps his footing and makes his way in situations where he would not venture, or venturing would fall, if wide awake.

Thus the fact of remembering has nothing to do either with sleeping or waking; for it may be present or absent in both states; and the probability is, that we think just as much in an hour of the most dreamless sleep as we do when we are wide awake for an hour. As little does the fact of remembering depend on the mere thought—the "act of the mind" in thinking, for that is too airy a nothing for the most lively imagination to give it "a local habitation," though we all can give it "a name," and "the sign" of that name can be written, and all can know it if they will. It is not very probable that when the author of "The Rejected Addresses" wasted his own wits in that most inimitable of all imitations, he had any intention of dealing in philosophy; but so philosophic is genius, even in its sportive moments, that the most ludicrous form of expression will not hide the sterling sense; and we never laugh happily and heartily unless at that which is full of meaning. In pushing the parody on Byron's philosophical but somewhat conceited misanthropy, to an absurdity, Smith says,

> "Thinking is but an idle waste of thought;"

but that, instead of being even an approach to an absurdity, is a positive and practical truth, and one of the most important that ever was uttered. If we do nothing further than think, then how fast soever the thoughts may arise, how profound or acute soever they may be in themselves, and how valuable soever they might be rendered in their applications, if they were rightly applied, they pass into utter oblivion, the oblivion of annihilation—a waste into which nothing material could pass but by the command of Him who made it.

And how can it be otherwise? For what, after all, is the act of thought? It is not a thing or being of any kind. It is not even a quality or appearance of a thing or being. It is a mere state or mode of the mind; and the mind can no more remember its states than men can build houses without materials. The mental state is a mere relation, and in itself it may be a relation which is altogether impossible in practice, or it may be one which is possible; for the relation is a particular kind of reference to two or more things and it depends on the nature of the things themselves whether they can or cannot have that relation to each other. The relation of jumping over the moon, or boring through the centre of the earth, comes just as readily to the mind as the relation of stepping from one side of the path to the other, or of boring through a sheet of paper with a pin; and in as far as the immediate act of the mind is concerned, it has just as much of what we call "power" in the two instances that are first mentioned, as it has in the other two: and ridiculous as it appears when set down in words, a man has mentally as much power to stand on the sun and kick all the planets in turn, or even all at once, as he has to kick even the smallest pebble out of his way. All are equally momentary in the thought, and there is not the smallest fatigue in thinking of either.

In the one case, we say that the thought is "unnatural," and in the other that it is "natural;" and there lurks an ambiguity in these words which mars our understanding, by leading us to confound one thing with another, or to consider two things as only one. A relation may be natural to the mind, or it may be natural to the subjects of which the mind considers it a relation. *To the mind that thinks, every thought must be natural;* because an unnatural thought would be a thought that the mind did not think, which is an impossibility.

That the relation shall be natural to the subjects of which we think it a relation, is a very different matter. It does not depend upon us or our thinking, but on the subjects themselves; and we cannot *think* *ourselves* into the knowledge of even the simplest subject, or the simplest quality of that subject. We can think only of *that which we know;* and, therefore, though we can apply relations to subjects to which they never were applied before, and thus find out combinations that are new, we cannot by mere thinking add one iota to our knowledge of subjects. If we could do that in any one case, we could do it in all cases; and we would know the unseen and the future, as well as that which is present before our eyes or sounding in our ears. The fact is, that if we could think knowledge, all the senses of the body, and the body itself, would be superfluities and encumbrances to us; and our whole being, instead of displaying, as it does, the very perfection of wisdom, would be an absurdity.

But though the mind cannot quit its unseen citadel, and go forth in quest of the knowledge, it can send out its messengers; and it can send them as far as sound reaches, or heat warms, or light shines. Thence the senses are capable of bringing the knowledge of all that affects them; and the mind can apply all the relations. Hence the great value of OBSERVATION, and the ignorance, blundering, and misery of those who do not duly practise it. The mind can compare subjects, or judge, as we are in the habit of calling it; but the mind always appeals to its witnesses, the senses, in the case of subjects and existences; and it can have firm and absolute belief no further than it is borne out by them.

It is here that the obstacle lies which keeps so many of us in ignorance, leads us into error, and causes us to be miserable amid all the fascinations of a world, the mere contemplation of which would, if we knew better, fill us with perpetual delight, and reduce to comparative nothing those little disappointments and cares which keep us in a state of annoyance, and hinder us from tasting "the good which God has given us." We do not distinguish between the purely mental act of perceiving *relation*, and the mind's act through the senses in perceiving *reality;* and for that reason we generally use only half our system—work with half our strength. Not half of it even—no, not a tenth; for the real power is in the union of the two.

When we use our senses, we do not think; and so the object of those senses can be turned to no profit, and give us no pleasure. If we do not think at the same time, the appearances of objects have no more effect upon our organs of sense than sunbeams when they play on the snow-clad summit of a lofty mountain; they are reflected away in an instant; and that which would have warmed a more genial place into life and beauty is gone—wasted, never to return. How, scorpion-like, a little bit of the tail of some day spent in favourable places, but spent thoughtlessly, will turn and sting us with the remorse of how much we have lost, and lost never to be recalled or replaced! How often, even when the most delightfully instructive prospects are before us, have we reason to address ourselves in the words of Macbeth to the ghost of his murdered friend:

> "Thou hast no speculation in these eyes
> Which thou dost glare with."

And we, too, are murderers, and murderers "red hand" in the fact, and not in the remorse caused by the dogging ghost of that which we are murdering. We are murdering Time—the means of all knowledge, and the measure of all enjoying; and, independently of the direct loss, which is irreparable, if the ghost of murdered Time shall, at any period, rise and haunt us, it is one of the most terrible of ghosts, and we must abide its tormentings alone and unpitied.

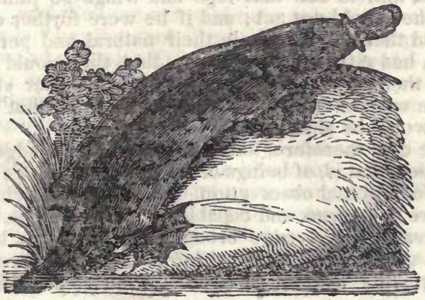
This abuse of our time, and neglect of thinking, instead of working its own cure, throws us into the opposite fault; and, just because we have gazed without thinking, we think without observing, and lose both the time and the thought; and lose it in utter oblivion, out of which not even the ghost of the departed day can return to torment us into the chance of amendment. If we would have the credit of being thought thinkers (for the course that we pursue is any thing but that which will lead us to the reality), we must "look wise," and turn up our eyes, and shut our ears, and, as it were, barricade ourselves against every possible intrusion of the external world. It is true that there is no direct harm in a man's looking as wise as ever he pleases, if so be his fancy—though looking wise is proverbially not one of the signs of being wise; but it is also true that men who always closet themselves for abstruse thinking, not only incapacitate themselves for active life, but defeat the very object they have in view. They become moping and absent; and, following their own particular study into holes and corners out of its connexion and use, they get narrow and conceited views of it, and not only make it repulsive to the more active part of the world, but actually advance it less than they would do if they treated it in a more popular manner, and blended their thinking with more of observation.

It is true that observation and thought cannot go equally together on all subjects of which even the plainest man may have occasion to think. Observation is chained to matter—limited in time and in space; and, in all respects, thought is free. So that any man's personal observation is the foundation of only a very limited portion of that which he learns. But still it is the test by which he tries the reality of the whole; and the only test by which he can try whether each part be true, and deserve the name of knowledge. That being the case, though we cannot extend our personal observation to every thing, the more extensive that we can make it, always the better. Truth—the agreement of the relation with the nature of the subjects to which we apply it, can be ascertained only by observing the fact that it is so: and, therefore, by having the test of observation always ready, we elicit valuable thought, and get rid of much useless thought altogether.

Besides, as we remember thoughts only from their connexion with what we have observed, or could observe if we were in the right place at the proper time, it follows that the results of our observations are not only the most easily remembered of all thoughts, but they are, as it were, "nails in sure places," to hang the rest upon. If a story, or an abstract truth, or any matter of that kind, be told when one first visits the sea, or a mountain top, or any place that is calculated to make a strong impression on the senses, it is rarely, if ever, forgotten. The old practice of whipping all the children of the manor at the march-stones, or on perambulating the boundaries, though both a little ludicrous and a little cruel, was a very certain way of getting witnesses to the identity of the stone. Men never forget those lessons for which they were whipped at school. That may not be the best, and it is certainly not the most pleasant way of "hammering things down on the memory;" but an impression on the senses, something that can be observed, and observed with pleasure, not with irritation, is highly desirable.

How often do we, because we want the test of observation, treat the unknown and the absurd as if they were true. That is not done from any imperfection in *the act of judging:* for ignorant people, *so far as they do know*, judge as correctly as the learned; and, indeed, often far more so, because, with ignorant people, observation, the test of truth in judgment, forms a much larger proportion of their thoughts. And indeed we cannot ascribe *unsound judgment* even to those who err the most in their decisions. The judgments of the mind are in all cases true and accurate, *according to the evidence which is before the mind at the time:* and if men were equally in possession of that, the judgment of one man would be just as sound as that of another. If that were not the case, it would be difficult to show how any person, unlearned or learned, could give any judgment at all. As that is a very important point, let us illustrate it by an example:

Suppose, then, that a man had the evidence of a long and intimate acquaintance, during which you had told him nothing but truth; suppose him at the same time ignorant of the structure of the mammalia, or quadrupeds with warm blood, and also of the animals of any distant country, as Africa; and suppose you told him, in your usual friendly and instructive manner, that there had just been discovered, in the interior of Africa, by a traveller who had penetrated farther into it than any former traveller, whole flocks of a new species of creatures, which had four legs, upon which they could run or bound as fleetly as antelopes, and on their shoulders, above the fore-legs, feathered wings, more powerful than the wings of eagles, by the help of which they could fly over the forests or the deserts at their pleasure: how could the man help believing you? If he were a mere surface dabbler in natural history, the chance is that he would believe you all the more readily; because he would of course have heard of, and perhaps also seen in a specimen or a figure, the *Ornithorhyncus paradoxus*, which is found in some of the pools of



New-Holland; and which, to external appearance, has the bill of a duck, the body of an otter, the feet of a turtle or water tortoise, and the spurs of a cock. That creature actually seems to combine the properties of quadruped, bird, and reptile; and, therefore, to one who did not see farther than the surface, the knowledge of its existence would tend to confirm the man's belief in your story of the winged antelopes.

But suppose, again, that a third party, whom the credulous man had known less intimately than he had known you, or who had "hoaxed" him on a former occasion, were to ridicule the notion of the four legs and the feathered wings; and even to say that these two sets of extremities were quite incompatible with each other, that would still confirm rather than shake the man's belief. Thus it is dangerous for hoaxers to tell ignorant people the truth, or to tell the truth hoaxingly; for in both cases error is fortified against it.

If however any one were to instruct the credulous man in the anatomy of quadrupeds and birds, or if he were to learn it from actual observation of the parts, or from representations which, in his belief, carried the same weight as observation, so as to enable him to see that legs and wings so jumbled together could not act; and if he were further convinced that no animals, in their natural and perfect state, had either legs or wings that they could not use; then he would not only disbelieve your story of the winged antelopes, but his faith in all that you said would be shaken.

We can, therefore, have no certain knowledge of realities, that is, of beings or things, but what we obtain from actual observation, or from that which we believe to be true, and capable of abiding the test of observation, if it were brought to it; and in both cases our judgments are either mere prejudices, or "judgments without or against evidence," or they are open to be changed by new observation or new testimony. View the matter as we may, therefore, we find that, if we be not diligent in observing, we never can avoid error.

There yet remains one other use of a habit of close and constant observation, which is, perhaps, more conducive to the dignity of our character, and our success in the world, than any of those more general ones that have been hinted at; and that is, the readiness and rapidity with which we can, not only judge, but judge rightly. That is what is called "*decision of character:*" and when genuine, and exercised within the proper bounds, it is probably the most valuable temperament of mind that man can possess.

It stands opposed to "*indecision,*" in which a man cannot weigh the evidence; and "*fastidiousness,*" in which the time and attention are wasted upon trifles which form no important part of the evidence at all. The first of these is a vice arising from want of thought to accompany observation, and make it ready for use; and as such it may be considered as a characteristic of the "shallow-minded," as we call them. The second is the vice of those who think more than they observe; and it is a characteristic of the "little-minded," among the learned.

But there are also counterfeits of decision of character; and they are vices of rude and vulgar minds. There is "headlongness," which rushes forward to decide and act, with little or no attention to the evidence; and "stubbornness," which will not reverse the judgment, although the new evidence be conclusive against it.

A genuine decided character,—one which will enable a man to carry all his plans into effect with success, and to ride buoyant upon every wave of the sea of trouble, is perhaps not to be attained, at least early in life, without a certain degree of stubbornness; and as that stubbornness produces a sort of contempt for advice and new information, even in the cases in which the obtaining of these is the most desirable, there is some danger of failure and reverse, after success has lulled caution, and time begun to blunt the edge of observation. The man of truly decided character must be one who is capable of taking long and clear views into the future; but as the past is the only telescope through which the future can be seen, the man of truly decided character must be an incessant and also a silent observer from his youth. The stubbornness which often combines with and tends to endanger decided characters, has in its nature some resemblance to fatalism, or a belief in the certainty of future events, without any evidence, or with very slender evidence from the past; and through that often leads to success, by keeping the thoughts fixed upon one object, and thus producing a continual tendency to find out and take advantage of every thing likely to forward the accomplishment of that object. Upon the same principle, prophecies made determinedly, and with knowledge of the means of accomplishment, are made conducive to that accomplishment. Napoleon Bonaparte is, perhaps, the most remarkable instance of decision of character, and also of the ultimate failure of that decision, that occurs in well authenticated history; and therefore his life, if properly written, would be highly instructive. But as times like those which called him forth do not very frequently occur (and the less frequently the better), he can serve as a model or a warning to few. Useful examples may, however, be found in most places, in men who from small beginnings have risen to eminence by means the most honourable; and without any of those unforeseen advantages which are usually called points of good luck, or good fortune.

Such are some of the advantages that result from observation, duly tempered with thought. We shall next show that there is pleasure in the practice; and explain how the works of nature are the grand field for its exertion.

SECTION II.

The Pleasure of observing Nature.

It is impossible to imagine a happier combination of qualities and circumstances than when that which is of the greatest use to us, at the same time affords us the greatest pleasure; and if it so happen that that pleasure, instead of palling upon the appetite, becomes the more exquisite the more heartily and the longer it is enjoyed, then the happiness thence arising may be considered as the very best that human beings can enjoy. That is the case with the observation of nature: nothing can be more useful than that, for it is the source of all that we know; nothing can afford higher pleasure, for it is the source of all that we can enjoy; and we can never tire of it—it never can pall on the appetite, because it is always healthful and invigorating in the pursuit, and new at every step we take and at every moment we live. It brings us a twofold pleasure: it saves us from misery, and it affords us direct happiness; and there is scarcely an ill in life for which there is not, if we could find it out and apply it, a balm in the creation around us. The Author of that has so tempered the productions of the earth and the waters, and the changes and the appearances of the atmosphere, to the wants of man in every zone, from the burning equator to the icy pole, that, amid all the varieties of season and climate, the man who knows and loves his country (and knowing it he cannot but love it), thinks his own country the very best; and would migrate in sorrow from the ice-clad rocks of Labrador to the perpetual spring and unchanging verdure of the Atlantic isles. The Bedouin, who careers over the sandy plain, fleet as the whirlwind, carrying his handful of dates for his day's repast, and marching twenty miles to the palm-encircled pool, at which he is to quench his thirst, would not give up the joy of the wilderness for the fattest plains and the most gorgeous cities. He has known nature, and seen the working of nature's God in the desert, and beyond that, or higher than that, the very excess and perfection of man's working cannot give him pleasure.

And who are they, whose ancestry in their present localities stretches backward till its fading memorials out-measure not only all that has been written, but all that has been erected in brick or in marble, or in the aged granite itself—the primeval father of mountain and of rock? Are they the inhabitants of fertile plains, spreading wide their productive bosoms to the sun, rich in flocks and herds, thronged with villages, and joyous with cities and palaces? I trow not. They are the men of the mountains; and if there is love of country upon earth, you will find it where there is only a mountain pine, a mountain goat, and a mountaineer, as fast rooted and as firm footed on the rock as either. Ask of the mountains of your own country; and Snowdon shall answer to Ben-Nevis, and Wharnside shall respond to gray Cairngorm, "We have known our people for a thousand years, and each year of the thousand they have loved us the more. Our summits are bleak, but they point to heaven; they are hoary with eld, but the hope of immortality breathes around them." Glance your eye over Asia, and you shall find, that while conquest and change of race have swept the plains of Euphrates and Ganges like floods, and the level steppes of Siberia like the north wind, Caucasus and Himmalaya have retained their people, and their tuneful cliffs echo the same language as they did in the days of the patriarchs. And who, too, had footing on the Alps before the Swiss, or on the Pyrenees before the

Basques; and how long did the expiring sounds of the Celtic language wail among the Cornish rocks, after the lowlands of England had become Roman, Saxon, Dane, and Norman, by turns, and the mingling of a fivefold race had given to the country the most capable population under the sun? Turn whithersoever we will, on the surface of the globe, or in the years of its history, the discovery is ever the same. The Phenicians were once great in Northern Africa, and the Egyptians mighty by Nilus' flood; but where now are the ships of Carthage, the palaces of Memphis, or the gates of Thebes; or where are the men by whom these were erected, or the conquerors by whom they were laid waste? The cormorant sits solitary on those heaps by the Euphrates, where the conqueror of Egypt erected his throne; the Goth and the Hun trod with mockery over the tombs of the Scipios; and the turbaned Arab has erected his tent over the fallen palaces of Numantia; but the cliffs of Atlas have retained their inhabitants, and the same race which dwelt there before Carthage or Rome, or Babylon or Memphis, had existence, dwell there still, and, shielded by the fastnesses of their mountains, the sword will not slay them, neither will the fire burn. Everywhere it is the same. If we turn our observation to the west:—the plains of Guiana, and Brazil, and Mexico, and Peru, and Chili, and Paraguay have been rendered up to the grasping hand of conquest; and, because of the gold and the silver they contain, the thickly-serried Andes have been held by the skirts; but the red Indian is still in his mountain dwelling; and in spite of all that fanaticism and avarice, yet more fell, have been able to accomplish, in the very passion and intoxication of their daring (and they have been dreadful in those sunny lands), Chimborazo looks down, from his lofty dwelling among the earthquakes, on the huts of his primeval inhabitants; and Orizaba yet mingles his smoke with that of fires kindled by the descendants of those whose ancestors tenanted his sides before Mexico was a city, or the Atzec race had journeyed into central America.

Now, whenever the globe speaks in unison from every point of its surface, and history brings testimony from its every page, we may rest assured that there is more than common instruction in the tale; and, therefore, we should read and meditate upon it with more than ordinary attention. And why is it, that man not only clings with the greatest pertinacity to those places of the earth to which, as we would say, nature has been the least bountiful, but also loves them with the most heartfelt affection, and acquires an elevation of mind, a determinedness of purpose, and a joyance of spirit in them, more than in places which abound far more in the good things of this world? The facts are certain and absolute; for there is not one exception to them; and therefore the lesson that they teach us must be wisdom. It is wisdom, too, which bears directly upon our present object; and it is wisdom which is soon learned.

It is simply this: that in those wild and, as we would call them, barren places, man's chief occupation and converse are with nature: whereas, in richer places, where there is more to tempt worldly ambition and worldly enterprise, art is his chief occupation, and becomes by habit his chief enjoyment. Now, up to a certain point, and that as high as you please, so that it is not exclusive, the practice of art is highly commendable; and people can never make too many useful things, make them too well, or be too diligent, or take too much delight in the making of them. It is that attention to art which has made our country what it is,—given to the humblest of our cottagers comforts for which the chiefs and kings of some tribes would be delighted to change their kingdoms and thrones. Not only that, but which, in absolute comfort, and in that greatest of all comforts, the means of acquiring information, has placed the peasant of the present day in circumstances more favourable than those of the peer two centuries ago; which has now rooted itself firmly throughout the country, and is like a goodly tree, ever verdant and ever fruitful, rearing its top to the heavens, and spreading its boughs to the uttermost ends of the earth. Well should we love that, and dear to us all should be that country, those fathers, and those institutions which have brought it forward, and preserved it for our use; and gladly should we bestow our brightest thought and our best nerved arm upon the farther spread and perfection of it; so that we may not have the ignoble name of the "idle generation;" but make our children still more indebted to us than we are to our fathers.

But though the obligation on us to do that be of the clearest and, at the same time, of the most imperative and binding character, it does not thence follow that we too should not have our full share of enjoyment. Indeed, that is absolutely necessary to the successful execution of the other; for it is matter of common observation, that the miserable work miserably, and spread misery around them, as an unclean thing spreads corruption.

And we really have the key to that enjoyment, in the character and conduct of those mountain races to whom allusion has been made, inasmuch as their love of nature, and nature which is barren as compared with ours, is really greater than our love of all the nature and all the art which we possess. The Grecian fable of Antæus, the earthly giant, wrestling with Hercules, the giant of celestial descent, is far from an uninstructing one; because it may show us, and probably was intended to show us, how we may most successfully wrestle with the giant of our cares, under what form or circumstances soever that giant may assail us. When Antæus was in danger of being worsted, he "touched the earth;" and the instant he touched that, he became renovated, and more mighty than his antagonist. So also, when we are worn out by business, when we are exhausted by study, when we "don't know what to do with ourselves" with listless idleness; nay, even when our limbs are pained, and our temples throbbing with disease, if we would "touch the earth,"—hold converse with nature for a little, in the way of knowledge, we would find relief in all cases, and renovation in many.

If we examine the matter aright and carefully, we shall find that at all ages, and under every circumstance of life, it is really nature which sweetens our cup, and that, skilfully used, there is no gall in life so bitter as that nature cannot turn it into honey. Look at a little child on the meadow,—no matter though it has been born in the very heart of a city, and seen nothing but brick walls, and crowds, and rolling carriages, and pavements, and dust; let it once get its feet upon the sward, and it will toss away the most costly playthings, and never gather enough of the buttercups, and daisies, and other wild flowers which prank the sod. And if it shall start a little bird, which bounces onward with easy wing, as if it were leaping from portion to portion of the sightless air, how it will stretch its little hands, and shout, and hurry on to catch the living treasure, which, in its young but perfectly natural estimation, is of more value than the wealth of the world. And if the bird perches on the hedge, or the tree, and sings its sweet song of security, "the little finger will at once be held up by the little ear," and the other hand will be extended, with the palm backwards, as if a sign were given by nature herself for the world to listen and admire. Infants are, in truth, our schoolmasters in the study of nature; and though we might feel our experience compromised in learning wisdom of them, there is no reason why we should turn our wisdom into folly, by refusing to learn a little happiness. Grant that age and gravity are as wise as you will, the palm of happiness must be awarded to early youth,—to those sportive days and nights of sound repose, before the business of the world has come upon us, and absorbed all our attention. Now, as the aim and object of all that we do is happiness, why should not we make the happiness of our youth a store through life, and an increasing store, as well as our knowledge? Our bodily activity and pleasure have their periods: they wax and they wane, just as is the case with matter and all the qualities of matter; but happiness, like knowledge, is in the mind, and they should strike hands like twin-brothers at our birth, and never quit us, or gain upon each other, till they bring us to those regions in which both shall be in maturity, and our bliss perfect.

In our business or profession, we cannot carry the child with us through life. Life is a succession of inferences, the fruits of experience; and in it we must have the wisdom of age to give counsel, and the vigour of manhood to carry that counsel into execution. But still, while we counsel with all our wisdom, and execute with all our might, we are like Antæus wrestling; and if we come not down and touch the earth, we shall be, as Antæus was when prevented from that, overcome and vanquished. So that, even in order to work properly and pleasantly as men, we should continue to play like children; and if our play-hours be shorter and farther between, they will be sweeter, because they will always have the freshness of novelty.

The value of things never strikes us so forcibly as when we are deprived of them; and if we were to think how sad an inroad would be made upon our happiness were we deprived of only a small portion of nature, or of one of those senses which were given to us for the purpose of knowing it, we would prize senses and their objects far more than we do. It is a dismal thing for an innocent man to be cooped up within the four walls of a dungeon for life, with only a little glimmer of reflected light coming through the grating, and never to behold the direct light of the sun. But even in that situation the man may study nature: there is that reflected glimmer fading off into the darker tints: there are the different spots and the colours they reflect; and the motes are dancing even in that dim light; and the spider is busy in the corner; and, it may be, that things which a man in the free air would call loathsome are crawling about the floor. But the solitary man can make all these lowly things his kingdom; can claim brotherhood with the spider, the snail, and the lizard; and, if his heart has been true to nature and to man, he will kneel down and thank Heaven as fervently for its bounty, when the morning gives him the first dawning of that streamy light, as if he beheld the sun rise on the sweetest valley in England, and could call all that valley his own: and, let but one drop of the bitter waters of remorse for wrong done, fall in the rich man's free and full cup, and he would give the solitary all his wealth for an exchange of feeling.

We would consider it a piece of most wanton cruelty to build up the little grating—the dim light to the captive; but even that would not deprive him of the pleasure of nature: even then he might "touch the earth," and, by so touching, his mind would rise up and wrestle with the giant, and he could seize happiness in the dark. It is a common observation, that blind people are always cheerful; and the fact is nearly as general that they are all musical. Now, as these are general truths, like all general truths, there is instruction in them; and it is instruction that any one may obtain without the form or intricate preparation of any thing that can be called learning or science. It is delightful to look on the glowing heavens and the green earth; and as there are few things more calculated to afford us pleasure than our sight, so there are few things that we suffer more by neglecting or using improperly. But from the proverbial happiness of the blind, and their fondness for music, it is extremely probable that all nature becomes to them as if it were one vast musical instrument. Nor is there any doubt that sounds convey to them the notions of form and distance, in a manner as intelligible to the mind as that which those who have the advantage of sight receive through that medium. Strange as it may seem, too, the touch of blind people may be so educated as not only to distinguish one colour from another, but to distinguish different depths of shade in the same colour. Human perception is a very curious matter; and the different senses so co-operate with each other, and they are all so linked with nature, that it is difficult to say within what limits we could confine that which any one of them might reveal to us, though we were deprived of all the others. It is probable, indeed, that sensation itself is a much more general principle than any of those modifications of it which reside in the particular organs; and that it is really those powers of the body by which we move matter from place to place, and change its appearance, that are the original sources of all our knowledge of the mechanical properties of matter.

In common language, indeed, we are accustomed to say that we measure visible distance by the eye, and the distance of sound by the ear; but it is exceedingly probable, nay, almost certain, that the origin of our knowledge in those cases is in our muscles, our organs of motion; and that, even in the case of the eye itself, which is the organ that we can best understand, and most nearly imitated by artificial contrivances, it is the muscular action by which it is adapted to different distances, and not the degree of light, or the magnitude, or intensity of the picture formed on the retina of the eye, that gives us notions of distance and also of magnitude. The formation of that picture, though, as there is little doubt it does, it takes place in the living eye, is, after all, merely a mechanical matter; and any one can produce it at pleasure, by closing the shutters, boring a hole in them, placing a glass which is convex, or thick in the middle, in the opening, and holding a sheet of paper at the proper distance behind. Not only that, but, by means of mirrors properly placed, or prisms of glass, which reflect from their hinder surfaces, we can convey those images of visible things whithersoever we will. That beautiful contrivance of Ramsden's, which, from being in itself invisible, is called "Ramsden's ghost," is a remarkable instance of that. In a fine astronomical instrument for taking the elevations of the celestial bodies, it is necessary that the plummet should, by means of the spider's thread, or whatever other delicate substance is used for marking it, pass in a downward line, from the very centre of the axis on which the instrument turns to the very centre of the earth. The axis itself is enclosed in the workmanship, so that the observer cannot see it, or make any direct reference to it for adjusting his instrument; but Ramsden's ghost brings it faithfully to his view, let the path be ever so intricate or circuitous. On the axle there is a dot no bigger than a pin's point: one prism receives the light from that, reflects it to another, that to a third, and so on, till the picture of it is thrown upon the limb of the instrument, just where it is crossed by the spider's thread of the plummet; and as those prisms are all perfectly parallel, the reflection is made to fall on the limb more exactly under the very centre of the axis than any one could discover by immediate observation. Thus we can, by means that are perfectly mechanical, do even more than eyes can do in the forming of a picture on the retina. Therefore, we are warranted in concluding, that that is not the act of sight, but that there is something mental consequent upon it, far more nice and curious than any thing which material eyes can discriminate. And we have proof of it, in those pictured scenes which, sleeping or waking, arise to the imagination, far different from any thing that the eyes ever beheld, and yet equally bright and perfect in the colouring. But those imagined views are, in truth, all made up of that which has been seen, or otherwise perceived by the senses; and, therefore, though, after observation has given us the materials, we can, by the operation of our minds, work it into endless forms and combinations of delight, we must obtain the materials originally from observation. Nor must we forget to bear in mind, that the case is here the same as it is everywhere else; we cannot "gather grapes of thorns, or figs of thistles;" we cannot build palaces of marble, if we have observed only mud and rushes. If our observation has been narrow, our imaginings must be meager; and if our observation has been vulgar, they must be mean.

The formation of those imagined works is perhaps the very highest pleasure we can enjoy, and it is the foundation of all that we invent and the greater part of what we do. If, therefore, we do not, by observation, find the mind sufficient materials whereon it may work, and out of which it may elaborate valuable or splendid combinations, we chain ourselves down, and are humble beings in the estimation of our neighbours, and wretched in our own feelings: we not only cut ourselves off from a vast volume of enjoyment; but we blight and wither our very powers of enjoying.

The ennui that comes upon us when we have been long idle and listless, and the revery and oblivion which are consequent upon excess of mere thought, without the exercise and use of the senses, are proofs of the pleasure that we do derive, and were meant to derive from observation, and especially from the observation of nature. All of us, too, may find practical proofs more convincing than even these. A sleepless night, even when the couch is soft, and the body free from pain, is one of "the miseries of human life." How long and how lonely it feels! The clock beats hours instead of seconds; and it seems an age before it will count to us that hour which is a pledge that the dawn is to break, and the sun to arise and reveal the world to our observation before the clock shall number another. But even then we have feeling, and the very darkness makes sound more audible. Yet still our situation is painful, and though we are fatigued and exhausted, we want something; and cannot, on that account, find repose. If we rise, and open the casement, and see the moon among the light clouds in the west, or the stars and planets in the clear sky, or the summer lightning playing from cloud to cloud; or if we even see the lamps in the street, or the outlines of the buildings, or of trees and hills, how dimly soever, against the sky; we feel our connexion with nature,—even that little of observation dispels the revery of the night,—our minds are tranquillized, we return to bed renovated in our minds, and refreshed in our bodies; and that sleep which fled us when we before sought it with diligence now comes unbidden, because we have wooed it in the right way—by the observation of nature.

If we loiter on the sleepless pillow, and have not resolution enough to get up, then our torment lasts till the dawn has so far advanced as that we can see distinctly, or till the beams of the early sun are breaking in through the chink of the shutters, or the opening of the curtains; but soon after even the articles of the room are revealed to our observation, our minds are tranquillized, and we glide into dozing slumber.

Even those contrivances to which we resort for the purpose of procuring sleep, are proofs that observation is the means by which we obtain that refreshment. When the mother stills her infant to repose, it is not by silence, which, as it is the accompaniment, we would naturally think should be the best means of procuring sleep. She sings her lullaby; and it is well worthy of remark that the sweeter her voice is, and the more musical and modulated its tones, the sooner does her smiling charge sink into that balmy rest which is so essential to its present health and its future growth. The ticking of the clock too, the slow dropping of water from the eaves of the house, the chirping of the cricket at the hearth, and the booming of the wind, and especially its soft music in the chinks and crannies, where it is murmuring in promise of rain, all lead us to that comfortable state of tranquillity which is the preface to balmy sleep.

In all these cases, it is really observation which is the solace of the mind—the all-healthful medicine which drugs the body to a state of wholesome and invigorating repose; so also, in the contrivances to which we have recourse in order to procure sleep, if it is not direct observation, it is something very much resembling it, which is the real cause why we obtain that refreshing sleep which mere quietude will not bring us. Ordinary people have recipes for sleep, which are all but infallible, in slowly repeating the letters of the alphabet, or counting the numbers upwards from one, until sleep puts an end to the monotonous repetition. Those who know a little more may be proof against these very simple contrivances; but they, too, have their resources, and they all in so far resemble observation,—they are all operations of the mind, upon something which stands out clear and graphic, as if there were a picture of it before the eyes, and only one step removed from actual observation. The multiplication of two numbers, the division of one number by another, the summation of a series, or the solution of an equation are all infallible recipes for sleep; and, if a moderate degree of preparation was necessary, I have never been able to keep awake so long, as to complete the square in a common quadratic. These may seem to be trifling matters; but, in truth, great part of the enjoyment and happiness of our lives is made up of such trifles; and it is very often just because the sources of error and misery are in trifles so light that we deem them unworthy of notice, that we do not stop them at the outset; but suffer them to grow and gather, till our habits are debased, and our happiness is destroyed.

Indeed, it is through affected contempt for what we consider to be small and simple matters—matters too minute and trifling for the range and grasp of our extended and powerful minds—that we are so often ignorant of what we might easily know; baffled with what we might easily accomplish; and, in consequence, miserable, when it would really cost us less time and trouble to be happy. In matters of bodily action only we do not so frequently fall into those mistakes. We are not vexed and mortified because we cannot shoot across the Thames by one motion of the swimmer, or because every stroke of the oar does not get us along a reach of that river. We feel no mortification because we cannot plant one foot at the general post-office and the other at Bristol or at York; and even Sir Christopher Wren thought it no humiliation that the splendid pile of St. Paul's had to be built up in a number of little parts, stone by stone, and brick by brick. In all these visible cases, which are, as we may term them, matters of pure observation, we are perfectly contented to take "the method of interpolations," and we should be accounted stupid—absolutely out of our senses, if we even spoke of jumping to the conclusion at a single bound. We know the length of our leap, and we know our strength. If the stream is too wide, we lay stepping-stones, and if it is also too deep, we take the boat, or go round by the bridge. In all these cases, the present step of our progress is the footing that enables us to take the next step, and we know that that is the case, and act accordingly,—if the last planted foot is not on firm ground, we pause, and consider before we move the other.

Now, it would save us from much disappointment and uneasiness, and so give us much indirect pleasure, as well as the immediate and positive pleasure of succeeding sooner and better, if in all matters of thought and knowledge we would take along with us the lesson which observation here gives us. In matters of mere thought, the mind neither knows its own power nor its own rapidity; because, in thought, we can do any thing, and we take no time in the doing of it. But there is no action, and no use, in which the body does not bear its part; and, therefore, if the mind does not take the body along with it, our thoughts are idle dreams, not capable of being reduced to practice, and hence of no use or value. It is the former step that supports us while we take the present one, as it is the former course of bricks or stones that supports the one which we are building, and enables us to build it; and as, without the former, and the former in immediate juxtaposition, we could not possibly have the latter in either of these, or in any one practical case that we can imagine; even so it is in all matters of thought, if these are to be of a practical kind, or in any way to deserve the name of knowledge, or even to return in that *suggestion* which we call *memory*, or be any thing else than an idle waste of the time that they take in passing, and anguish and remorse because that time has been wasted to so little purpose.

If we could always thus " keep sight of observation," in our thinking, we would have the consolation of knowing that we were in every instance "thinking rightly and to some purpose,"—that every thought would "tell" practically; and that alone would give us both collectedness and pleasure. As we would then never attempt any thing but what we felt confident we could do, we would always have the exultation of success to cheer us on.

Now, it is only in the observation of *nature* that we can get that ready-mindedness which cheers us on with the confidence that we are always thinking aright and to good purpose. Our business, if we are to conduct it in the most successful and proper manner, must not be half so wide in its range as a mind of even any ordinary capacity will wander; and as for the productions of art, though many of them are curious, and far from unworthy of our attention, in order that from them we may "learn to excel," they are at best but second-hand applications of those properties and principles which we find original and fresh when we turn to nature itself. The very depth of human knowledge, and the very height and perfection of human art, are, in truth, nothing more than the revealing and applying of a few of the laws and principles of nature; and though we often flatter ourselves that there is something profound in what we know, and mighty in what we do, it is still all in nature; and what we call inventions, even clever ones, are only the applications of discoveries; and of discoveries which lie as much in the way of one man as another, if both are equally diligent in search of them.

It is matter of common remark, that many of the most valuable discoveries, or applications of discoveries (call them inventions, if you will), have been made as it were by accident, by persons not having many of the ordinary pretensions to knowledge, or not being those to whom we would have looked for such discoveries or inventions. The mariner's compass and quadrant; the steam-engine, and the apparatus by means of which it opens and shuts its own valves; printing in all its forms, and with all its improvements; chronometers that keep correct time in spite of the changes of heat and of cold; and, indeed, all the more wonderful and useful applications that have been made of the properties of matter generally, or of the particular properties of particular kinds or combinations of matter, have almost all been the result of what we, in common language, are in the habit of calling *chance:* that is, they have been made by those who, as we say in common language, were not "the most likely persons to make them." But when we say that, we are wrong; and the discoveries are not owing to *chance*, any more than any thing else is so owing. They are the effects of causes, just as certainly as burning is the effect of throwing a lighted brand among dry straw or chips of wood, or as pain in the fingers is the consequence of taking hold of a live coal with them; and the persons who made those discoveries—every discovery that has been hitherto made, as well as all those who shall make future ones, have done so, not by any thing that can in any way be called chance, but simply because they were in the right road to the discovery—a road which all the rest of mankind had missed. No man can go a determinate way to the discovery of that which is not known, because, before he can go to it he must know both what and where it is; but, where all is unknown, no man can tell what he may not discover, if he has but field enough. The field for all discovery is nature; and, therefore, he whose observation commands the most of that, is the man most in the way of useful discovery, whatever that discovery may be.

Now the man who has it in his power to make useful discoveries is placed in the very highest and happiest situation in which a man can be placed

The object of all our honourable exertions is, that we may stand higher than our fellows, not by thrusting them down, but by raising ourselves up; and we nowhere get the vantage-ground so much or so certainly as when we are in a condition for making discoveries that may, and must, be useful to them. The making of the discovery, so far from impoverishing us, puts us more in the way of making fresh discoveries; and when we communi cate it to others, that takes nothing from us, while it gives us the highest of all pleasures,—that of being benefactors, and benefactors in a way and to an extent, to and in which the objects of it could not benefit themselves. Thus, the observation of nature is not only a never-failing resource to us amid all contingencies and ills of life, but it gives us means of elevating ourselves, which we can obtain no other way. If we are rich and bountiful—and if we are the one, it is our duty and should be our pleasure to be the other—we are restrained and limited within a certain measure in our benefactions; and if we exceed that measure, we not only destroy our means of continuing to be bountiful, but directly and immediately bring upon ourselves those miseries from which we sought to relieve others. If we have gold, it can be weighed, whatever its amount may be; if we have notes and bonds, they can be counted; if we have acres or even provinces of land, they can be measured; and, take but one grain from the gold, one farthing from the notes, or one inch from the acres or the provinces, and the remainder is less by the quantity so taken. But when we are rich in observation, and when, in consequence of that, the gift which we can give is useful practical knowledge (and it never is so unless the foundation of it is in the study of nature), we really become richer by the very process of giving away. The exercise of our powers is not only the enjoyment of life, it is life itself—a real and growing treasure to us; and, whatever may be the fate of external property, the change of persons or of things about us, our true treasure—that which is life and life's gladness to us—is beyond the reach of accident, and proof against every contingency.

But if we do not observe nature, we incur disgrace as well as suffer loss,—we are ungrateful to our Maker, and we are unworthy of ourselves. Wherefore were the organs and faculties of observation given us, if we do not use them? The senses, though, as we have them without cost or study, or effort on our part, and so are apt to undervalue them, are, in reality, choice gifts; and the productions of nature are so admirably fitted for the gratification of those senses, that it is altogether impossible for us not to perceive that the one must have been made for the other.

Why was every tint and tone of colour so mingled in the light of day as that they all come out clear and perfect, and tell us, not merely of substance, but of space? and wherefore, when the sky is clouded and the blackness of darkness shades the landscape, is the arch of Hope with its sevenfold glory set in the rain cloud, if it be not for us to look, and admire, and learn, and love? Why does the rose give forth its odour, and the scent of the lavender and of the mignionette steal viewless upon the still air around us, and the blooming bean and the new-mown hay outscent all the preparations of the apothecary, if it be not to wile us unto the garden and the field, in order that we may breathe health, and at the same time cull pleasure and instruction there? Wherefore sings the breeze in the forest, why whispers the zephyr among the reeds, and how comes it that the caves and hollows of the barren mountains give out their tones, as if the earth were one musical instrument of innumerable strings, if it be not to tempt us forth in order to learn, how ever-fair, ever-new, and ever-informing that great instructress is who speaks to all the senses at one and the same instant!

And the pleasure goes deeper—strikes more home—cleaves more closely—remains more permanently—than can be supposed of the external organ of sense. So exquisite and at the same time so mysterious an action is life, that it does not appear that the same particle of matter can abide with it for two moments of time that can be separated, or considered as a succession even in thought. It is probable that the same material eye never sees two successive objects; that the same olfactory surface never conveys two successive odours; that the same material ear never hears two successive sounds; and that the same sentient palate never tastes, or the same sentient finger touches, twice. It is probable that they perform their offices and are gone—dissipated into the thin air, or absorbed by those vessels which, ramified all over the body, collect the waste from every part; and by one of the most beautiful processes in nature, constantly remove death out of the body, while the equally wonderful system of nutrition is at the same time everywhere furnishing the materials of life.

But although those individual portions of matter are far too minute for the cognizance of any eye or of any miscroscope; and though, as composing our organs of observation, they are more fleeting than observation itself, yet they are faithful to the mind, and their memory never perishes.

This is an exceedingly curious as well as an exceedingly interesting speculation; and, even if we had no more, it alone would be sufficient to make us happy. The matter which thus passes from death to death through life, and is not a measurable moment on its passage, bears upon its invisible and rapid wings all the information that we receive, and all the happiness that we enjoy. It delights us with softness in touching, with raciness in tasting, with perfume in smelling, with music in hearing, and with all the world in seeing; and what would we, what can we have more than that?

Thus, as the ACT OF LIFE is, as it were, not a matter measurable in duration, the quantity of happiness that we enjoy is not a sum of measurable durations; and thus it has nothing to do with time, in the common way of estimating it by the visible motion of visible matter. It is said or fabled of the ancient Scythians, that they slew the wise in order to inherit their wisdom, and the strong in order to inherit their strength; but if we would only use our senses—our powers of observation aright, we might inherit the wisdom and the strength of all past ages, as well as those of the present, and even behold and grasp forward into futurity without ever injuring a hair of any living creature. In that way an observant man may and does actually concentrate more enjoyment into one brief hour, nay, into one immeasurable moment, than a dull and careless man drawls out of his threescore and ten years. And it is in the observation of nature only that this unbounded happiness, this happiness which time cannot measure or space bound, is to be found out. All that is of human making or human possession is measurable, and we speedily get to the end of its pleasure; but, even in this world, the pleasure of nature is absolutely to our fondest wish—infinite and eternal.

SECTION III.

Nature and Management of the Senses.

Very little preparation is necessary for observing nature, because we are all formed for that express purpose; and, instead of it costing us any effort to observe, our powers of observation torture us with listlessness and ennui if we shut them up idly, and will not suffer them to instruct us. Still, all those powers are capable of improvement; and the beauty of the matter is, that the exercise and the improvement are exactly the same. No sense of the body is in a state fit for accurate observation unless the body generally be in a state of health; an excess of any kind renders the hand tremulous, the eye dim, the ear either dull or painfully sensitive, and nothing is fragrant to the smell or pleasant to the taste. Those who commit excesses get their punishment in this way; and a severe punishment it is. We are accustomed to say of those who are in such a state that they are "half-dead;" and the expression is very correct; for each sense may be diminished to a half, or even to a smaller fraction of its healthful quantity; and thus the person who is in that unfortunate condition is literally dead to the full measure of the deficiency. No matter what the excess consists in; for though various kinds of excess have different effects, and the effects of some are more permanently mischievous than those of others, yet every kind of excess is a mischief; and we cannot gratify any one sense—or even insensibility itself, to a state of intoxication, without paying for it in our general happiness. Excess of food leads directly to stupefaction; excess of stimulating drink ends in stupefaction still more complete, but it arrives at that conclusion through a delirium of very strong, and, up to a certain point, of very delightful excitement—just in the same manner that the excitement of eating wholesome food in moderate quantity when we are hungry is very delightful. The sottishness of the continually intoxicated, with whom drunkenness has become so much a habit that they absolutely cannot get drunk (for that, and indeed any excess, may be carried so far as to destroy its own effect, by deadening that part of the system on which it acts), is next thing to an absolute extinction of the observation of nature; and when the powers are absolutely gone in that way, they are in most instances irrecoverably gone. Occasional intoxication is also an occasional destruction, by means of which time is lost, and from which the powers seldom recover with all their former tone and activity. But still there is a point even in the progress of that, up to which all is wholesome and profitable; and as every nation under the sun which has discovered any thing at all has discovered some drink or substance of a stimulating nature, the temperate use of such stimulants must not only be not improper, it must be natural and necessary. Thus, in order to enjoy nature fully, and crowd into the years of our time the greatest amount of life, or, in other words, the greatest enjoyment, we must not have a prejudice against any thing, any more than a predilection for it beyond its proper measure. There is some pleasure to be got out of every thing, be it what it may; and thus, though the place and the circumstance of our lives limit us to only a few, we should be ready both in knowledge and in aptness to enjoy any new one that comes in our way. Still, the tastes and the other sensations connected with eating and drinking are the most merely animal parts of our whole system; and as the animal works by instinct, which is an innate property, like the common properties of matter, and mind works by experience, that is, by successive portions of knowledge received from without, through the medium of the powers of observation, it follows that those tastes and sensations are less susceptible of being educated or improved than any of our other powers; and as we say of a dull fellow, who comes (as is sometimes the case) idealess from school, "a college education is thrown away upon them."

The sense of smelling, though some of the pleasures that it gives us are very delightful, and some of its warnings are most wholesome and necessary, has its immediate excitement so much out of the way of the other senses, that the eye, the ear, the hand, and even the palate cannot cross-question it; so that we do not fully understand its testimony, and therefore cannot do very much towards improving it. Yet it does admit of some more improvement than the sense of tasting; and it is possible, nay likely, that our perception of odours is a different matter altogether from that of mere animals. The vulture and the raven scent carrion, and the bloodhound follows on the slot, in cases where the human nose gives not a jot of information; but the vulture would instantly quit a bed of roses for a rotten carcass, and the bloodhound would forsake all the perfumes of Arabia in order to gnaw a bone, although he had to scrape that bone out of the dirtiest corner of the court-yard. No doubt the sense of smell in man goes so far hand in hand with the merely animal process of getting nourishment; for, as the proverb says, "a hungry man smells meat far;" and everybody must have felt how grateful the smell of the kitchen is before dinner, and how intolerable just after. But still the sense of smelling is not, as is probably the case with that of tasting, wholly subservient to the animal process of being fed. There is a surplus part of it. That which distinguishes violets, and roses, and orange flowers, and clove pinks, and all the blooming perfumes of the gay globe rises above the mere getting of nourishment; and therefore it is a mental surplus given to us for the joint purposes of knowledge and enjoyment. It must, therefore, admit of being improved by education; but the means of improving it necessarily partake of the niceness and obscurity of itself, and all that we can say positively about it is, that "the longer we are among the sweets, they smell the more sweetly."

There is no such educatability in mere tasting. There is, in fact, rather the reverse; and when the epicurean ransacks the three kingdoms of nature in all their provinces, and even presses in putrefaction itself, to give a flavour to his mess, he has actually less animal pleasure in that mess than the rustic has in a crust of wholesome brown bread, or a potato nicely roasted in the turf ashes. His sensation may be different, but it is not better; and let a man be but hungry enough, and give him something to appease that hunger, and all the cooks that "the devil ever sent" to mar Heaven's bounty can give no more enjoyment. So also in drinks—wines have their gusto, and other potations their exhilaration; but "Adam's wine," as it wells living from the rock, free from foreign substances, and showing every gem of the casket in each drop, is, in truth, and will remain "the liquor of life." The weary, the fainting, and the dying call not for burgundy, or champaign, or tokay; the longing of their heart, the hope of their recovery, or the alleviation of their anguish is "water,"—water clear from the fountain, or fresh from the cistern. Thus we see that, even in those cases in which art and luxury have done the most, human nature, when it comes to the hour of tribulation—to the moment of peril—to the article of strife with nothingness—clings to the freshness and simplicity of nature. And it is even so in every thing. When cold sweat bedews the temples of the monarch—when artery and vein have forsaken each other, and the curdling fluid is breeding corruption in the little capillary tubes between—when the heart's feeble pulse is flung back upon it by the dying vessels, and it is about to be broken by its very strength—when the lungs will no longer remove the charcoal, but make, as it were, the fire of life to smoulder in its own ashes—when the currentless throat begins to be choked up by its own refuse—when the angel of death stands ready to loosen the "silver cord," and break the "wheel at the cistern, and the pitcher at the fountain,"—what then recks the monarch for his state and his diadems! Cast aside that sceptre, it is a bawble; doff that crown, it is nothing; rend away the velvet and the tinsel, they are trash; remove that coverlet of satin, it is a burden: give him the fresh air of heaven—the first draught of nature that he drew—so that the king may die easily and in peace; free the monarch of all the trappings of his grandeur—so that the spirit of the man may mount in triumph to its God.

Our other organs of observation, the eye, the ear, and the hand,—though in the last case we make the hand a tyrant, by appropriating in language to it a faculty which really belongs to the whole fibrous or muscular part of our frame,—admit of more improvement by cultivation; and their improvement by cultivation is like that of all other natural things—plant them in the right soil, and keep them from weeds, and they will grow of themselves. We cannot analyze the process of tasting so as to find any thing intermediate between the sapid food and the sapent palate; and though we know that scent is wafted to a distance through the air, while taste is not, we can discover no medium between the delighting flower and the delighted organ. In the one of those cases, therefore, there is probably nothing that we *can* discover so as to improve it, and in the other there is nothing which we *do* discover. All that we know of these two senses is, that their acuteness of perception is always in proportion to the wholesomeness of the state of the body; and therefore, study them as we will, we can derive from them only one lesson, and that, too, merely a surface lesson—a lesson as palpable to the man who knows not a letter as to him who is most deeply read in all the sciences. Yet that surface lesson is one of great importance and value. We should be regular, and preserve our health, because that is the only way in which we can make sure that nature will smell sweetly and taste deliciously; and even that is a secret worth knowing.

Of all the human powers, the hand is perhaps that which admits of the most education, because its education is twofold—it may be educated in knowing, and it may be educated in doing. The education of the hand in doing is a matter of observation, and any one hand can improve either upon other hands or upon itself; but still that improvement in performance is grounded upon improvement of the hand in knowledge; and of its process in knowing we know about as little as we do of that of the palate in tasting, or of the nose in smelling. It consists but of one process—the contact of one substance with another; and the most acute observation cannot divide that into parts so as to obtain a more intimate acquaintance with it; and whenever we can no further divide or analyze, we come to the ultimate fact, and can know no more than simply—that it is.

And yet the education of the hand in knowing, and the state to which it may be brought by circumstances, are very wonderful, and in some instances would appear almost incredible. The hand of the blacksmith is so educated as to handle iron that would burn, and the hand of the sailor is so educated that it can glide safely along a rope which would cut any other person to the bones.

The hand of the Greenlander reposes comfortably on the ice, and that of the Bedouin just as comfortably on the burning sand. The hand of the porter is hardly sensible to an ounce, but it can move hundredweights; and while the hand of the delicate workman would tremble or give way under these, it feels to the minuteness of a grain. Allusion has often been made to blind Dr. Moyes, who could feel colours and shades of colour. And the blind engineer of the midland counties felt the level of very irregular surfaces with his feet, as accurately as any engineer having eyes, with all his telescopes, and levels, and scales for determining the variations. It is impossible, indeed, to set a limit either to the weight or to the measure which the human hand can determine; and not the hand only, but the foot or any part of the body, so that there are muscles in it. Lines can be ruled much more finely by mere touch in the dark, than they can be by the eye with the aid of all its microscopes; and the number of curves that a healthy and well-educated hand can delineate is perfectly endless, and it can delineate them as well in absolute darkness as in broad day.

How varied are the tones produced by the touch of the pianoforte, by pinching the holes of a flute, or by fingering and bowing the strings of a violin. These are all exquisite; and the flute with Nicholson, and the violin with Paganini, are almost superhuman, and give us a taste of what we would call celestial; and yet, they arise from positively the simplest of all imaginary causes—the fine mensuration of distance and space—the pressing a little more or a little less with the finger: and any man who can simply lay his palm on a loaf of bread, and feel that he is so laying it, might educate himself up to those exquisite touches, and have the delicious pleasure of enjoying their effects whenever he chose. We often neglect it, but we absolutely have a mine of wealth in those ten fingers, which the longest and most observant life cannot exhaust. Exhaust! the use of it is the very reverse; for we absolutely multiply it in the same proportion as we use it; and the hand which can do the most is the readiest in the successful performance of any thing new.

But still, exquisite as is the discrimination of the hand, it can take note only of that which has the most obvious properties of matter. It has, indeed, a sensibility to heat and cold, but that is vague and variable, inasmuch as it is only the difference between the touching body and the substance touched, and the body gives no information as to its own temperature, and but a shadowy one of the relative temperatures of other things. The real offices of the hand, or rather of that muscular feeling of which the hand is one of the most perfect instances, are, acting as a balance to measure pressure and resistance, and as a line to measure space; and though its sensibility in both these respects is exquisite almost to infinitude, we can collect the little differences until their sum is of such magnitude as that we can recognise and cross-examine it by the eye, so as to make the one organ of observation establish the truth of the other.

But exquisitely fine as the discrimination of the hand can be rendered, arm's length bounds the range of its knowledge; and muscular power can take heed of nothing save that which resists it by contact; so that if our observation were limited to the hand or the muscular feeling, it would be less excursive than that which we obtain by smelling—which does not define or even point out the situation of its object at all. Thus, though we may grope our way very minutely and very nicely to the details of nature in the dark, we should never be able to group them, or to comprehend the beauty or grandeur of nature, if we had not powers of observation scarcely less limited in extent than excursions of mind itself.

Now we have two remaining senses, the one of which more immediately enables us to learn from nature, and the other to learn from our fellow-men, and yet the two work beautifully together for our instruction, and, as one may say, take counsel and strive together to make us wise and happy. These are our sight and our hearing, and so admirably are they formed that they are not only more easily, and may be more extensively educated than any of our other senses, but we can heighten their powers by artificial means.

The speaking-trumpet augments the sound of him who speaks, and the hearing-trumpet concentrates and strengthens the sound to him who hears; and those who are acquainted with the observed laws of sound can so manage matters as that a whisper can pass silently over a crowd, and be heard distinctly by a more distant person by whom it is intended to be heard. Sound also may be doubled and redoubled by reflection from surfaces; and it is very possible to hear one of those reflected sounds when the original sound is not heard. There is a very familiar illustration of that. If you are in a house with equal windows, equally open on all sides of it, and if it thunders, or if ordnance fire, or the bell tolls, or any other loud sound is produced, you are utterly unable to tell on which side of the house the sounding body is situated. If there are windows only on one side of the apartment, you get a notion of the direction of the sound; but it is probable that notion is a wrong one, because the room has four sides; and unless you have something else to guide your conclusion, you invariably suppose that the sound is upon the side where the open windows are.

The ear is a beautiful instrument, and the degree of nicety to which it can be educated is quite astonishing; but still we are unable so to understand the instruments or analyze the process of hearing as to be able to say in what it consists; and, as a direct means of observing nature, pleasure rather than information is what it brings us. We know that sound is produced by some sort of motion in the sounding body, and that it is propagated through the air, so that what we immediately hear is really the air, and not the body the motion of which first originates the sound. It also goes in the direction opposite to that of the motion by which it is originally produced; and against the motion of the air which is the medium of it, though that motion both retards its progress and diminishes its loudness, yet not to the same extent as the motion of the air. The wind renders sound less audible; but the audibility is diminished in the direction of the wind as well as in the opposite direction, though not quite to the same extent. When a coach is on the road, and not in sight, we can hardly tell whether it is before us or behind; and if there be any thing near us that will echo the sound, the sounding body may appear to be sometimes on one side of us, and sometimes on another. The swelling and sinking of the sound are the only means that we have of ascertaining whether it is coming nearer to us or going farther away; and there are many circumstances by which we may be deceived even then. A clump of trees, or any other object that can deaden the sound, will make us think that which is actually approaching us is retiring; and the clearing of such an obstacle will make that which in reality is approaching be heard as if it were going away. Thus the ear has, in itself, no more power of enabling us to discover that the voice which we hear in nature is the true voice, than it has of letting us know that what our fellow-men tell us is the truth.

It is principally on account of this want of connexion between the hearing of sounds, and knowledge of the nature, or even the existence of the sounding body, that we are more startled by sudden, loud, and unusual sounds than by any other sudden and strong affection of the senses. In the discharging of firearms, it is the report which frightens both men and animals, and not the bullet, though the report is perfectly innocent, and the bullet carries wounds and death on its wings. Lightning, too, is not only much more sublime than thunder, but its power is, in some instances, tremendous; so that we cannot set bounds to its effects; and yet it is the harmless din of the thunder which terrifies. The motion of the air which produces sound seems to be quite different in kind from that which overcomes resistance, and affects the skin and the muscles. The ear will catch the tones of a bell at the distance of eight or ten miles on a still evening, though the vibration of the bell does not at that distance produce a motion of the air that will bend the spider's most slender thread; and yet the same ear gives no notice of the approach of a bullet, by which it may be the next instant dashed to pieces; and the first notice given, whether the bullet strikes, or passes near, is a muscular impression, and "the wind of a bullet" is a wind that blows, not a wind that sings. It is much the same with noisy things as with noisy people: they are always less effective in proportion as the noise is louder. A deeply honey-combed ball, which whistles as it flies, goes less fleetly and directly to its mark, and does less execution, than one which speeds on in silence: and, in blasting rocks with gunpowder, it is the stifled smouldering shots that do the execution. Thus it would seem, even in inanimate things, that sound is the wail of weakness,—the crying, the childishness of the creation, as it were.

And it is worthy of remark, that our hearing partakes more of the nature of a child, and must be schooled more nearly like a child, than any of our other faculties. In itself, it is indeed a child; an infant at the very commencement of life: it has sensation, but it has neither knowledge nor the means of getting any; and unless it is first taught out of the mouths of others, or schooled by the co-operation of the other senses, it never can reveal to us the simplest fact.

When, however it is once educated, it can take the lead of all the senses, and be foremost in the career of knowledge. That is a very beautiful confirmation of the superiority of man to the other animals, and of his reason, which is nothing without education, to their instincts, which require none. The young partridge of an hour is firm and fleet on its legs; some species of *aphides* are matured even in a shorter period; while Newton or Watt, if left to themselves at the first, would have soon perished; yet Newton gauged the universe, and divided the beam of the sun into all its radiant colours. He did not, indeed, give godhead to man, for man is man still; but he opened up a passage whereby those who proceed aright may approach near the footstool of the throne, and admire, and worship, and learn still higher knowledge, and taste still more unmingled happiness. Thus, although the ear brings us no direct knowledge of external things until it has been instructed, we must not slight it, or deem it at all imperfect on that account; for in proportion as it is educated, it becomes the gate of wisdom; and it is rich in pleasure, and the pleasure which it brings never fatigues and never cloys. Nor must we forget, that the ear is the instructer of the hand in those immeasurably small differences of motion in the touch, by means of which skilful musicians repay the ear for its labour in tones so sweet, and cadences so soft and fine, that the sound feels drawn out to the very verge of matter, and ear and instrument are lost notice of, and naught remains but the delighting music and the delighting mind. There is probably not one feeling of our nature—certainly there is not one sensal feeling—where we can so completely put off the animal, and bring the mind unclogged to its enjoyment, as in the hearing of sweet sounds. And that is the reason why the pleasure which those sounds produce is so exquisite, so ready, and so constantly on the increase. No doubt, if we are to have that pleasure, we must cultivate the ear; that is, we must exercise it among pleasant sounds; and where can we do that so well as among the voices of nature, which are all musical, all true, and have no corrupting associations blended with them. The ear is thus well worth the cultivating to as great an extent as possible; and where that is vigorously and successfully done, it will accomplish many things. It cannot, indeed, give eyes to the blind, or feet to the lame, but it makes a substitute; and if we may judge by the light hearts and gleesome dispositions of blind people, as contrasted with the gloom and even moroseness of the deaf, it is probable that a soundless world would be more desolate than a sunless one.

It is quite impossible to say what may be the particular state or action of the air in the curious tubes and labyrinths which make up the beautiful internal cavity of the ear; but it is certain, that the fine membrane called the tympanum is not the organ of hearing; because there have been frequent cases in which deafness has been cured by the destruction of that membrane. The sense which it most nearly resembles is that which is called touch, though not that branch of the very complex sense of touch which is made up of a succession of feelings and leads to knowledge, but immediate and instantaneous touch. The one of these gives us no more information about the object producing it than the other. If a person is sitting, musing in a dreamy revery, with his senses idle about him, and you steal behind him unobserved, and slap your hands smartly together, it will take him some time to find out whether you slapped him or not. Then, as to the knowledge which is obtained of the object of immediate (even pretty smart) touching, the absurdity of it is well exposed by Butler in these lines:—

"Some have been beaten till they know
What wood the cudgel's of, by the blow;
Or kick'd until they can tell whether
A shoe be Spanish or neat leather."

There are many proofs of a very close resemblance between hearing and instantaneous touching. A sound which grates on the ear produces a tremulous motion in the whole body, and the instances of "setting the teeth on edge," that is, irritating the sensitive substance which lines their sockets, by whetting scythes and sharpening saws, or crushing cinders under the foot, are quite familiar. Hogarth, whose philosophy was as true to nature as his painting, never was more happy than in the discord of "villanous noises," by which the "Enraged Musician" is tortured to his very finger-ends, and would have appeared so down to the toes, too, if it had suited the painter to bring them into view.

This coincidence of sound and touch is worth knowing and attending to; not only that we may observe nature readily and pleasantly, but that we may, in some instances, do it safely. If a timid man stands high upon an insecure footing, the kindly admonition to "hold on," if given too hastily or too loudly, is the most likely means of tumbling him down; and on that principle, they who have not familiarized themselves to sudden sounds, so as to distinguish the impression on the ear from an impression on any other part of the body, cannot go safely to those places where nature is seen to the best advantage. He who starts at the crash of a falling stone cannot stand safely on cliffs; and he who shudders when a sea breaks over the bows, dare not rock on a mast-head in a gale; and yet he who has so schooled his senses as to be able to keep them ready, and his mind calm, in those situations, sees views and enjoys pleasure of which the careless and the timid can have no conception. Collins knew that well, and expressed it beautifully:—

"First *Fear*, his hand, its skill to try,
Amid the chords bewilder'd laid;
Then back recoil'd, he knew not why,
E'en at the *sound* himself had made."

The same principle carries us a great deal further; and it is worth following for at least part of the way, because, being always collected and ready, is the very soul of observation. Now just as we are never in the least surprised at our own thoughts, however extraordinary they might appear if they were told to others, and never have the least doubt of the truth of even the most absurd and practically impossible of them; and not only so, but we stand up manfully for them, and resist with all our might and as long as ever we can the external evidence which, in the end, convinces us that we are wrong; so, also, we are never frightened or alarmed at any one of our single sensations, be its subject or its consequences what they may. The soldier who, in advancing to the charge, receives his death wound, continues to rush on a few steps, and falls painless and dead; and if that extreme case can be met without any thing that causes unhappiness, surely all the inferior cases may.

Everybody must have felt the truth of the mind's satisfaction and confidence in its own thoughts, from what occurs in dreams. A man who dreams that he is flying, or standing on the cross of St. Paul's, or walking on the bottom of the sea, never has at the time any more doubt of the fact than he has of the fact of being himself. That is the mind acting with little more co-operation of the senses than suffices to bring the dream back in waking suggestion; but still the dream is mentally possible, and certain truth, up to the moment when he awakens, and finds, by actual observation, that he is snugly in his bed. The body takes part in matters at that stage, and thus the mind loses its wings, and is clogged so that it cannot soar. But we are startled at the thoughts of other people, because they are communicated to us in the very same way as we get all our experience,—that is, all our knowledge; and so, if the thought which is communicated to us is in accordance with that knowledge, we cannot help believing that it is just and true; but if it is not in accordance with that knowledge, we can as little help believing that it is absurd or false. It is altogether impossible for us to judge of that which we learn from without, by any other standard than that which we have; and as rightness and readiness in those judgments are that which gives perfection to our character, we cannot be too constant or too careful in our observation.

But every sensation, however fleeting it may be, and through whatever material organs it may appear to come, is really an act of the mind, and an act of the whole mind; because the mind is *one*, and it is utterly impossible that *one* can be in *two* states at the same moment, how short soever that moment may be. Hence it follows, that if we are to apply our minds to observation by means of any sense, the other senses must be kept still, so as to leave that one to work to the utmost bent of its power; for if that is not the case, as they all have a resemblance to each other, and perhaps are all only the general muscular sense of resistance modified by organizations, one will be constantly breaking in upon another, and we shall start from sight to hearing, and from hearing to touch, until we become perfectly incapable of knowing what sense is affected, or indeed whether the sense is affected at all. That is the state of momentary or periodical non-existence, with which the lives of the heedless are so much spotted, and by which even the most careful of us sometimes waste our time and mar our plans. It is what Milton calls the "brute unconscious gaze," and the Scottish peasantry very appropriately call "looking from them;" and it is literally *from* us in these cases, for the senses are flood-gates, in which there are always currents when they are open, and if new knowledge does not flow in, time will flow out, and bear off our old knowledge on its tide. There is no means of avoiding the last of these but by pursuing the first; and thus observation is really our guardian, as well as our guide. In our business or profession, how much soever we are occupied with it, it is impossible to get as much observation as will keep all the senses up to their proper tone; and therefore the observation of nature comes in, not to draw us away from our callings, but really to work along with us and encourage us, as a most ready-handed and gay-hearted auxiliary.

There remains only one sense to be noticed, and that is the sense of sight—a sense, the organs of which in their structure more resemble contrivances that we can make than those of any of the other senses. On that account we can assist and improve our eyes more by artificial helps than we can any of our other sensal organs. If the sight is too short, we can lengthen it by spectacles hollow in the middle; and if it be too long, we can shorten it by spectacles of the opposite form; so also we can make distant objects appear near with the telescope, and small ones appear large with the microscope. These are very useful contrivances; but the use of them is limited to a small number of people, and not a great number of occasions. When we go out to recruit ourselves by the popular observation of nature, we are not to carry spectacles, telescopes, and microscopes with us, but to use our own eyes; and to nine hundred and ninety-nine in every thousand of us, well-educated eyes, used to good purpose, are superior to all the philosophical instruments in the world. Those instruments are valuable to such as require them, just as the tools of every trade are useful to those who follow that trade; and improving the tool is the best and most certain way of improving the trade itself; but the eye is a tool in every trade, a universal tool; and therefore everybody should be diligent in its improvement.

The eye can work to a greater distance than any other organ, and it works much faster. When you come over the last height, and look down upon a fine city, with its domes, and spires, and pinnacles, and surrounding villas, and gardens, and groves, and rich fields, if your eye has been duly exercised, the city is taken and your own at a glance; and we very frequently find that a keen-eyed visitant, who remains but for an hour, will discover in a place many beauties that were unknown to the whole of its inhabitants, but which have been afterward found worthy of admiration, and admired by them, and have been visited and admired by others, and the place has thriven and grown from a small village to a goodly town, simply because one man, who had eyes in his head and could use them, happened to look at it, possibly without any intention but that of feasting his hungry eyes at the moment.

A disquisition on the anatomical structure of the eye forms no part of the eye's education; because it is not the matter of the eye that wants to be taught, it is the mode of its action; and all that can be said is, give it plenty of exercise; keep it always hungry for knowledge of whatever can come before it, and do not fatigue it either by excess or monotony. The invitation of all nature to the eye is, "Come and see."

SECTION IV.

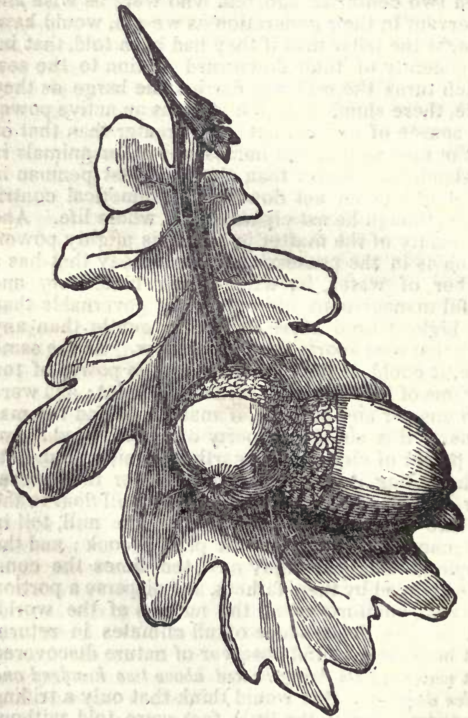
Precautions in observing Nature.

The precautions necessary to be observed in contemplating the works of nature are very few. It is not necessary to allude to personal safety; because it may be presumed that everybody can attend to that, by keeping out of dangerous situations, and from eating unknown vegetables. But still, there are some prejudices to be avoided, as well as some general laws which must not be violated, else in either case the result of our observation will be error, and not knowledge.

However tastes may differ,—and tastes, which are habits formed by the thoughts running more in one direction than in others, are perhaps as often founded in error as in truth,—there is really no ugliness in nature unless it is actually made by the observers themselves. The exercise of the senses, and especially that of the sense of sight, is always pleasing—a gratification, and the only way in which both mind and body can be gratified. It is gratifying, because the probability is, that sensation is in itself a direct renewal of the organ of sense. It is probable that the exceedingly small and delicate texture in the eye feeds upon and drinks up the colours of the landscape, or whatever else it sees, in the same manner that the mouth receives food and drink for repairing the general waste of more rude and common parts of the body; and it is equally probable that the immediate organs of all the other senses receive the same renewal from exercise; and that, as the eye gets healthy, and fat, and vigorous, by beautiful views, just so does the ear fatten upon sweet sounds, and the nose upon grateful perfumes. We must not be startled at the immeasurably small quantity which is added, or passes from object to organ in these cases, because supposing that size and weight are necessary for the accomplishment of nature's purposes, and that the purpose effected is in proportion to either of these, are among the prejudices against which we must especially guard. In common materials, size and weight are so far the measures of strength, but beyond a certain extent they become weaknesses; and there is an elevation, and not a very high one, to which, if reared, a tower would crush its foundations, though of adamant, or a mountain reduce its granite to dust. But, in all cases where there is natural *action*, we must bear in mind that size and weight, instead of being elements of that action, or assistants to it, are clogs and hinderances, and probably the only clogs and hinderances by which it is restrained and diminished. It is, indeed, the same in all action, whether natural or artificial. Action is exactly the same thing with motion; and in all cases of change of matter, which is the only evidence we can have of action, there is change of place, though in many instances that change is so small that we are unable to perceive it. When brine, that is, water holding common salt dissolved or in a liquid state, is boiled, and allowed to evaporate until the salt crystallizes or forms into little solid lumps, there is motion in the case; and we can trace the process backward till we find motion, and motion alone, for which we cannot account. The invisible atoms of salt which were scattered through the clear brine must move towards each other in order to form the little crystals; and the law which regulates their invisible march is as perfect and as uniform as that which regulates the motion of the earth upon its axis or round the sun; for, unless in cases where we can find a cause preventing them, those crystals always assume the same form. The formation of the crystals is one motion, and it is a very important one; because as there is no other substance which crystallizes under exactly the same circumstances as common salt, it is by knowing and bringing about that small and invisible motion that we are enabled to give a pure and wholesome relish to our food; for even common salt, as it exists in nature, is mixed with magnesia and sulphur, and other ingredients which render it unpalatable and unwholesome.

The previous state of the process is also motion. A certain quantity of water, having a certain degree of heat, is necessary for separating the natural salt into particles so small as to be invisible; and the quantity that can be dissolved in boiling water is far greater than that which can be dissolved in cold water. Now it is the property of water that it begins to boil at two hundred degrees of the common thermometer, or a little less or more according to the state of the atmosphere. When that is light, boiling water is a little cooler; and when heavy, it is a little warmer: but the variations are trifling, and not necessary to be taken into account in common observation, though we cannot observe even the operations of nature to proper advantage without knowing something of their causes.

When the water comes to the boiling point, if the surface of it is freely exposed to the air, it never becomes any hotter; and after it fairly boils, one could not warm it one jot, except it were in a closed vessel, even though it were exposed to a fire of the greatest strength for twelve months. And the water contends for this law of its being, even when it is in small quantity, with strength far exceeding the strength of armies. It is the resistance of water to being heated above the boiling point which has enabled England to add the steam-engine to the implements of her labour; and thus leave the horses to the plough and the team, and man to superintend and to *observe*, and thence to learn and to do, more and more for his own enjoyment, and the improvement of his country and his kind. The people who lived two centuries ago, and who were as wise and observant in their generation as we are, would have thought the teller mad if they had been told, that independently of their downward motion to the sea, which turns the mill and carries the barge as they glide, there slumbers in the streams an active power —a source of motion, not only greater than that of all the men and all the horses and other animals in England, but greater than the expertest penman in the world could set down by arithmetical contrivance, though he sat ciphering his whole life. And the beauty of the matter is, that this mighty power, which is in the possession of everybody that has a pitcher of water, is, with proper machinery and skilful management, not only more governable than the highest bred horse, but more gentle than any lamb that ever sported in the meadow. At the same time, it could, if need were, bring the power of ten millions of horses to bear on a single point; and were it to answer any purpose, if man could find the machinery, this simple property of water would give the power of cleaving the earth in twain. But, notwithstanding it can spin a thread finer than gossamer, and weave it into gauze which will float in the air like a vapour; it will grind at the mill, toil in the manufactory, and it will print a book; and the people of England enjoy now ten times the comforts enjoyed by their fathers, and disperse a portion of those comforts to all the nations of the world, and receive the produce of all climates in return, just because a skilful observer of nature discovered that *water resists being heated above two hundred and twelve degrees*. One would think that only a trifling discovery; and if the little fact were told without any of the consequences, nobody would give a farthing for the information. But great trees grow from little seeds. The Thames, notwithstanding the length of its course and the beauty and usefulness

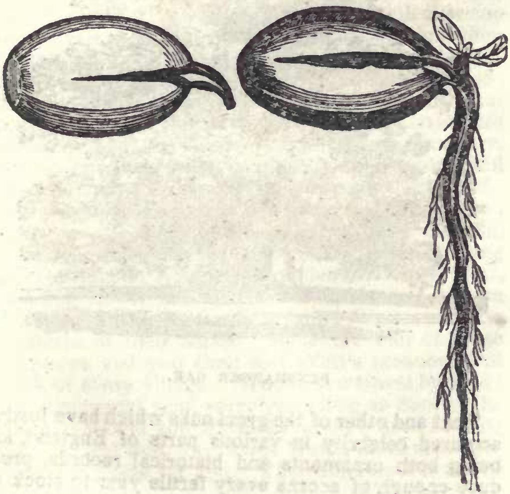


OAK TWIG, NATURAL SIZE.

of its tide, steals back again from the sea in vapour; and it is tempered with so many delightful sensibilities, that it waters the fields, and refreshes the animals, even when on its aerial flight to those mountains which collect and give forth the fountain-springs. The beginnings of all things are small; and if we take weight and measure as our proofs of existence, the origin of every thing is in nothing. Of what magnitude and of what weight is the acorn of even next year in that little bud at the tip of the oak twig?

Of what size and weight are the acorns that are to be produced a hundred years hence in that little oak which is not yet a finger's length, and wears the first leaves of its childhood?

A B



A. Acorn germinating. The shell ruptured at the top; an umbilical vessel from each lobe of the nut; the germ at their union, but hardly visible.

B. The young plant. The root extended; the plumule, or future stem, barely developed.—Durable trees make roots first.

What scale so fine as to measure, or what balance so delicate as to weigh, the present germes of the thousands of giant oaks which are all to be produced by that little thing in its infant dress, and which are to form those future navies by which the sea is made to rule as well as encompass the land!

PENSHANGER OAK.

That and other of the great oaks which have justly acquired celebrity in various parts of England, as being both ornaments and historical records, produce enough of acorns every fertile year to stock a forest; and yet the germes of all their generations must have been contained in the first oak-bud that ever sprouted; and but for the germination of that, we should never have had an oak. Nor is the oak a solitary instance; for as we trace any thing towards its origin, we find that the limit which we approach is that "nothing" out of which Almighty Power spake and commanded "all things."

It is, therefore, always dangerous to slight little things, for little things are all beginnings; and in obtaining knowledge, and thence enjoyment, it is at the beginning only that we can begin. All those beginnings are in nature; and those who discovered and applied the property of water which has been mentioned had no more to do in the making of that property than those to whom it is altogether unknown. Anybody, too, who possesses the organ of sense necessary for the purpose, and will exercise that organ, may know those beginnings; and then comes the proper exercise of man. One thing is compared with another; the process is continued; the relations of these things to each other are again compared, those that are fit are adopted, those unfit rejected: and thus discovery is piled upon discovery, just as one little brick is piled upon another, until the observant and reflective man rears a splendid edifice, and calls it an invention; and it adorns human nature as much as the most magnificent material palace adorns the earth. Even now they are erecting in Westminster Abbey a monument to James Watt, and, perhaps, it had been as creditable had it been done some time ago. But James Watt needs no memorial at their hands. Make the tour of these kingdoms, and you shall find Watt's monument at work at every village. Would you travel by land? that monument shall carry you along as fleet as the winds. Would you travel by water? heed nothing for wind and tide, for James Watt's monument will overcome these for you. That monument is at this moment dividing the waters of every navigable stream, and the waves in every ocean, in and between all highly-civilized and active countries; and if, when one is in St. Paul's, "look around" be enough of reminiscence for the genius of Sir Christopher Wren,—climb the highest mountain, get the most ample range of land and sea; and, in what part soever of the busy world it may be, "LOOK AROUND" will still be the epitaph of James Watt.

But what he and his co-operatives have done is but a single series of the applications of that one property of water. Those applications are very many, and our salt-making is one and a highly important one; and there are places where, if the people could find materials, they would prize the making of salt more than the making of gold. It is reported that there are some tribes in Africa who give away gold-dust, but reckon value in salt as we do in money. Well, the moment that the water is raised to the boiling point, it will receive no more heat into its substance, or allow any more to pass through without exerting the resistance to which allusion has been made; and if it is not everywhere resisted in return by something stronger than its own resistance, a portion of the water goes off, and carries the heat along with it, so that the water where it just begins to mingle with the air is far hotter than it is at the bottom of the vessel. Every one has noticed the force with which the steam of water in a teakettle issues from the spout, and may have seen the force of boiling water drive off the cover of a saucepan; and it is said, and possibly it is true, that the discovery of the steam-engine was owing to one or other of these; but when, as in boiling brine for salt, the surface of the water is freely exposed to the air, the heat and water go off together; and if the boiling were continued long enough, the water would pass entirely into the atmosphere. Salt does not pass so easily into vapour as water; and, therefore, as the water boils off in vapour, the remaining liquid becomes salter and salter, until at last there is much more salt than the remaining water could keep dissolved if it were cold. If the boiling were carried on too long, the salt, together with the other matters in the water, would begin to form a crust at the bottom; but the salt-makers here "observed" the proper strength to which the brine should be boiled; and they stop the boiling and allow the water to cool, in that state when there is not so much water as is sufficient to overcome the tendency which the invisible atoms of salt have to form themselves into crystals, and so as the stronger power invariably acts in nature, the salt crystallizes. The brine is thus obtained by motion (it becomes brine by the ingredients of water and salt, which are at the least four in number, moving into a very intimate connexion with each other). The brine is warmed by motion; the surplus water is carried off by motion; the water is cooled by motion (the motion of the heat out of it), and the salt is crystallized by motion. If we were to follow the processes through which the salt, or any other substance whatever, passes even in the longest series of changes or events, we should invariably find each change to be a motion of some kind or other; and that any particular motion always arose from some power or source (beyond which we could not trace the motion) overcoming another power which, had it been the stronger, would have produced a totally different result; and given rise to quite a different chain of appearances. Take, for instance, a bushel of barley, and steep it in water, and it will drink up some of the water, and swell and become sugary to the taste, and begin to sprout; and it will do that whether it is steeped by the maltster, or sown in the earth and steeped by the moisture of that. Thus, a succession of events is begun, which in each case we can trace no farther than the grain of barley, unless we trace that through the plant on which it grew to the grain which produced that plant; and after we had known all the steps of growth and ripening, between one grain and another, we might repeat the same circle over and over, but would never get any additional information. But at every stage between the one perfect grain and the next in succession, the plant has a different appearance, and is fitted to a different use; and the maltster knows that if the natural progress of the plant be arrested, and its power of again returning to that progress destroyed when it is in the sugary state, it will become malt, and the brewer will purchase it. So, as soon as the maltster has steeped it to perfection, he tosses it about, and breaks off the sprout, and dries it; whereas, when it is left in the earth it roots itself there, and sends up its stem, and becomes a plant; and if the man can wait and will attend to it, and collect each year's produce, and sow it again next year, his one bushel will soon become a thousand bushels. In these instances, again, there is nothing but a succession of motions; and in them all there is a point at which the thing gets too fine for weighing or measuring, and there it glides slowly beyond our comprehension altogether; and the very minutest guess, as it were, that we can get of a thing, is the proper point at which to begin the study of it.

The neglect of small things is, indeed, the grand error, in consequence of which so many pass in ignorance and heaviness that life which nature and art (for, after all, art is merely the application of nature) are capable of rendering so intelligent and so full of happiness. The fable of "The boy and the goose with golden eggs" applies in most things to many people, and in many things to all people. The eggs of the goose were brought to their proper size by a process of nature, which the owner of the goose could forward in no other way than by giving the goose plenty of wholesome food, and otherwise keeping it comfortable; and when the silly boy killed and opened the goose, and found the germes of the eggs no bigger than grains of mustard-seed, he was not only disappointed in his expectations, but he was deprived of those eggs which, if he had waited, he would have got in the course of nature. Just so, in every process, whether of nature or of art, there is one succession of events which leads to the proper result; and if at any stage of those events the least change be made, the result will be changed, and the labour will fail and be useless. The nearer the beginning that the deviation from the right course is, the farther are matters put wrong. One-tenth part of an inch of error in the levelling of a gun, may throw the bullet fifty yards wide of its mark. One pace taken six inches longer or shorter than the one before it, will turn quite aside and cause to lose his way, on a trackless moor and enveloped in fog, a man who started in the proper direction to where he was going. Life is to us all not unlike the moor in the fog, we must find our way much more by that which is in us than from external things; and if we are heedless of steps, we never can get straight on to our purpose, but will often wander so obliquely as, without being at all aware of it, to turn completely round, and end where we began. That is the case with those who go occasionally to the foggy and pathless moors. They set out from the cottage on the one side in exactly the proper direction, but as they have been accustomed to follow beaten tracks—*to be mere copyists of others*, they deviate without knowing it, and very often night brings them back hungry and exhausted, though all the time they have a firm belief that they are going in the direction of that place on the opposite side, which they ought to have reached before mid-day. Indeed, to those who do not take heed how they walk, sunshine and surrounding objects are not to be depended on, because, in places that are strange to us, we sometimes cannot convince ourselves that the south is not the north, although the mid-day is shining there in all its splendour. There is no man, who has walked much about among lonely places, that has not often experienced that; and, therefore, though our object is only to cross a portion of country by the shortest road, observation is the most certain means by which we can attain that object; and thus, one of the earliest lessons that the observer of nature requires is "how to keep his way." Take the most intelligent friend that you have in or near London, who has lived within view of a certain reach of the Thames, till he has associated the direction of the river there with the other points of the horizon, put a compass in your pocket and walk with him along the bank of the river from Vauxhall to Windsor, or for any other considerable distance, and keep him engaged in conversation all the while, so that he should take little notice of the objects which he passes, then stopping at any place you will, where there is only a small straight portion of the river in view, ask him its direction and get his answer. Then pull out your pocket compass and learn the true direction by that; and you will find that your friend's notion has little, if any, reference to that, but that with him the Thames always runs in the same direction as it does within his own "reach." Even you yourself, although you may try to guard against it, will find that, as the river bends gently northward or southward, your compass becomes false both ways by turns, and that the very sun shifts about in the heavens, gets sometimes very rapidly westward, and at other times retrogrades eastward.

Where there are pathways people can "keep the rut," and hold on their journey and arrive at the end of it with certainty, just as the dull plod on in life by imitating others; but in the new, whether on a journey in life or in action, there must be observation, and careful and connected observation, all the way from that which was familiarly known before, otherwise there is no security against failure. The man who "loses the points," or gets the "compass in his head" reversed, may always be assured that he does so in consequence of some deviation or double that he made, and made just from want of attention to what he was about. As to the fog, there signifies little whether that is in the atmosphere or in the mind; and, indeed, it is far more dangerous in the latter case,—the fog of the moor may go off without our attending to it, or we may get out of it; but we never can escape from the fog of our own inattentive and unobservant minds.

That there are some principles by which we can find our way, in cases where we can neither see it with our eyes, nor grope it with our hands, is a fact; and any one who attentively observes the footpaths that are formed on a common or field, where there is no hedge, or any thing to determine the direction, may, in part at least, see and understand the reasons. If we can get instruction from the mere fact of treading a pathway across the common, we surely need not despair of getting instruction from any thing that we choose to observe; and that will be another argument for attending to small and everyday matters,—matters that lie within our observation, and may exercise our thoughts without expense or loss of time. Why should there be a trodden path at all? is the first question. People do not follow each other by the scent, as dogs follow their prey; and their persons, legs, and dispositions differ: so that they cannot have either the ability or the desire of going all the same way. But quadrupeds, such as sheep, rabbits, and hares, form tracks; and so do some insects—ants for instance. The tracks of ants are nearly straight lines; and those of quadrupeds are much straighter than human footpaths, if there is nothing to confine them to a particular direction. So that the formation of the path is not a matter of reasoning and judgment at all, but purely mechanical. When an animal, however small or large, walks, it must always so move as that its centre of gravity is supported, otherwise it would fall. Now that is obtained partly by the motions of the legs, and partly by those of the upper portions of the body. The more legs there are, the centre of gravity has the more props, and so there is less need for counterbalancing motions in the body above. Ants have six legs, quadrupeds four, and man only two; so that man needs more exertion of his body to balance himself than the quadruped, and the quadruped more than the ant. The man too is upright, and even the quadruped is higher in proportion to its breadth than the ant. Thus the centre of gravity swings by the longest lever in the man in proportion to his whole weight, and by the shortest in the insect; and thus the man is more affected by the position of the surface on which he walks than the quadruped; and the quadruped is more affected in that way than the insect. Where the ground is perfectly level, the man's path is nearly straight; but if the ground rises to the one hand, the path always takes a twist to the other, because the foot which is on the high ground throws the centre of gravity the other way, and the other foot is advanced towards the low side, in order to support the centre of gravity, and keep the body steady; and as long as the one side of the ground continues higher than the other, the track continues bending towards the low side. If the ground again becomes level, the path, if not counteracted by observation and design, goes on in the last direction of the body, how different soever that may be to the direction of the path on former level ground; and if the ground begins to slope the other way, a bend in the other direction takes place, unless where observation prevents it. Any one who looks at foot-paths, not designedly made, even when they lead across the common from one well known and often frequented spot to another, will see that they are made a great deal upon those mechanical principles, and not only so, but when there is, upon ground having side slopes, a beaten track on the grass by the side of a perfectly straight artificial walk, the effects of this natural balancing of the body may be seen. It does not require hills to produce them, for the ground immediately at the sides of the track may be perfectly level, and yet the track as much twisted as if every little swell extended onward and rose to a great mountain. A slope forwards or backwards does not produce similar effects; but when there is an increase, and at the same time a twist in the ascending slope, the natural paths of men, and even of large quadrupeds, have generally twists there, and twists which are very dangerous for wheeled carriages in moving rapidly. In the early ages of English history, men and horsemen, and pack-horses, appear to have been the only engineers in road making; and as, in a horse with a rider or a load, the centre of gravity is higher, and consequently swings more than in an unloaded horse, those twists at the double curvature of the steep hill occur in many places where the old line has been preserved, and among other places, just near the top of Highgate Hill; and it is a fact, that though those twists are dangerous for carriages, they are easier for those who walk, or ride slowly, than if the road went straight up.

Any one may convince himself of the truth of these effects of the centre of gravity by trying to run in a horizontal direction round a hill, without getting farther from the summit or centre of the hill; or how difficult it is to run round on the slope of a circular basin or hollow without getting nearer to its centre or bottom. If the battlements of a circular tower which has no parapet, slope outwards, it is not only difficult but highly dangerous to walk fast round them; but if they slope inwards, they are safer and more easy than if one were walking in a straight path having the same width. Upon a similar principle—though there the forward motion of the centre of gravity has more to do in the matter—if a circular turn in a road slope outwards, a coach, if moving rapidly, is apt to be overturned or the passengers flung off towards the outside, but if, on the contrary, the road at such a place slope inwards, it is safer than if it were level. On this principle, coaches are much more endangered by passing rapidly loops of road at the hips of hills, than similar loops at the heads of valleys. Thus, we perceive that there is no little information even in that which to those who "see things but do not look at them" appears to be a merely accidental path, and that should lead us to be careful to "look at every thing we can see;" and if we once do that, we are independent of the lessons of other people.

But we further see that there is, in the nature of the surface over which we proceed, a tendency to turn us from the purposed direction of our path; and if we do not observe the variations of surface which act mechanically upon our centre of gravity, and occasion these deviations from the straight line, we never can get to our intended place by the shortest road,—and very often we cannot get to it at all. The inequality of our steps increases this tendency to deviate; for if, upon level ground, we take short steps with the one leg, and long steps with the other, it is altogether impossible for us to keep the straight line; and if we are on a slope, it is just as impossible for us to prevent ourselves from curving down that slope, if we do not take short steps with the higher leg and long steps with the lower; and if we would gradually climb the slope with the least exertion, the higher leg must take little mincing paces while the lower leg takes strides. Here there are some beautiful morals; but we have no time to bring them out; only we shall remark, that, as in walking, so in living and in learning, there is a gravitation in us; and if we do not, by careful observation, adjust it to the circumstances through which we have to come, our path not only becomes crooked, but we are always getting lower down; and that the grand cause of the crook and the descent is, over-exertion of our higher foot: our ambition strides away; our industry cannot keep pace with it; and down we come.

Both those causes of deviation operate upon the man who tries to cross the foggy moor ignorantly; that moor shelves in all directions, and he knows not how to counteract the shelvings; and as little does he heed the differences of path or the regulation of his paces, so as to adapt himself to these. But the man who is intimately acquainted with such places finds out those matters; and let the moor be ever so wide, and the fog ever so dense, he knows the direction of the place where he wishes to go, sets his face directly to it at the outset, and attending to his own steps, and to the form of the surfaces over which he passes, he accomplishes his purpose with ease and certainty.

The sailor is another remarkable instance of what may be done by observation, and working to circumstances. No matter though the wind blow directly from the place to which the sailor is bound, he trims his vessel so that it works within less than eight points of the wind, and thus, by a combination of observations, and of contrivances founded upon those observations, he so tacks and zigzags across and across that wind, as to make it actually blow him towards that point from which it is itself blowing.

To beware of slighting any thing, on account of its supposed insignificance, is the grand precaution for those who would pleasantly and profitably study nature; but there are a few others. We must not abstain from the examination of any thing on account of the ignorant having a prejudice against it. It has been already said, that no production of nature is ugly; and it may be added, that when we are properly acquainted with them, none of the productions of nature are injurious. It is true, that there are some that would poison us, if we ate them: others would burn the body, if they came in contact with it; and others again offend, and even waste and wear our organs of sense. But it is our own fault, if we allow them to produce any of these bad effects. We need not swallow arsenic, be bitten by rattlesnakes, offended by the sight of toads or newts, or sickened by noxious effluvia. We should find out their properties, and shun those that are hurtful, at the same time that we turn to advantage those that are beneficial. Deadly as the white oxide of arsenic is when taken into the human stomach, arsenic, used for proper purposes, is a highly valuable substance. Some of its oxides are beautiful paints, others give purity to glass, hardness to the metal of printing types and the mirrors of telescopes; and even the deadly poison itself is the most effectual remedy in some diseases. Prussic acid, again, which in certain states is a more deadly poison, perhaps, than even arsenic, is not only in other states a valuable medicine, as well as a most essential ingredient in some of the most grateful tastes and odours, but it is highly probable that it tends as much, and perhaps more than any other substance in nature, to produce the colours of those flowers which render the fields and the gardens so gay. These are, no doubt, extreme cases; but they are cases to the purpose; and with them before us, we must learn not to have an aversion to, or to despise, any one of nature's productions, until we can be sure that we know all its properties and all the purposes that it will answer. And as that is a degree of knowledge at which we never can arrive, it is tantamount to saying, that we should never despise, or cease further to examine, any natural object whatsoever; because, even in the most common and neglected one there may be properties more really useful than those of that upon which we, with our present knowledge, whatever the extent of that knowledge may be, set the highest value. There was a time when people little dreamed that common coal might be made to circulate in pipes like water, and light up streets, roads, and dwellings, and yet be nearly as serviceable as ever for common fires, and more serviceable in all cases where smoke is objectionable; and there was also a time when, if any one had said that the elements of water, mixed in the same proportion in which they form that liquid, could, by being burnt from the state of two separate airs to the state of liquid water, produce about the most intense heat that could be produced, the statement would have been treated as the dream of a distempered imagination. There are innumerable cases, too, in which that which has for centuries been thrown away as the refuse has, upon further discovery, been found to be the most valuable part of the whole composition. The ore of zinc, which united with copper forms brass, used to be considered as a useless encumbrance by the miners in several parts of the country. The bones of meat, which were once scattered both unsightly and unprofitably over the waste places, are now, in consequence of a few very simple discoveries, made probably more valuable, weight for weight, than the meat itself; and the very dust and rubbish of the houses, which in the places where it collects is absolute filth, is found very serviceable in many of the arts, so that large fortunes are made by people who collect it at their own expense. It is scarcely possible to turn one's attention to any one branch of industry in which there shall not be found some substance of the greatest importance and value, which used on former occasions to be despised. Therefore, as we must beware of neglecting small things, so also we must not refrain from observing and examining any thing, though that thing may be neglected or despised, or even derided; for a thing which is any or all of these may contain the substance of the most valuable discovery that it is possible for us to make. There is no substance and no event independent and of itself alone. They belong to the great family of nature and the vast succession of appearances; and, whatever their aspects may be to our mere gaze, they may have a long tale to tell of the past, and a most important revelation to make of the future. To the unreflecting observer, the chalky cliffs of Kent, with their dispersed nodules of flint, may seem very dull and senseless instructers; and yet those beds of chalk have once been sea-shells, and those flints have once been sponges; so that the two together tell us that those very cliffs, which now stand beetling over the ocean, must at some period or other have been far below its surface. Indeed, there is not a substance with which we meet, or an appearance that can strike any of the senses, but which, if we will hear it, has got an interesting story; and whether we visit places thickly tenanted with animals, places thickly planted with vegetables, the barren wilds, the ocean shores, the wide expanse of its waters, or the wastes of drifting sand,—nay, even if we could mount up from the earth altogether, and visit the region of clouds, we should find enough to exercise all our observation, occupy all our thoughts, and gratify and delight us to the full measure of our capacity for enjoyment. We speak of the waste and the wilderness; but, in truth, there are none such in nature: the only deserts in creation are human senses which do not observe, and a human mind which cannot compare and think. Thus, if we complain that we are deserted and solitary, our complaining is unjust: nature never forsakes us and leaves us alone,—it is we who are insensible of and neglect nature. And when we do so, we violate our own nature as much as we belie and libel the rest of nature around us; for our natural bent, our natural pleasure is to observe every thing, be it what it may, which comes within the range of our observation; and if we refrain from doing so, we are degraded from our proper rank in the creation, and the degradation is our own fault. And the punishment of shame and inferiority, and the misery of a useless and ungratified mind, which are upon us, are of our own bringing, and brought by us against every inducement to an opposite course; so that, even though there were any one to pity us, we merit not pity, but ridicule; because our eyes are open and all our senses fitted for the perception of something better; and we, from mere laziness, and not only that, but by stifling with labour, and often with hard labour, the powers which have been given us, knowingly remain ignorant when we might more easily be informed, and take the crooked path of error when we well know that the straight road of truth is both shorter and more easy.

Those two which have been mentioned, together with some ramifications into which they may branch, are perhaps the most stubborn obstacles in the way of the successful observation of nature; and if we could get the better of them, we should have a will to the work, and where there is a will, it is true, and common even to a proverb, that there is a way. But as, even where they exist, and are acted upon in all their inveteracy, we are not very willing to confess them, it may, perhaps, be as well to suppose that we have got the better of them, and are disposed, not only to push vigorously onward in the road of observation, but to be informed of every thing that can speed our advancement, or prevent our turning aside from it.

Those who would be profitable observers of nature must have very clear and correct notions on the subjects of weight and magnitude, which are the general qualities of matter in all its varied forms, whether living or dead: they are the standards by which all things are determined, and the only means by which one thing can be accurately compared with another: and when we come to any thing, be it what it may, that we cannot determine either by weight or by measure, our knowledge of that thing is always vague and imperfect.

Weight is nothing more than the tendency which all portions of matter have towards each other; not in the formation of crystals of a certain shape, as was mentioned in the case of common salt, or in the formation of drops of water, masses of stone, plants, animals, or any thing else that has a specific or individual form and character; but a more general property, common to all matter, and, in fact, the only test by which matter is known, or its real quantity ascertained. In material bodies, near the earth's surface, where all the productions of nature that we can more immediately observe are, weight means the same thing as the tendency which those bodies have to fall to the earth when not supported, and to remain on its surface after they have fallen or when they are once there, if not raised up by some other force powerful enough for counteracting that tendency. As this weight is, as we may say, a universal property, it should be understood by even the most unpretending observer, if he is to apply his observation to any useful purpose, how simple soever that purpose may be. Its laws are as simple as itself is universal; and as they can be stated in very plain language, every one should bear them in mind. They are these:—

First, the tendency which any piece of matter has to gravitate, or, as it is termed, to fall, is exactly in proportion to the quantity of matter in that piece; and though its effects may be varied by circumstances, in itself it remains unaltered. So that, if the piece were broken into the greatest number of smaller pieces, the amount of gravitation in them would be exactly the same as that in the large piece before it was broken. So also, if any piece or pieces of matter be joined to another piece or other pieces, the gravitation of the collection is always exactly equal to the sum of all the gravitations of the individual parts.

This property is indestructible; and not only forms part of the constitution of matter, but is the property by means of which alone we acquire any knowledge of matter at all. That which the tongue tastes, or the nose scents, we cannot measure, or in anywise know but by inference; and it is by inference that we know what the ear hears, and even what the eye sees, though after long practice we take no notice of, and therefore forget, the process of inferring. Our knowledge of extension or magnitude, too, is an inference; and it is impossible for any one to say how many millions of feelings a child must sum up before it can feel the length of its own finger, or make sure of touching the finger of the left hand with the finger of the right. It is clear, however, that in this dawn and birth of knowledge—this fountain and day-spring of all ingenuity and of all action, we borrow nothing from the eye; for we can lay our finger upon any reachable point of our own body with our eyes shut as accurately as we can with the eyes open, if, indeed, not more accurately.

Any one may be convinced of the truth of this, by extending his arms, clinching his hands, except the forefingers, and then bringing these to touch each other, in front where he sees them, and behind him, or over his head, where he sees them not; and, if he will but shut his eyes at the same time, so as to prevent the distraction of sight from without, he will find that the unseen touch is more easily and more accurately performed, than that upon which the eye looks, and, as we suppose, directs with the most studied attention.

Thus the gravitation of matter is not only the most general property of matter, but it is the source and foundation of all that we can observe or know about material things; for our *first* sensations, which the mind must have before it can either compare or infer, are, and can be, nothing but resistances of gravitation to the action of our muscles; and the probability, nay, the certainty, is, that we feel them in the weight of the muscles themselves, before we can have the slightest notion of the existence of any thing else. It is impossible for us, by any actual division we can make, even by the aid of the most powerful magnifying glasses that can be made or even imagined, to arrive at any knowledge of the primary atoms, beyond which matter cannot be divided. But it is probable that the first sensation is that of a single atom in the muscle; and that, consequently, the first element, or, if you will, the first material of our knowledge, is the first element of matter itself,—that we learn by mere atoms, which we can no more know than we can remember the original sensation or feeling to which they give rise. It has been already noticed that the muscular action of the hand,—and the stronger and more healthy that the hand is, it does it the more nicely,—can not only divide space a thousand times more minutely than the naked eye, but that it can beat the eye, notwithstanding all the assistance of its magnifying glasses. And now we can see the reason: the eye is a pupil; and not only knows no more than the hand or the muscles can teach it, but as it knows through the medium of a second material apparatus, it is a stage further removed from mental perception than the muscles; so that while the muscular feeling proceeds by atoms to which we can assign no measure of bulk or even of gravitation, the eye can take cognizance only of collections of those atoms (the smallest most likely amounting to countless millions), which have been known in their succession, and compared and summed up by the mind from the action of the muscles. So, our first knowledge of matter is the knowledge of gravitation, and nothing but gravitation; but it is gravitation which we cannot measure in the primary particle; and therefore it would be vain for us to inquire, or seek to be informed of what gravitation is, because we have pursued our analysis to its very beginning, and there we equally speak truth when we say "gravitation is matter," and "matter is gravitation;" for to our perception they are one and the same.

The second law of gravitation, which it is necessary for every useful observer of nature to know and to bear in mind, is the law of its variation. That law is no variation in the quantity of gravitation itself, because, being the primary quality of matter, gravitation is as indestructible, either in whole or in part, as matter itself, and can be destroyed only by the same power that made it. When we divide matter, we divide gravitation along with it; but there is no ingenuity in man, and we know of no process in nature by which any one portion of material substance can be deprived of the least shade of its material quantity. The little particle of water, while it is rising in vapour through the dry air, so fine that no eye or instrument can recognise its existence, has the quality of gravitation as perfect as if it were dashing down the rocks in the mighty flood at Niagara; and the smoke which ascends upward in the free air would, in a vessel from which the air had been all pumped out, lie at the bottom the same as a stone. The cork that floats on the surface of water has the very same gravitation, in proportion to its quantity of matter, as the lead which sinks to the bottom. The absolute gravity of any one substance is exactly the same as that of any other; and the only variations are, there being less or more of the substance in an equal space, or substances being nearer to each other or farther asunder.

The variations of weight in an equal bulk, or of bulk in an equal weight, of different kinds of matter, are called their *specific* gravities, because they are one of the means by which the *species* of matter are known and distinguished from each other. The specific gravity is known by weighing equal bulks, or measuring equal weights; and that which measures least when the weights are equal, and weighs most when their bulks are equal, has the greater specific gravity. It is of no consequence to which of these methods singly we have recourse, or whether we have recourse to both of them jointly —as we must have in all cases where the specimens which we compare are neither of the same weight nor of the same bulk. In those cases the common mode of expression is, that the specific gravity is as the weights directly, and as the bulks inversely —which means, that if both substances are weighed, and both measured, by standards which are the same as applied to both, then, if the weight of each be multiplied by the bulk of the other, the products will express the relation of the specific gravities.

But the specific gravity of particular substances is not, like the absolute gravity of one substance, unalterable. The very notion of it is compound: both weight and measure enter into it, and its value is expressed by their product; and the same product may be obtained from any two numbers, if the one be increased in the same proportion as the other is diminished. Thus the number sixteen is four times four, or two times eight, or one and one-third times twelve, or one time sixteen, or one-half time thirty-two, or one-quarter time sixty-four—or, in short, some product of any number that can possibly be named. There are various natural causes that alter the specific gravity of substances, though more extensively in some than in others; and some of the most important, as well as the most curious results and appearances in nature are owing to those changes. In dry wood, the changes of specific gravity, in the same piece, are very small; while, in the common air that we breathe, they are great; and in countries and at seasons that have the weather variable, they are constantly taking place. They are, indeed, among the immediate causes of some of the changes in the weather, and they are in other cases the effects—on that subject it is not very easy to distinguish between causes and effects. In the events themselves, there is no difference between what we call causes, and what we call effects; for every cause is the effect of a former cause, whether that cause be known to us or not; and every effect is the cause of a future effect, whether or not we shall discover or otherwise know that effect.

The only other variation of gravity which it is necessary to mention, for purposes so very general as ours, is the variation of its intensity with change of distance. The farther any one piece of matter is removed from any other piece, the less does the one gravitate towards the other. If, for instance, one body be removed to twice the distance from another, its gravitating tendency will be only one-fourth of what it was before; and if it be brought to one-third of its former distance, it will gravitate nine times as much. It is usual to say that bodies gravitate towards each other inversely as the squares of their distances,—that is, if one body is at the distance two, and another at the distance three, the body at two will, on account of distance, gravitate as nine, while the body at three, gravitates as four.

We must not, however, misunderstand what is meant by distance from a body in respect of gravitation. It is not from the surfaces of the bodies that the distance is estimated, it is from their centres of gravity, or of weight. Those centres, in bodies, are the points into which the whole would be squeezed, if the different parts of the body itself gravitated so strongly as to be able to reduce the whole to one point; and they may or may not be the measured centres of bulk in the bodies. In a perfect globe or round ball of uniform matter, the centre of gravity is the same as the centre of the ball; but if half the ball were lead, and the other half cork, the centre of gravity would be so far into the leaden half that it would scarcely be possible to roll the ball, and it would always lie on the centre of the leaden surface. Very amusing toys for children are made upon that principle, by carving little figures in the pith of elder, or any other very light substance, and gluing a half leaden bullet on the bottom. The figures are so much lighter than the lead that they get up again when they are upset. Toys for children of an elder growth, such as bowls for playing on the green, are loaded in the same manner, which gives them a *bias*, or makes them run crooked; so that an expert player can bring his bowl in at a side, and take the mark away from a bowl that touches it. On the same principle, ships' boats are ballasted, to prevent them from upsetting by the action of the wind on their sails; and coaches that have a box below, for heavy luggage, are much safer than those that carry a much smaller weight of luggage on the top.

The gravitation of distance, or of the position which one body has with regard to another, depends, like specific gravity, on two elements,—the absolute weight of the body, and the distance; and it varies with every change in either of these. It is inversely as the square of the distance, and directly as the absolute gravity or quantity of matter. But the gravitation of distance is not affected by the specific gravity; for if it were not that the air resists the one more than it resists the other, because there is more weight of air opposed to the same weight of it, a cobweb would fall as fast and as straight from the top of St. Paul's, or any other height, as a mill-stone.

But though the place of no substance can be even in the least changed without a change in the gravitation of distance, yet the alterations produced by small changes at long distances are very small. The distance of the mean surface of the earth from its centre is about four thousand miles, and the highest mountain known is less than five miles more, so that the weight of an ordinary man would not be half a pound less if he were on the top of the mountain than if he were on the seashore. Substances that have elasticity or spring in them, so that they are affected by pressure, show even a much less elevation than that. The air is altogether a spring, pressed down by its own weight, and it shows the changes of height very nicely. Water boils with less heat too; and the human body is affected,—the air which is with the blood or other liquids, in the very small vessels, under delicate skin, swells the vessels, and sometimes bursts them and they bleed.

Gravitation is the grand principle by which Nature, on the great scale, is held together; and, under the same circumstances, it is uniform in its apparent effects. In itself it is always the same, following matter through all its changes, dead or alive, at rest or in motion. The paper of this book has, in the same identical particles which now form it, been changed from one visible substance to another, probably millions of times since it was created; and it has very likely been scattered through millions of substances at the same instant; but not one atom of it has been lost; and in all its changes the amount of its absolute gravitation has remained the same—the test and evidence of its being; and always acting according to circumstances, instantly, and in the most unerring manner.

But though the force of gravitation, or more correctly the phenomenon, or appearance of gravitation (for all that we know about forces or powers is only appearance), be thus universal, and in its tendency to act invariable, it is so finely divisible that we can follow it down, from suns which retain their surrounding planets in their paths by its influence, even at the distance of full eighteen hundred millions of miles (that is the mean distance of the planet Herschel from the sun), to mites and motes, and to the particles which circulate in the vessels of animalculi whose whole bodies have to be magnified many thousands of times, before the finest eye can see them; and though it can lead a globe nearly one hundred thousand miles in diameter, or fourteen hundred times as large as our earth, more easily than we can lead a lamb; yet it is so pliant—harmonizes so well with all the other powers of nature, that instead of hindering any thing, it promotes every thing.

The unity of purpose with which even things which to our observation, when we think of them singly, would appear to be of the most opposite character, work in nature, is one of the most delightful rewards of observing them in their combinations. The sun, the moon, and the planets all work together in producing days and years; so that all the living creatures, vegetable and animal, may have their due times and seasons of activity and repose. The night restores from the fatigue of the past day, and tunes all the powers of nature for the day which is to come. The winter howls in storms, and the spring is inconstant with sunshine and showers, only that the summer may bloom in splendour, and the autumn ripen the seeds of young life for the coming year.

Of all those appearances which, blending together, produce so much beauty, and beauty so constantly varying, and yet so constant in its succession that it flows on in one unbroken stream, and which, as we observe it, receives, in our knowledge of it, an increase every moment, just as a river gains a rill from every dell that it passes, we cannot say that any one is the cause of any other. When we push our observation of them, and our reflection on them, as far as human knowledge can go, we find that they all equally demand causes; and that nothing but A UNIVERSAL CAUSE could have produced them, or can satisfy our minds when we come to the bourn where observation stops. And whithersoever we direct our contemplation, upwards or downwards, forwards or backwards, in the extension of space, or in the succession of time, we really can find no boundary —no greatest, no smallest, no first, no last; and yet, as appearance follows appearance in time, we find that the whole are in succession, and that nothing that now is could have been, if something had not been before it; and yet,—though any one of those successions of appearances (which we call the laws of nature) can be suspended by the action or resistance of some, almost any of the others, no one of them can be destroyed or changed into another—how much soever its effects may be modified,—we cannot even imagine that any of them could have been the first cause of any other, or could have existed without something preceding.

It is much the same with the productions of nature as with the laws; and it cannot be very different, as the productions are just the results or consequences of the laws. We see that the habits of plants and animals, and the properties of compound matter, can be changed; and when we once observe how the change takes place, we generally are able, within certain limits, to bring it about. And, just as we expect, when we think over the matter correctly, we find that we can effect the greatest and the most beneficial changes in those things of which we have the most knowledge. Dead substances we can manage the best, because we can in most instances take them to pieces, and in many we can put them together again. Vegetables rank next; after them animals, and then ourselves—in so far as we are material. But, even in the simplest, that is, in the best understood of these cases, we find a boundary which we cannot pass. No art of man, and not any process of nature which we know, can make an eagle graze on the common like a goose; as little can the lion be made literally to "eat straw with the ox;" and even in dead matter, we, in every case, come at last (and the road is seldom a long one, though often difficult to find) to substances which we call "*simple*;" and as those simples are not convertible the one into the other, and as they are all as necessary to the things and appearances of nature as well as the laws are, the whole must have had a simultaneous origin. Whether, therefore, we look at the objects or the events in nature, we are alike convinced that they could not of themselves have begun, but must have had their origin in ONE, and One greater than them all—One who knew before any of them was in existence how they all were to act, singly or in concert, and what were to be the whole of their appearances, throughout the entire period of their succession. That is the ultimate lesson which concludes the book of nature; and if we read that book far enough "with our own eyes," we are sure to arrive at it; and there is this consolation in the matter, that instead of our tiring of it, it ceases to be felt as a task, and becomes play, the moment we enter upon it—or, at least, the moment that we become in earnest with it.

There are various other principles and properties which it is desirable that they should know who are anxious to observe nature with pleasure and to profit. But they are all either less understood, or less open to the common observer, than the great principle of gravitation; and so they may be more advantageously noticed along with the substances or the places in which their operations are displayed. Those that perhaps demand the first attention are they which, without any other apparatus than the substances in which their effects are seen, counteract or suspend the general influence of gravitation.

SECTION V.

Observation of Light and Heat.

The class of agents or agencies (for we have no means of ascertaining whether they are the one or the other—whether they be real *things*, or *mere phenomena* of other things) to which we shall very briefly allude in this section, are light, heat, electricity, and some others, which are sometimes (not very sensibly) called "imponderable" substances. Being "ponderable," that is, having weight, is the only real test that our observation can have of what we are accustomed to call material substances, that is, can be the objects in which those phenomena which we are in the habit of calling the effects of the "laws of nature" can be exhibited or revealed to us through the medium of the senses. And even weight, though we can feel it, in resistance to our muscles and in the muscles themselves, in more minute portions than we can see with the eye, is yet never felt *alone*, so as that we can have any knowledge of it. In order to that, there must be something which we can call *substance*, and that substance must be of some *extension*, or *measure*, or *bulk*; that is, it must occupy *space*, and space in which there can be no other substance at the same time. That space must be of some *shape* or *figure*, too; and the shape of the space must be exactly the same as that of the body which fills it; and the substance which thus occupies space must have some *consistency*, in order that we may know by muscular resistance that it exists; and its consistency must depend, not only on what has been already noticed as its gravitation of quantity of matter and position, by which it keeps its place among other substances, but it must have a consistency of its own, by means of which it preserves its shape. That is called the *cohesion* of the body, which means the tendency that the still smaller bodies, of which we must suppose even the very smallest that we can examine to be made up, have to stick together. And this last property, of which there are many varieties, has no necessary connexion with universal gravitation. The same bulk of water is, under ordinary circumstances, much heavier than cork, for cork swims on the surface of water; but water can be held up in a vessel made of cork. Indeed, the cork is really heavier than water; for it may be so soaked in water that it will sink like a stone, and at the same time be no larger than before. But the water cannot possibly be heavier than itself; and so the cork must be heavier than water. Quicksilver too is much heavier than glass; and yet it can be contained in a glass vessel; but still quicksilver, though when laid or poured on the table, it spreads, yet shows that it has still the property of cohesion, though only to a limited extent. That principle or property cannot resist the action of a pound or an ounce; but the little beads of it are quite round, and they dance about like small balls of polished steel.

It is necessary that the observer of nature, if he is to be any thing higher than a mere "unmeaning gazer" (and those who are contented with that have little chance of reading these pages, even though ten times simpler than they are), should have accurate notions of the consistency of substances. It is that which the unaided senses immediately observe; and all the changes or phenomena that take place in nature are brought about through the medium of the consistency of bodies. Be the sensation what it may, taste, odour, sound, colour, warmth, or resistance, still it is in the consistency of the body that we find it out; and after mere motion, which though in conjunction with other agencies it often changes the appearances of things, is nothing but change of place (and place without substance cannot be known at all), all our knowledge of action or appearance in nature is change of consistency.

There may be changes of consistency brought about by motion and resistance: and the motion may be the result of any thing that can cause motion, and the resistance any thing that can oppose motion. Thus bodies that are compressible may be squeezed into less space by the gravitation of heavy weights placed on them. Cheese is generally pressed in that way; and smoothing-irons and mangles compress the linen by their weight. A less compressible body being made to approach a more compressible one very slowly will squeeze it together with far greater force than any weight that is at all manageable. Screw-presses, which are used for so many purposes, and Bramah's hydraulic or water-press, act on that principle. The finer the threads of the screw are the more powerful is the press; and so, as there are no particles or parts that the eye can find or the finger touch in water, so as to take note of their magnitude, the column of water which moves in the cylinder of Bramah's press is the same as a screw, the threads of which can be made finer than we can know or even imagine. Thus, as there is no limit to the slowness of the motion of the water, there is none to the greatness of the power of the press. We shall see in a future section how powerful and general an instrument water is in nature's working; but as it is only men who, like Bramah, understand the properties of substances well, and are at the same time very ingenious as mechanics, that can apply those principles to useful purposes, we, who are not so gifted, can often understand the great principle in nature, from the small application of it by man, better than we can from nature itself. The principle of the press is this: water is forced into a large cylinder through a very small pipe; and, without making allowance for the friction, the pressure on the cylinder is as many times that on the pipe as the surface of the cylinder contains that of the pipe. If, for example, the little pipe through which the water were forced in had its bore something less than one-tenth of an inch in diameter, and if the cylinder that received the water were about the size of one of the gasometers at the large gas-works, one man forcing in the water with the pressure of a single hundred-weight, would communicate so much to the water in the cylinder as that it would raise up ten thousand ships of about three thousand tuns each, or move Highgate Hill in one mass; and all that power would be obtained by the application of a very simple principle, of whose operation there are countless instances in nature, together with less water than is contained in an ordinary mill-pond. It is true that if we were to try such an experiment we should have some difficulty in finding a cylinder; because it would give way, and give way with a dreadful explosion, if it were not, at its very weakest point, more than able merely to balance the weight of the vast fleet or the entire hill. With us such vessels would be out of the question; but still, as we have no occasion to lift large fleets or entire hills,—for we take hold of other natural principles, and make the fleets sail, and dig through the hills, or break them up piece and piece by gunpowder,—we can have cylinders for water-presses as strong as we have any use for. But nature is not limited in her instruments or operations as we are. We are spectators, and can only imitate that which we have found out; whereas that which we call nature is the thing itself which we observe,—all substances and all their properties. Thus, in the resistance of pressure, nature can have her apparatus strong, up even to the tearing asunder even the globe itself; and we know not how many powers in addition to those with which we are acquainted there may be linked together to prevent that catastrophe; but we do know that if a carriage-wheel, made of the toughest iron, were made to trundle round at any thing nearly equal to the rate at which the earth moves, it would not only be in a moment scattered to atoms, but those atoms would speed away on fire, burning and being burnt with more intensity than any furnace that we could kindle or even imagine as being heated by all the art of the founder, and spread conflagration far and wide. Yet that motion of the earth bends not the slightest thread which the little spider spins from stubble to stubble in the autumnal field; and it is as silent as if the mighty careering mass were in a state of perfect repose.

What effect the rapid motions of the earth may have upon light and heat is quite another matter; but it is a matter so exquisitely nice and delicate that it will not come at all within the range of our observation. If the earth will not pause in its path round the sun until we can find out the general influence which its motions have upon the creatures on its surface, and their phenomena, much less can we hope to question the march of the sunbeams, which actually speed in about twenty-four seconds of time, over a distance equal in length to the earth's annual path. Instead, therefore, of being able to question light so as to know whether it be substance or merely motion, we cannot divide time so minutely as to take the slightest note of the duration that it requires to pass from one pole of the earth to the other: and before we can think of the gleam that shoots past us it is millions of miles into the regions of space, shedding its benignant influence upon other and distant worlds. The matter of the earth and also that of the atmosphere, moving so rapidly as they do, and in the direction across the path of the sunbeam, must produce an effect different from that which would result if the earth were at rest and the beam only in motion; but as we know nothing of either of the two, we cannot compare them or state what phenomena of nature result from the compound motion. There is no doubt, however, that the action is greater than it would be if there were only one motion, because we find that to be a general law of nature. Where two currents of tide meet at sea, the water is trembling and agitated, while a single tide having a greater velocity runs comparatively smooth. When opposing winds strive together upon the face of the waters, the waters are not only thrown into commotion, but a vortex is formed, a cloudy pillar twines upward, and if the striving winds are powerful, and their strife long continued, a cloud may be made to ascend, which may be borne landward, and fall in deluge and devastation, or falling seaward it may scatter navies, and entomb the most gallant vessels in the deep.

So also in smaller matters, opposing the direction of a motion by another motion gives to the collision the joint force of both. If stopped at the same length, a blow hits harder when received on the advancing arm, than when on the arm at rest: the shock of one carriage coming into collision with another one from the opposite or a cross direction is much greater than when the one carriage is standing still; and that again is greater than if they are both moving one way, and the swift one runs up on the slow. In all these cases, and in every case that we can examine, the swifter of the two impinging substances produces a proportionally greater effect than the other. Soft iron can be made to move so rapidly as not only to cut hardened steel as freely as a steel saw cuts soft timber, but it can be made to burn the steel as easily as if that were the most inflammable of substances. The purest water of the brooks and streams wears away their channels; and the winds, which are but the thin air in motion, level the abodes of man with the earth, and sweep the productions of the earth into the sea: nor is there the least doubt that if a spider's thread of sufficient length, and no thicker than those threads generally are, could be borne onward against the globe with sufficient velocity, it would cleave the globe asunder more easily, and in less time, than the arrow of Tell cleft the apple on the head of his son.

If light and heat (for in the beams of the sun they come together, and have many curious combinations in them) be matter, they must be matter in a state of far more minute division than we can ever observe with all our artificial helps. Were they of the size of the most minute grains of dust, even of that which floats invisibly when the immediate rays of the sun are not admitted into the best-lighted room, but which those direct rays disclose as "the light motes that dance in the beam," they would tell upon the earth like cannon-shot, and it would have been long ere now pounded to dust; but instead of that, they are the most kindly as well as the swiftest messengers that visit our abodes; and though they bring us no matter that we can know by bringing it to the test of matter, they bring us active energy, without which the mere gravitating matter of the earth would be of very little value. Where they have been for some time absent, nature saddens and languishes; life becomes dormant or extinct; and there is no motion, save those general motions of the earth, which still have reference to the sun; and would in all probability cease if the earth were deprived of that luminary. But the return of the sun is a time of revival,—the bonds of nature are loosened, and all her tribes are in motion.

No matter how brief the privation is. Be it only the passing of a dense cloud, how much it saddens the face of Nature, in all the more airy and delicate parts of her kingdoms. The polished leaves and petals and the glassy waters glitter no more; the myriads that were, but the instant before, winnowing the air with tiny wings, and breaking the light into all the shades of the rainbow, are sporting no more. There is not a chirp in the grass, not a buzz in the air, not a hum over the flowers. The birds of the free air are silent, as if the inspiration of the sky were away. The skylark drops down like a stone, to the covert of the clods; not a bird sings from those sprays that erewhile were so sonorous as well as so sunny; and the only sounds that issue from the grove are the wood-pigeon moaning from her tent of leaves, and the owl answering dismally from the hollow tree. The chickweeds, and other little plants of delicate texture, fold together their leaves, and the daisy vails its golden eye, as if both were hiding their precious germes from the effects of the impending gloom.

But still those temporary absences of the sun, though they have a gloomy influence upon the merry sounds and the gay colours of nature, and though they drive for a moment the very odours into their dells and hollows, or make them stagnate among the sources that produce them, until they concentrate there into rankness; there are other parts of nature that derive relief from the temporary gloom. The leaves of the trees, which the joint action of the light and heat had caused to droop, and if continued would have worn out by excessive action and withered in premature decay, have the draining of their juices suspended, so that without dew or rain they have their strength recruited through the vessels of the plant, and they stand up and are ready for new exertions, not only in bringing the fruits of the passing season to maturity, but in preparing the germes from which new leaves and flowers and fruits are to be evolved by the suns of future seasons, when the leaves, that are in the mean time replenished, shall have fallen and been dissolved; and the very same matter which this year is stinging in the little prickle of a nettle, may next year be glowing in a tulip, perfuming in a rose, luscious in a peach, or refreshing to the spirits in a grape.

Nor is there in the suspended action refreshment only to the leaves of plants, there is a preservation of beauty to their flowers. Those agencies of matter, which we are unable to trace, saving in the effects they produce, and of which, apart from the substances in which those effects are displayed, we can obtain no knowledge, are all too mighty for the matter on which they act; and the same light which gives us so much pleasure and so much information through the medium of our eyes may be so concentrated, or its action so long continued, as that it may instantly strike the eyes blind in the one case, or waste them beyond all power of recovery in the other. So also the same heat and light, and other less perceptible, but not on that account less curious, agencies of the sunbeams, which communicate all the fine tints to the petals of the flowers, have far more intensity than those little pieces of delicately formed matter can bear; and if they are too long or too immediately exposed to the direct action of the sun, the sunbeams are instrumental in destroying those very beauties of which their own action is the cause. Cultivators of auriculas, and tulips, and carnations, and other blooms of the richest tints, are aware of that fact, and take precautions against their consequences. The beds of auriculas, whose finely dusted purples and greens are the admiration of their fond cultivators, are matted up; the tulips, if their tints are to be of the most brilliant lustre, are shaded with awnings; and for a similar purpose little caps or helmets of paper are suspended over the carnations. Thus it is not in either extreme of the beauty-producing energy that the perfection of beauty, either in intensity or in duration, is to be found,—there is a fading towards each of them, and so the best state—the point of *maximum*, is somewhere between them.

There are few, if any, instances in nature, in which that is not the case; and the knowledge that the case is so is very pleasing and encouraging to us, and it shows how admirably nature is fitted for our instruction and enjoyment. We cannot reach the extreme limit either way, and so if knowledge and pleasure had been in the one extreme or the other, we could never have hoped to reach either; and thus we should have been dispirited, and have slackened in our exertions. But knowing, as we always can do, the limits between which the perfection must lie, we know and are in possession of the field in which we are sure to get it; and so we labour in hope, and if we do it but skilfully and diligently enough, we are certain of success.

It is in consequence of this knowledge of the limits that we are able to cultivate the plants and the animals, and turn all the productions and agencies in nature to our purposes. It is thus that men, by means of the observations and discoveries of successive generations, and the applications of those discoveries in such a manner as to make each one an improvement on the one before it, have been able to cultivate the *cereal* grasses into the wheat and barley which are now the bread and the drink of so many millions. In the same manner, by cultivating the apple, the pear, the peach, the plum, and countless other fruits, we have been able to turn an operation of nature, the natural purpose of which was subservient to the maturing of the seed of a plant, so much from the natural purpose of the plant and to our own purpose, that the ripening of the seed is actually secondary to the growing of a repast for us. In all nature, the application of similar observations has produced corresponding results; and in some we have destroyed the purpose of nature altogether, and made the plant wholly our own and for our own use, in its living state as well as when it is matured and fit for our purpose. Many double flowers, and the dahlia in an especial manner, which in their natural state had only one row of petals, have been so much converted into petals by skilful culture, and the size and beauty of these have been so much increased along with their number, that the flower has really ceased to be a flower, in the natural sense of the word, though it has thereby become one of the brightest ornaments of our gardens. There are cases in which we have carried the matter even farther: we have taught a number of the *cruciferæ*, or plants with four petals in the flower, arranged like the arms of a cross, to linger in the bulbs of their stems, their leaves, or their flower-buds, and there form stores of provision for us; and we have educated some of the early varieties of the potato out of the habit of bearing flowers altogether, just as we have educated other plants out of the habit of maturing seeds. All that has been done in consequence of careful observation of nature; much of it by observing the effects of the sunbeams in their compound state; and not a little of that which regards colour, by observing the action of those beams considered merely as light.

Sunbeams are indeed wonderful things. It has been remarked that we have no means of finding out whether they be things at all or only appearances of other things. But that does not in any way lessen either the instruction or the pleasure that they give us. We can divide and subdivide all our "somethings" till they be very small by the line, and very light in the balance; and we can follow the operation mentally till we lose them all on the verge of "nothing;" and that whether we trace backward the real succession in nature, or imagine an artificial one of our own. But they do not serve and please us the less on that account; so neither is light, nor the beauties which light brings to reward our observation, altered one jot in their power of pleasing, whether the light be a substance spreading over them, or merely an agency which calls their properties so into action as that we can see the results.

The sunbeam, when divided by passing a small parcel of it through a triangular prism of glass, which gives in a smaller space, and therefore with greater brightness and perfection, all the colours which are seen in the rainbow, and which on a very dark cloud, opposite to the sun when nearly setting, is almost half a circle and very beautiful, is found to have other properties than its bright colours. These cannot be found in the rainbow, for that recedes as we approach it; and though the rain-drops on the verdure sometimes bring it apparently to our very feet, all our speed cannot come up with it. We may follow it into the cloud, but we cannot gain upon it; and though the cloud seems dark before us, the passage of the sunbeams is so easy that we can follow the bow till we lose it; and "chasing the rainbow through the shower" is (or once was) a summer amusement with the hind-boys on the moors, who took to the observation of nature, because they had few other amusements.

When the little bit of bright rainbow, or *spectrum*, as it is called, is examined, it is found that the beam of light is bent out of its path, and lengthened in the direction in which it is bent; and the parts nearest and most distant from the original direction of the light, which bound the length, are the ends, and the intermediate boundaries the sides. The colours lie across it from side to side; first red, at the nearest end, then yellow, and then blue; but from the red to the yellow the colour passes through every imaginable shade of orange; from yellow to blue, it passes through every shade of green; and the blue fades off in brightness till it vanishes in that soft purple which often tints the clouds in the evening, and sometimes in the morning, and often gives the last tint to the clear sky.

Now there is most heat in the red end; that heat is greater without, or on the edge of the colour, than where it is most intense; and it diminishes as the blue end is approached, so as to be barely, if at all, perceptible there. Heat is the grand agent in burning, the result of which is the union of the whole or part of the substance burned with that part of the atmospheric air which is called *oxygen;* and it also favours the union of oxygen with substances when there is merely heat but no flame. Substances which are combined with oxygen are said to be oxidized; the red end of the spectrum, which heats the most, also oxidizes the most; and that property becomes less and less till the middle is arrived at, and there it is not perceptible even by the nicest tests. That middle is in the green, just about that shade of it which we call grass-green, and seen in a well-kept lawn of fine forest grasses. At the blue or most distant end, there is a property the very opposite of that at the red; and, like the former, it is strongest without, or at the edge of the colour, and it becomes less and less, till where the green is reached it is as imperceptible as that which begins at the red end. The property which begins at the blue end hinders oxidation, and in some cases restores oxidized bodies to their former state.

When vegetables are in a state of vigorous and healthy action, they absorb or drink up the red rays of the sun's light, and return the green to the eye; and the red light, or that invisible oxidizing agency which accompanies the red end of the spectrum, facilitates the combination of the oxygen of the atmosphere with the surplus carbon of the plants, and also forms the acid juice of unripe fruits; while when they decay, and the oxidation ceases, they give out the yellow or the red rays, or the russety and brown tints, which are various mixtures of red, yellow, and green. Fruits too, which are almost all green in their growing states, receive the yellows and reds, and sometimes pass into black, or absorb the entire light, get very sweet and mellow, and soon decay. Coe's golden drop, or any of the plums which ripen to a golden orange, spotted with red, are so far instances of the progress of this action of light upon fruits—or of fruits upon light. While green they are very austere; but as the green fades into yellow, the austerity diminishes; and when they begin to be spotted with red, they have little or no austerity. These changes are not, however, universal, or even general; for many of the sweetest fruits that we have are green when they are ripe, and red vegetables are often the sourest of their class: so that, though the light may be the agent in these cases, its action is modified by the nature of the plant; and it may return the red rays from being already saturated with, and as well as from ceasing to elaborate, acid juice.

The philosophy of light is, however, a very obscure and imperfect philosophy; and there are not many parts of knowledge in which theories are more likely to lead us wrong. The observation of it has the advantage of being, perhaps, the most pleasing and certainly the easiest of all observation: and thus, with a knowledge of some of the best known and most obvious principles, any man who chooses may derive his full measure of enjoyment from it. Cloud or no cloud, the light on the scene changes its appearance every hour; and there is a gradual change throughout the seasons. In the spring, the red and the oxydizing heat, as well as the fading of the blue into the violet tints, and the deoxydizing energy of that end of the spectrum, are busily at work in bringing forward all the young leaves of the year; so that the yellow and the blue are sent back to refresh the eye with the lovely green—the indicator of the greatest action in the majority of vegetables. Thus, when the plants of the season and the annual shoots of the trees have attained their full size, and the seeds of the future successions are about to be prepared, the oxydizing action becomes less in the delicate texture of the flowers; and most of their petals absorb chiefly either the yellow or the blue, so that they seldom give back the green. The colours approximate to the golden yellow, the orange, and the intense red, in proportion to the warmth of the climate and the year, and also to the advanced heat of the season. Few early plants have red flowers, though some of them are tinted with pink. In cold places, also, there are not many of the flowers red, while the little ones on the stony and warm moors, even at considerable elevations, are of that colour. Tropical vegetation, on the other hand, is rich in scarlet and gold, and the tints of the flowers of early autumn are the richest in the whole season. Autumn is rich in hues for a while; but they are, like the hectic flush on the cheeks of the consumptive, the signs of dissolution, and when they have passed the dingy hue of winter is put on. In the northern regions, the snow serves as a mantle to cover the earth, and suspends all action between its surface and the sun, while the days are short, and the few hours of mid-day sun would only rouse the energies of vegetation for a little, to be destroyed by the rigour of the long night. But though the light and heat are thus, at those times, in those places, excluded from contact with the earth, and action upon its vegetable productions, they are not lost. The white surface sends them upwards to warm the air; and as there is little evaporation there, and little vapour in the sky to absorb the heat, the atmosphere maintains a far more comfortable temperature than one would be led to suppose. Thus, in every place, and at every season, there is something in nature to compensate man for what the inhabitants of other countries regard as his privations.

Heat is still more wonderful than even light, wonderful as that is, and abundant as are the information and the pleasure which we derive from it. Like light, we never can find heat alone; for as light is only perceived when something lightens or is lightened; so we become conscious of the existence of heat only when something heats or is heated. Thus, as we never can by any process in nature, or any experiment that we can perform artificially, obtain any knowledge either of light or of heat as a distinct substance, or even as a material and measureable part of any substance, we cannot know any thing further of either than as a property of those substances in which we perceive its effects. To speak of the properties either of light or heat is an absurdity, because we know light and heat themselves only as properties; and therefore all their countless variations are variations only in degree; and as no property can be the measure of another property in the same way that one weight is the measure of other weights, or one length the measure of other lengths, there is no standard to which we can bring either light or heat, except we make some degree of each which we find constant, as displayed in some substance, the measure of the other's degrees. The variations of light are so very delicate in themselves, and they are so much confused by the variations of colour, that it is scarcely possible to obtain any contrivance by which light can be made the measure even of itself.

Various instruments called *photometers*, that is, "light measures," have been invented by ingenious men; but the majority, if not the whole of these, are affected by, and therefore measure heat, and not light; and thus they are, in truth, *thermometers*, or heat measures of more nice construction and greater sensibility than the common ones.

It is, indeed, exceedingly difficult even to contemplate light without having the notion of heat along with it; and, indeed, we have not much knowledge of especially great degrees of heat, without light along with it. In poetical language it is not uncommon to speak of "the wan cold moon," and "the cold moonbeams;" and there is truth as well as poetry in those expressions. It has been mentioned that the red rays of the sun penetrate the most readily into the substances on which they fall; and the greatest heat, which is at the red end of the spectrum, penetrates still more readily than the red rays. Now, our moonlight really comes from the sun, and is reflected to us from the surface of the moon, just as we can throw light into a dark room by a mirror, or by whitewashing a wall opposite the door on which light can fall. Now the heat of the sun's light, and also the greater part of the red rays, enter into and are absorbed by the moon; and thus moonlight wants the golden brightness of the direct rays of the sun, and is in consequence silvery, and has a little of a bluish tint in it.

This "soft moonlight," not only delightfully varies the months with its waxing, its fulness, its waning, and its extinction, and not only gives us landscapes of new and softened tone, which it would be altogether impossible to obtain by any modification of the sun's direct light, but it answers many other important purposes in the economy of nature. When the sky is darkened with clouds, even to the deepest gloom of a close November day, and over the black earth or the barren moor, which drinks up all that falls upon it, the little fragment of solar light, that glimmers by countless refractions and zigzags through the little drops that compose the thick clouds, has no resemblance whatever to moonlight. The fact is, that those little drops decompose the light, as well as retain and reflect back again a considerable portion of it; and the light which reaches the earth at those times is a *mêlée* of little rainbows, each probably not so broad as a spider's thread, in which one colour so falls upon and blots another that the compound has hardly any colour at all.

We know little of those matters; but as dry air is as perfect a non-conductor of electricity as dry glass, it is exceedingly probable that when clouds arrive at a certain degree of density, they actually extract their own lightning out of the sunbeams; and that that which gleams and strikes, and makes air strike against air with as loud a sound as if rock were dashed against rock, or mountain against mountain, is nothing more than the red light, and the heating and oxidizing rays of the sun, collected by the minute drops of water, and tempered by one of those curious processes in Nature's chymistry which human skill cannot imitate.

The subject is one upon which it is altogether impossible to have experimental information; but as thunder and lightning are among the most striking, and, according to circumstances, among the most sublime, and even the most terrific of natural appearances, it is altogether impossible to observe nature without speculating about them; besides, the countries where there is the greatest heat and the warmest seasons are those in which there is most thunder. Thunder-storms are also most violent, or rather one should say grandest, when the clouds are formed in an atmosphere which has for a considerable time previously been dry as well as warm. We see that in our own country. We have often violent thunder-storms, with showers of very short duration, and very local and limited in their range; we have also thunder-storms at the commencement of broken and rainy weather; but when the rain fairly sets in, and extends over a large tract of country, it lightens and thunders no more. In tropical countries, where there are seasonal winds, or monsoons, some dry from the land, and others moist from the sea, the lightning and thunder at the commencement of the rainy monsoon are often, and indeed generally, absolutely terrific. When the south-west monsoon sets in upon the west coast of India, and is directed upward by the ridge of mountains that skirts that shore, the strife between it and the warm and dry air over the Balaghaut country above the mountains, is terribly sublime. It lightens as though the air were ten thousand furnaces; all the artillery in the world would be but as an infant's cry to the thunder; and the rain falls so fast, and so consolidated, that the trees are broken or uprooted like dried stubble, and the rocks scattered about as if they were pebbles. In some parts of South America, where the plains are parched up by the summer heat, and the snowy summits of the Andes are at no very great distance, the thunder-storms are said to be even more violent; and in tropical, and even in southern Africa, their violence is equal, if not greater.

That thunder-storms occur during the night is no argument against their formation by the action of the light and heat of the sun; and the close connexion between them and heat and light is proved by the fact that lightnings very generally accompany the smoke of volcanoes, and are the more brilliant the more violently the fire rages in these. Independently of faint flashes of lightning not being so well seen in moonlight as when there is none, it is matter of common observation that it lightens less on moonlight nights than at other times, even admitting the general state of the earth and the air to be the same. That is a further confirmation of the very intimate connexion there is, not only between solar light and lightning, but between the red and heating rays of light and that phenomenon; and it is probable that the moonbeams, consisting chiefly of the middle and other end of the spectrum, take the quality of lightning out of the clouds, or of the moisture that is floating invisibly in the air. Experiment increases the probability of that; because the artificial lightning that can be excited by peculiar combinations and actions of substances, and of which electricity, galvanism, and magnetism are the modifications with which we are best acquainted, has always two poles, the one of which has a relation to oxidizing and producing colour, and the other an opposite relation.

And we can observe a very beautiful instance of that in the beams of the moon. These, as has been said, contain little of the red or the heating rays; and it is well known how very efficient moonlight is in performing those operations which are more immediately performed by the rays towards the deoxidizing end of the spectrum. Every housewife knows how nicely her linen is whitened if she can leave it out during the moonlight; and many know that muslins which the sun would render yellow or brown can be preserved as white as snow if dried by the light of the moon. Every farmer, too, that takes notice (and surely the most unobserving farmers watch the progress of their crops), must have observed how very rapidly the moonlight, not merely whitens, but actually matures and ripens his corn. In that respect, one fine moonlight night is equal to at least two days of sunshine; and that circumstance, while it lets us see that moonlight has other qualities besides poetical beauty, tells us, that Nature is a WHOLE, and that the parts which we would suppose to be the most distant and unconnected yet co-operate with each other in the most perfect and wonderful manner.

In consequence of that obliquity in the earth's path round the sun which gives summer and winter alternately to the two hemispheres, and a regular succession of the four seasons to all the temperate latitudes, and in consequence of an additional obliquity in the moon's path round the earth, the full moon rises just at sunset for about a week together. That takes place during the harvest; its mean season being about the twenty-second of September, and the middle of it never more than fifteen days sooner or later than that. That is called the harvest moon, and though in the early districts, where there is plenty of solar action to ripen the crops, it be not much heeded, it is very beneficial in the cold districts; and as the obliquity to which it is owing increases as the latitude increases, the harvest moon continues for the greatest number of nights in the cold climates. Thus we see how far the influence of what we would deem a simple cause extends in the operations of nature, and how well that which our ignorance is apt to regard as a disadvantage works for our good. Indeed, there is not an object or an occurrence in nature which has not its use, if we would but look for it; and it is just because we are ignorant of the uses of little things that we fail in the execution of great ones.

It is in the perceiving of these connexions which appear remote and unexpected, that men who combine science and observation together have so much the advantage of mere men of science or mere surface observers. One would not at first suppose that the study of the mere motions of the earth and moon, and the fact that the light of the moon is a secondary or reflected light, had any thing to do with the whitening of linen or the ripening of corn; and yet the two are as closely connected as if they were parts of one single process. That should teach us not to pass any one thing or occurrence unobserved, or any one observation without reflecting on it; because there is knowledge in them all; and, at a time when we may have no means of obtaining it, we may be greatly at a loss for that very knowledge which we pass over unheeded.

There is another circumstance connected with moonlight which is worthy of notice, and that is, that where there is least sunshine there is most moonlight. The full moon is not always directly opposite to the sun, but sometimes a little higher and sometimes a little lower than the point opposite, but directly opposite is the average place of the full moon; and thus the full moon is, on the average, just as long above the horizon and shining, as the sun is below it and set; and if the sun is high at noon, the moon is low at midnight; also, if the midday sun is low, the midnight moon is correspondingly high. The influence, or action of the light, both of the sun and the moon, is in proportion to the length of time that they shine, and also to their height above the horizon; and thus, during winter, there is the greatest duration as well as the greatest strength of moonlight; and always as one goes into a higher latitude, the winter full moons shine longer and more brightly. The Lapland moon is an object far more beautiful than they who live in more genial climates and have the atmosphere loaded with vapour can easily imagine. The intense frost there sends down every particle of water in a state of finely powdered snow, each little piece as hard and bright as rock crystal; and the strong power of crystallization so holds the particles of those little pieces together, that even when there is a glimmer of mid-day sun, that produces no vapour. The winter sky is in consequence perfectly pure, dry, and transparent. No sapphire can rival the depth of its blue; every star blazes like a diamond; and the light of the moon, of which every particle is sent down through the pure air, well deserves Milton's epithet of "peerless." It is so bright and silvery, and so gratifying, without being the least painful to the eye, that it is probably the most glorious sight in nature. But it can be seen only at some distance from the unfrozen sea, and the collected habitations of men, as there is always some action in the atmosphere at such places.

Moonlight is not the only instance that we have of cold light; for the first beginnings of flame, in substances that are easily kindled, and also the last glimmers of smouldering fires, are cold and blue as compared with the light of vigorous combustion. That may be seen in the lighting of a common match, the flame of the easily burnt sulphur on which is cold and blue in comparison with the flame after it has reached the splinter of wood. Phosphorus, and also those substances which give out lights that are called phosphorescent, are also cold and blue. One of the most remarkable of these is the IGNIS FATUUS, or "Lantern Jack," which floats over marshy places, and in all probability, consists of hydrogen gas combined with phosphorus and sulphur, which, being exceedingly inflammable, may be set on fire by the friction of the air in a breeze too gentle for agitating the branches or rustling the leaves. The motion of a human being through an atmosphere strongly impregnated with those highly inflammable gases, may be sufficient to produce a train of the cold blue flame. It is from the decomposition of animal and vegetable matter that those gases are produced. The quantity of small animals—chiefly of the insect tribes, that are continually perishing in marshes—by falling from their island-habitations in their rushes and reeds into the water between, is much greater than would readily be supposed; and when those waters are shallow, and the air and light in consequence act powerfully upon them, there are materials and means enough for the production of ten times the number of *ignes fatui* that ever were observed. Church-yards are very favourable for their appearance; and hence probably the reason why they have been associated with spirits, and considered objects of terror, while they are in themselves not only perfectly harmless, but exceedingly beautiful, especially when seen in lonely places and through between trees.

In tropical countries, where the action of the sun is more powerful during the day, and longer suspended during the night than with us, and where consequently both growth and decomposition go on much more rapidly, those airy meteors of the night are much more common than they are with us. They are more common at sea too than they are on land; though there they seldom rise above the surface unless the water is agitated. But when that is done, in certain states of the weather, namely, after long calms, when the water has not been much disturbed, there is a ripple of light at the bows of the vessel, and her wake bears some resemblance to the tail of a comet. Every splash of the oars flings radiance and a hand skilfully dipped in the water appears to be kindling. There seems little reason to doubt that all those lights are produced by decomposition, whether of the ultimate destruction of dead animals or of the separation of waste in living ones; and that they are nothing more than some of the highly inflammable gaseous compounds kindled by the friction of motion. That they do exist in living animals is seen in the various species of fireflies, which in some parts of the tropical countries make the evening sky as brilliant as if the whole heavens were hung with countless myriads of little lamps, and all those lamps were dancing in mazes of incessant motion. We have no luminous flying insect in this country; but the female glow-worm, which is not uncommon under hedges in the warmer places of England, and at the warm season of the year, emits a beautiful bluish white light, which appears much brighter in consequence of the dark and shady places in which it is seen. The male of the glow-worm is a winged insect, which flies low in the evenings, but emits no light.

THE GLOW-WORM, MALE AND FEMALE.

But we must just notice one or two of those effects of heat which are not so obviously connected with the display of light; for though we should continue to write, and read, and observe till the light of our own eyes were extingished, we should be no more near the end of the beautiful subject of light than we are at this moment.

The most general and most active property of heat is that of overcoming the cohesion of the parts of substances; and thus softening them, and expanding them into more bulk or space. It acts with very different degrees both of rapidity and of energy in different substances; but it is probable that there is no substance that could not be melted, and after that changed into air or vapour, by a sufficient degree of heat applied under proper circumstances. Some of those substances which we call simple, because we have not been able to find more than one ingredient in them, cannot be melted into liquids in the open air. The diamond is one of these; but though the diamond cannot be melted, it can be burnt, or reduced wholly to vapour; and there is no doubt that, if sufficient heat were applied to it under sufficient pressure, it might be made as liquid as water. Marble, or limestone, or chalk, or shells, when burnt in the open air, give out the very same kind of air into which the diamond is converted by burning, and the lime (for it is lime in them all) remains and falls to powder when water is sprinkled on it. But marble and chalk, even when in powder, have been artificially melted by heat under pressure, and have been so completely melted that in cooling they formed into crystals of the very same figure as those which the same compound of lime naturally assumes in the rock. Nor is there any doubt that any substance whatever might be melted by a similar mode of treatment.

Heat is thus the grand instrument in perhaps all the operations of nature; for our not being sensible of it is no proof that it is not there, any more than our ignorance of any other truth is a contradiction of that. The different susceptibilities of different substances to heat are the means by which almost every change is performed, not only in nature but in the arts; and even when we cut wood with a knife, or grind iron upon a stone, it is by no means improbable that we effect our purpose chiefly, if not wholly, through the instrumentality of heat. When we work hard, the tool gets heated in its whole substance; and when a blacksmith has no other means of lighting his forge, he has only to hammer a piece of iron on the anvil till it be red-hot, and thrust it into the coals, and he instantly has a fire. Even when we move our bodies the parts moved become heated, nor can we get any instance in which motion is not accompanied by heat, and heat by motion; and if there be enough of heat, there is light along with it. Sometimes indeed we are sensible of the one of these, and not of the other two; and sometimes we are sensible of any two of the three, and not of the remaining one; but though, in all cases, our senses are our evidence of that which they do reveal to us, they can in no instance be evidence of that which they do not reveal.

The general action of heat, both in nature and in art, is thus to separate the particles of simple bodies, and the parts of compound ones; and there can be no separation without motion, whether that motion be such as we can divide in succession, and by that means observe, or not.

In bodies which are simple, or in compounds the parts of which are equally sensible to the action of heat, heat merely softens, melts, and converts into vapour. But the heat does not proceed uniformly in its action: there is one point at which the substance becomes liquid, and another at which it passes into the state of air or vapour; and in each of its three states it can, generally speaking, bear a certain range: though there are cases in which the melting and the passing into vapour follow each other so very rapidly that the process of melting is not usually observed.

It is equally probable that in every motion whatever, even in the most gentle and cool that it is possible for us to imagine, there are the elements both of sensal heat and of visible light; but that these only become apparent when there are certain degrees of resistance to the motion. Two pieces of dry wood, rubbed against each other, soon become heated, and they are not very long in taking fire, and burning with light. But they do not heat so soon if they are wetted, or covered with oil, or with any thing else that lessens the resistance they have to the motion. We feel the same truth in our own bodies. When all the systems of vessels in which the blood and other fluids circulate or move are in a healthy state, we feel no sense of heat from the various motions, though all of them are continual, and many of them are rapid; but when any part is so diseased as that the motion is resisted, we then feel heat as well as pain: and if the disease is only a whitlow, or something of an equally local nature, we feel the part as hot as if it were burning; and the feeling is not a merely inward feeling, like that of pain, it is an actual increase of temperature, which we can discover by the healthy hand, or measure by the thermometer, just in the same way as if it had been communicated by holding the part near to a common fire. In cases of fever, the sense of heat is general all over the body, and it too is discoverable by the touch of another person or by the thermometer.

In all these cases it is resistance to motion that causes the heat to appear; and the heat is always in proportion to the motion and the resistance jointly. Local inflammation, such as that of whitlows, is most common in young persons, in whom the circulation is quick; and fever is more severe and burning in the robust than in the weak. Some species of fevers indeed have cold and shivering fits; but these are occasioned by the motion, as it were, shrinking back from the resistance, and the pulse languishes during them, just as it does in fainting. The fire of life smoulders, as it were, at those times; and if they continue too long the resistance is consolidated and the system will not react, but the patient "goes off in a fit." That part of the subject is, however, very nice; and it requires to be treated with a little more of general philosophy than has yet been bestowed upon it, notwithstanding the number of able and eminent men by whom it has been treated.

Whether it is in the living body or in any other kind of matter, in any state where there is no resistance to motion there is no production (as we call it) of heat; that is, there is no heat which becomes sensible either to the touch of the human hand or to any other test. Different kinds of matter resist differently, according to the nature of the cohesions by which they are held together. Thus, some of the compound metals melt in the palm of a healthy person's hand, while platinum is stubborn in even the hottest common furnace. Some too, such as arsenic, pass into vapour the instant that they are melted; while others, such as gold, melt at a temperature not very high, but if pure can hardly be changed into vapour by any ordinary heat.

The cohesion of matter resists the motion of its particles *from* each other, which is the effect that the heat in all cases tends to produce, and which if urged far enough it in every case actually does produce. As there is no power of mere adhesion between mass and mass, mechanically united, how small and how close soever the masses may be, which can resist the force of crystallization between the ultimate atoms of the same kind of matter; so also there is no power of crystallization that can ultimately resist the force or action of heat. It is heat, indeed, which holds those powers of crystallization in restraint, and allows compounds to be formed, and vegetables to grow, and animals to live; and were it not for the mysterious motion of heat, which, for aught we know, may all have been originally produced by the sunbeams, the earth would not only be plantless and tenantless; but earth, and sea, and sky would be reduced to one mass of crystals, probably to one crystal, and that crystal so small, and so near the verge of that mysterious nothing out of which Almighty power and goodness evolved all the worlds in all their variety and in all their beauty, that it might escape the senses, and we might be altogether unconscious of its existence. With God all things are possible, and in his sight there is no miracle. Large as is the earth, vast as is the solar system, boundless as are those systems of which the suns are the stars of our sky, and indescribably distant as they glide off into the depths of space, and set at naught the eye and mock the telescope, they, in their, to us, innumerable multitude and incomprehensible variety, are in his sight less than the "small dust of the balance;" and howsoever they may seem to change appearances, they all obey the one commandment—the single creative fiat. When we glance back to the first stage of creation's history, which it is consistent with finite minds to comprehend, weight and measure, time and space gradually melt from our view, and we feel as if all nature were converging into one single point, and that one more look would reveal to us the first, the immaterial spring which was touched by the Almighty hand, in what was no time and yet included all time, and in what was no space and yet included all space. But the frailty of flesh is in the eye, the dimness of matter is upon it, and we cannot see. Yet here we can infer that the "glory to be revealed" shall as far exceed all the glories of all the material works of God as the incomprehensible universe exceeds the stretch of the human hand; though we cannot push our analysis any further than observation and rational inference would bear us out; and thus cannot approach either the infinitely great or the infinitely small, so near as to have even a conception of them farther than that they can differ from each other as material things differ; and that any or both are perfectly capable of coexisting with an infinitude of knowledge—knowledge or intelligence, which is one and indivisible in its essence, but of which the manifestations can have no limit, and which cannot be divided in any other way than through its manifestations, either in space or in time.

There are many places of the world where, if a stranger were to come at certain seasons, he would never imagine that the fields would be clothed with vegetation. A native of the green savannas of America, coming to England in winter, or after the fields were ploughed and the seeds sown and covered, would think it mockery if he were to be told that it was from these black wastes that the people of England reaped their bread. So also if one unacquainted with the changes of the seasons trod the snows and the mountains when these lay deep and hard so that not even the top of the highest bush appeared, he would regard it as mockery if he were to be asked to come back again in six months to be feasted with delicious berries. And there are other cases much more mysterious to unthinking observers than these. The endless variety of fungi, and lichens, and moulds, and other plants, many of which have their seeds too small for the eye or even the microscope; and the entire plants of many of the species are too small for the microscope even taken as wholes, are yet always found whenever circumstances are favourable for their production. The waste of the year, the refuse and rubbish that have been left after the other tribes have performed their annual renovation, is the food of those singular vegetables; and whenever disease comes upon the vegetable structure, and even when a certain stage of corruption is arrived at in the animal, those *cryptogameæ*, or plants of hidden production, fail not to appear, and to perform their functions. Nor is there the least doubt that those little things, and many of them are probably as momentary in their duration as they are minute in their size, are as faithful to the decree of their kind, and that the mysterious action in them, to which we give the name of vegetable life, is as true to its temperature and its humidity, and as strong against the resistance of merely dead matter, as in the most stately oaks of England, or in those giant pines which wave their spiry tops in mid-heaven on the western shores of North America.

The tendency of heat is, as has been said, always to separate the particles of substances; but it was already mentioned that all of what we call "the principles of things" admit of a certain play, or have, as it were, an extent to which they can be bent or driven, and yet recover themselves, if that which bent or drove them is withdrawn. A bow is no bad illustration here; because the elasticity of the bow is an instance of one of those very powers. Now when the skilful archer bends his bow, it pulls the string to a perfectly straight line; then when he grasps the bow with his left hand, sets the arrow upon the string, holds the string on the fingers of his right hand like hooks, that arm being doubled back into that position in which it can bear the greatest strain without moving, which is when the bent fingers are a very little behind and under the right ear; then if he stretches his left arm with proper skill and rapidity, and so plunges the whole mass of his body and the whole effect of its velocity into the bow, the elasticity of the bow gives way, and "the cloth-yard shaft" is drawn to the head. But if the bow is "made of a trusty-tree" not a jot of its elasticity is destroyed, but the more vigorously it is drawn the more it accumulates; and if the bowman slips his fingers at the very instant of his utmost stretch, the returning bow sends the arrow in perfect silence through the air fleeter than an eagle. If, however, the bow were too small for the man, he could draw it either till it broke or till its substance were so much injured that it would not spring; and if it were made of brittle wood, or of a pliant osier twig, it might be overcome by the strength of a child.

It is the same with matter in resisting heat: in some kinds of matter there is much resistance, and in other kinds there is little; but there is none in which there is not some resistance; and there is perhaps no substance that becomes sensibly hot to the full extent of the heat applied to it, but shifts its bulk, of course insensibly, by the very slightest variations of temperature; when, however, the resistance of the substance is overcome, and there is no other opposition to the motion produced by the heat, no more sensible heat is shown; though it continues to drive off the particles of the substance until, if it be in the free air, they are dissipated through that, and the object is lost to the senses, except indeed the viewless and touchless particles remain to bid adieu to the sense of smelling; and it is not a little curious that that sense, which has much less apparent connexion with external things than some of the other senses, should yet be, in many instances, the first to find things, and the last to lose them.

After the power of heat has overcome that of cohesion in the heated substance, so as that substance would spread in vapour through the thin air, the heat instantly commences its attack upon the vessel, or whatever else confines the matter which it has overcome, and subdued to its purpose. The general principle in this has been already noticed and illustrated at some length in the case of water, but there are still more magnificent displays of the triumph of heat over matter, which take place on the great scale. Volcanoes, whether under the dry land or the sea, are instances of that kind of action, and so also are earthquakes; and the chief difference between these is, that in the volcano the heat drives the expanding matters through one aperture, while in the case of the earthquake, the escape is by one rent or many rents. The difference between the eruption of the volcano and the shock of the earthquake very much resembles that between shots which "blow out" with a loud report and shots that smoulder, in the blasting of rocks.

The shot with the loud report may raise a few fragments, and send them to a considerable distance, but it is the smouldering shot that tears the rock to pieces. Just so the volcano may raise to the summit of the loftiest mountain, from a great depth in the earth, a vast mass of materials, and according as those materials may happen to be, it may pour over the mountain, and even over the surrounding country, a deluge of boiling water, or boiling mud; or it may cast red-hot stones and cinders, and volley masses the size of little hills, red-hot, to great elevations in the air, from which they may descend with crashes like thunder; it may turn day into night by clouds of ashes in the air, and those clouds may fall (as they have fallen) upon cities, and bury them and all their inhabitants, or they may be wafted across the seas and produce disease and famine in other countries; or the mountain may give a specimen of the mode in which nature can play the founder, and after the most stubborn strata of the earth have been molten, the fiery flood may be poured from the mighty crucible, roll down the slope, and proceed over the country, tumbling and curdling, and creeping more and more slowly; but still so terrible in its heat that all the vegetation is on fire, and the abodes of mankind crumbling into powder at a considerable distance before its march of terrific desolation. So also, if it is situated under the sea, no matter for the depth, let there be but heat enough, and the substance which opposes that will be sent burning to the atmosphere, although the very depth of mid-ocean lie between. Indeed, the water tends in two ways to facilitate the ascent of the submarine volcano. First, it consolidates the external crust by cooling it, and thus prevents the spread of the matter over the bottom; and, in the second place, as water presses in proportion to the depth, and presses equally in all directions, the pressure on the top of any mass is less than the pressure upon an equal portion on one of the sides. Thus, there is a considerable resemblance between the ascent of a volcanic column through the water of the sea, and the ascent of a column of smoke through the air; and so, by means of the cooling influence and pressure of the water acting jointly, buildings may be erected there far more gigantic than any which man, or any power of nature with which we are acquainted, could erect upon the land.

Those who look at the productions of nature, without taking nature's powers of producing into the account, are in the habit of considering it a very marvellous thing to find shells and other productions which are not only of the sea, but of the very depths of the sea, near the summits of some of the loftiest mountains on the surface of the earth; but truly it it is difficult to imagine how the case could be otherwise; for there is nowhere on the globe an apparatus in which great mountains *could* be manufactured but just the great ocean; and it is very likely that so much of the earth's surface is covered with the ocean just in order that those powers with which the Almighty has endowed matter for the accomplishment of his pleasure, and which, measureless as they are in their intensity, and majestic in their effects, may have room and scope enough for making great mountains.

It is true that considerable portions of matter are thrown up at a few points by volcanoes on the land; but still it is doubtful whether any one mountain has ever added permanently to its height by that means. The present Vesuvius is to observation a volcanic pile, but it is surrounded by the remains of a former and loftier mountain, the summit of which has fallen in after the former volcano has excavated the interior. We know, too, that when the connexion of volcanoes with the sea is cut off, the volcanoes become still and cool by slow degrees.

Thus we can see, as the power of heat has really no material limit, how it can work, in successive exhaustions and renovations, the continents and the oceans, just as in revolving seasons it renews the plants and the animals, and just as in the reciprocal actions of containing vessels and contained fluids, it repairs the waste of plants and animals by successive assimilations of nourishment. This heat, we have already seen, is, even in the strength of its working, not a thing that would measure one hair's breadth by the scale, or cause the thousandth part of the smallest grain to mount up on the balance; but still it can lay upon the whole globe, and all the material works of the Creator, the gripe of a giant, which nothing can resist,—that before it the ancient mountains are lighter than thistle-down, and the fathomless strata of the earth itself are weaker than cobwebs. What then shall we think of Him who could with one word, or even without word or wish, create this mighty energy, and send it down to us in a garment as lovely as a sunbeam, and as gayly tinted as a rainbow, and make it our best friend and our most obedient servant,—and, saving where immortal spirit is concerned, make it throughout all nature life itself!

SECTION VII.

Observation of Air and Water.

As we can know and contemplate the powers with which nature works only through the medium of those substances in which they are manifested, a considerable portion of that which would, perhaps, with more propriety, come in under this or some of the succeeding parts of the book, has been already anticipated, and what remains to be said may, in some instances, have the appearance of repetition. But that is unavoidable; for if we are to view nature as it exists —living nature, we must view it in its connexion. There is no dissecting till after death; and then the very finest anatomy that can be practised gives us only disjointed members. But the observer wishes to know nature in its activity and life; and, therefore, there is no possibility of noticing any one thing usefully to him without a glance at collateral things.

In the case of the great agencies of gravitation and cohesion, and light and heat, and motion and resistance, that is especially necessary, inasmuch as, apart from the subject in which their effects are displayed, we have not the slightest conception or means of knowing any one of these. There is no weight, unless there is something that is heavy, and has other properties besides weight; there can be no cohesion, unless there is matter to cohere; light never appears but when it illuminates something; we know nothing of heat, unless there is something that is warmed by resistance to it; and we can know that there is motion, not merely when something moves, but when there is some other thing moving differently or at rest, by means of which we can know and judge of the motion. We can treat only of what we know; and thus every attempt to explain the principles or agencies which have been noticed must be made through the medium of those matters in which their effects are displayed.

Now, however, we come to a real substance, or perhaps, more correctly, to a state in which some substances generally, and all substances at times, exist. That substance is AIR, the lightest, the softest, the fleetest, the most gentle, and the most obedient of all material things, of which the human senses can have any knowledge. The common atmosphere which we breathe, and without which we could not possibly live, is the type, and most familiar instance of air. But it is the state, and not the substance, that is aerial. Besides water, and other foreign substances, of which it always contains some portion, however small, the common air, or atmosphere, consists of two ingredients—*oxygen* and *nitrogen.* The first of these forms part of water, of every animal and every vegetable, and of many mineral or earthy substances; and the latter forms part of every animal, and of some vegetables—of *caoutchouc*, or Indian rubber, for instance, and of course of the trees whose juice consolidates into that substance.

But though the atmospheric compound of oxygen and nitrogen be the type, and, to popular observation, the example of air, yet air may mean any thing, or all things; because all things, or the elements of which all things are composed, may exist in the state of air.

The most accurate definition of air is, "*matter subdued by heat*,"—so overcome by the tendency to motion which heat imparts, that it has no cohesion, and none of the common properties of matter, excepting gravitation—the property which matter never loses, or can lose, while it exists. No matter what the substance be which is in the state of air; be it *hydrogen*, which when in a state of air is the lightest of known substances, and on that account used for filling balloons, which, because of their lightness, rise in the air and carry up men and their instruments of observation; or be it gold or platinum, which, when in the solid state, are the heaviest of known substances, still if it be in the state of air, all its properties, as solid or as liquid matter, are subdued and suspended by heat, when it is in the state of air, excepting gravitation or weight. The direct action of that is also suspended, and a heavy metal may, by being reduced to the state of air or vapour, be made to float in the atmosphere, and to pass upward rather than downward. But that is owing to the dispersion of the minute parts of it through much more space than they occupied in the solid or the liquid form. Could all those scattered particles be collected, they would at all times weigh exactly the same; and if they were made again to occupy just the same space as the solid or the liquid, all the properties of the solid or the liquid would return, and it would be the same identical substance that it was before the action of heat turned it into air.

In the actions or changes that take place in nature (for action is but another name for change) the state of air is of the utmost consequence; and it is highly probable, nay, absolutely certain, that, without that state there would be no action whatever. The state of air is the end of every thing old and the beginning of every thing new. The matter of which any thing—all things, is composed is altogether indestructible by any natural cause; and, therefore, the only way in which any thing can be destroyed is by the destruction or complete suspension of all its peculiar properties, by the conversion of it into air through the action of heat. While it retains all the former properties, it is the former substance; and while it retains some of them, after others have ceased to be apparent, it is the ruin of the former substance; but when the whole of the former properties are suspended, and the substance (still identically the same substance) is in a state of air, it is literally, and in the truest sense of the word, a *material*—a material which the plastic hand of nature can mould and fashion into any new production for which it is adapted, with far more ease and certainty than the potter can out of the same clay mould "one vessel for honour, and another for dishonour," or the builder can apply the same bricks as part either of a palace or a pigsty.

This, when we think seriously of it, is really the most wonderful part of the whole wide field of nature; and it is the one in which the foundations of all our knowledge of nature's working are laid. The solvent power of heat, which loosens the firm cohesion of the diamond with as much ease and certainty as it melts ice into water, or the sunbeams into all those tints of colour that enliven the face of nature, overcomes all, but destroys or injures nothing. It holds all matter captive; but the captivity is only that the purposes of matter may thereby be fulfilled; for the moment that the proper ingredients of any compound come together in due proportion, and under the requisite circumstances, the heat which held their properties suspended lets them slip, and they instantly act, and the compound is formed, with the same ease and the same certainty as if it had existed from the beginning.

Not only that, but the heat is as powerful in escaping away, and allowing the qualities of materials, which it had held in the state of air, to act, in the formation of new substances, as it is in the suspension of those properties, in bringing about the destruction of that which is old,—that which has already served the purpose of its being, and is occupying materials to no use.

Oxygen and hydrogen, the component parts of water, can both be obtained in the state of pure and colourless air, the first a little heavier, at the same temperature, than the common air of the atmosphere, and the second a great deal lighter. Each, in its separate state, may have a great variety of temperatures, and have its volume augmented by heat or the removal of pressure, or diminished by pressure or by cold; and though that has not yet been satisfactorily done by human experiment, there is not the least doubt, that by sufficient cooling, both might be condensed into liquids, and crystallized into solids. We do not know that these elements of water are absolutely simple; but we call them so, just because we are not able to resolve any of them into two substances bearing different properties; and the ancients thought water simple, and called it an "element," for the same reason. But we can work any of those (to us) simple substances through a very great range of temperature, and still get them back again in the very state with which we set out. But bring them together in the proportions in which they form water, and apply a lighted match, and the combustion is terrible, probably the most brilliant display of the action of heat with which we are acquainted, and perfectly irresistible in its effects. When those elements are in sufficient quantity, and free to mix with their natural rapidity, as much heat would come out of the materials of a pitcher of water, when passing from the state of separate airs or gases to that of the compound liquid, as would suffice to kindle the globe, or loosen from their cohesion the particles of any substance in nature, whether compound or simple.

The progress of decomposition is always the same as that which is produced by the action of heat; the solid is first changed to a liquid, and then the liquid into an air or vapour; but there are many cases in which the process is altogether invisible; and there are others in which the two parts of it follow each other so closely that we cannot distinguish them. There is no doubt, however, of the perfect uniformity of the process; and that whenever a solid disappears, it passes through the liquid state into vapour.

So also, in the formation of new aggregations, whether these be liquid or solid, or whether they be what we call simple or what we call compound, the primary state—that in which the combination or the aggregation begins—is the state of air. It is of no consequence whether the result be what we call a new body, or what we call the repairing of an old one; for the process of nature, however it may vary in appearance, and whether to our senses it be visible or invisible, is always the same. Air with air is the only state of intimate union which we know of that is primary, or that of atom with atom, so that the compound or the mass may, to our observation, appear one substance.

Liquidity is a weakening of the cohesion of particle with particle; but it is not, in the case of any liquid with which we are acquainted, a total suspension of that cohesion. There is no liquid but which can form into drops, or be poured in a continued and connected stream, which shows that the particles have still some *attraction*, as we call it, for each other. They are not quite subdued, but, like the bent bow, retain their capacity of returning from the bend. Some, no doubt, pass very soon into vapour. In dry air, single drops of ether will evaporate before they reach the ground from the usual height of the hand; and there are many instances of showers being evaporated in their fall, and never reaching the ground; indeed, most showers are less or more evaporated in their falling by the warm air near the sheltered and low places; and thus there falls more rain even at the top of a place of ordinary elevation, than on the same surface of the ground on which the house stands. But still, even the most rapid of those evaporations takes some time, and the cohesion of the particles forms a drop at the beginning, in opposition both to the liquidity and gravitation. The mixture of liquids is, therefore, only a *mechanical* mixture, even when the parts that are mixed are far too fine either for the senses or the microscope. It may be the means of a more intimate union—of those unions that produce compound, and organized, and living substances; and as we cannot see the masses of the different matters in the liquid, we cannot of course see the future and ultimate process; but we may rest assured that the *chymistry*, the χῆμια, the "secret process," of the matter—that from which the forms of things originate, is always a union of air with air.

And the facility given by this aerial state, in which, to our observation, the atoms of all matter are nothing, and yet fit and ready for every thing, is truly wonderful; so much so that we can hardly name one ultimate substance and a primary purpose, and dare say that the one of them is not fit for the other. A cinder, a bit of burnt stick, or the snuff of a candle is, in our estimation, not only a useless, but an offensive thing, and we throw it away as such. But it is far otherwise in nature; and those things which we cast away as useless and offensive are, in her working, far more valuable than gold.

Let us examine the matter a little; it may be useful to us on other occasions. What can nature do with the cinder, the burnt stick, or the candle-snuff? Why nature can make them serve more purposes than man can serve by the most valuable material that he knows. In as far as they contain charcoal, nature can make them into marble, and limestone, and black-lead for pencils, and shells of all kinds, and every plant that grows, and every animal that lives; and, with very few exceptions, all the parts of all those plants and those animals. There is not only charcoal in them all, but it is the charcoal that gives the soft parts their firmness and solidity; and part of the brightest eye that now beams in England may once have been, and may be again, the snuff of a candle. The "rival lustre" (only it is a dead one, and wants the "speculation" of the other), is charcoal, and nothing but charcoal.

To the unreflecting, it may seem very wonderful, if not altogether incredible, that marble palaces, and loaves of bread, and blooming roses, and clean hands, and eloquent tongues, and smiling faces, should all be made, and made with equal ease, out of burnt sticks. But such parties should consider *whose* working they are thinking of; and then the whole becomes as simple as it is true. And, if the patience of any reader, not accustomed to think on such subjects, shall have carried him thus far, we have no doubt that he will find in their "airy passage" from old to new, and from death to life, enough to make him wonder why he has not been an observer of nature all the days of his life; and, perchance, he may regret that he has not. But there is no need for regret; that only wastes time, and makes bad worse in all cases where we suffer it to intrude. There is plenty of time still, if it were well applied; and there stands at the porch of nature no snarling Cerberus, with his three heads, all wrong ones, and his "confusion of tongues."

How this singular action of matter in the state of air is carried on in all cases, so as to produce the endless variety that we see in nature, we cannot of course know; but we do know the results of it in many instances, and that knowledge is the foundation of nine-tenths of those arts by the practice of which we get our food, our clothing, and all our accommodations and comforts. Men have "groped their way" to some portion of that knowledge; but it is only since the introduction of modern or pneumatic chymistry, that is, the science of "the secrets of airs," that it has been followed as a regular science: and when we think of gas-lights, and steamboats, and ten thousand other things that we possess in consequence of it, we cannot be too grateful to those who made and applied the discoveries to which we owe these. And we have this to encourage us in the matter, that the whole is the result of *observation*—of that observation of nature which is far more open to us than it was to those men, for they have left us their keys.

But if the aerial state of things be, as it certainly is, the real and only state in which nature acts, then the atmosphere must necessarily be the general theatre of nature's acting. Nor is there any doubt that it is. There are, indeed, some operations which could not be carried on in the atmosphere, because some of the materials would be dissipated by that; and there are others in which all the materials would go off together. Thus we can get the water out of brine, and leave the salt, or the spirit out of wash, and leave the water, by boiling in the open air; but we must be contented to lose the water in the one case, and the spirit in the other. Nor have we any means by which we can, in the open air, and by boiling, get out the salt and leave the water, or the water and leave the spirit. In like manner, we may in an open fire drive the charcoal and the bitumen out of common coal, and leave the clay and the iron with which coal is sometimes mixed; but we cannot, in an open fire, refine the coal by taking out the iron and clay. Every change that we make in the heat of any thing, the atmosphere affects that thing in a different manner; and it is the same whether the change be produced by nature or by art, or whether it take place in the atmosphere, or in that which is exposed to the atmosphere. Only, we must bear in mind that the atmosphere and the object act differently; and thus the effect of heating the atmosphere is the same as that of cooling the object, and that of heating the object is the same as cooling the atmosphere.

The perfect mobility of the atmosphere is one of its most striking and its most useful properties.

We are not authorized to say that it moves without any friction; but its friction is only the friction of particles; and, with moderate velocities, the resistance of air rubbing on air is very small.

The atmospheric air is at once the most delicate and the most powerful of all springs. It actually yields to the touch of a sunbeam, and yet it can cleave rocks, and shake the surfaces of countries to pieces in earthquakes. It is more nice in the detection of pressure than any instrument that we can contrive, and no thermometer can measure heat with nearly the precision of an air one. The air is, indeed, not only fine beyond all sensation, but it is the immediate object of all the senses. It is the air which the eye sees, the ear hears, the nose scents, and the finger touches. We know nothing of what sight might be in a vacuum, or space where there were no air, because the eye would be destroyed if it were in such a place, even though the apparatus were so contrived as that the operation of breathing could still be carried on. Once remove the pressure of the atmosphere, and the fluids of the eye would burst the vessels and coats, and there would be an end of its curious structure, as well as its power of seeing.

Smell and taste are not in the air, but still the fragrance and the sapidity are "melted or dissolved in air," before we can perceive them; and in those internal parts of the body which we may suppose that the atmospheric air does not reach, we have no perception of any thing like either smell or taste. Then as to hearing, it is the air that we hear. Air is the instrument, and the only instrument of sound; and if it were taken away, all nature would be as dumb as a little bell is when it is tolled or struck within an exhausted receiver. Indeed, it not only requires air, but it requires some body or substance of air to produce a sound that can be heard; for we are not able, by even the best air-pump, to exhaust even the smallest vessel completely of air, as there must always be as much remaining as has spring enough to raise the valve of the pump.

Then as to touching, if we touched things themselves, and not the air, they would stick to our fingers, or our fingers would stick to them. The mean pressure of the air is about fifteen pounds on every square inch of surface; and so, if even the strongest man were to grasp a stick without air between it and his hand, he would never be able to unclasp his hand and let it go. As little could a man walk if there were no air between his feet and the ground. If there were no air, each foot of a full-grown man, if the sole were entirely on the ground, would be pressed to the ground by a weight of about four hundred pounds; and thus the man could never lift a foot, but would stand on the earth, as still as an earth-fast stone.

The little ridges of papillæ that are on the palm and fingers of a healthy hand, and also on the sole of a well-kept foot, contribute to the ease with which the hands and the feet can be separated from that which they touch, by the air that is lodged in the little hollows between; and though by close squeezing the sides of the fingers may be made to stick together, the fronts or tips of the fingers never can.

If there were not atmospheric air in the interstices between all substances, nothing which had a base, or surface, of any size that could be placed in contact with another, would fall. In that case, a man would not need to hang his hat on the peg; he would only need to push it to the wall, and it would remain there. So also he might stick himself to the wall, or lie down on the ceiling on his back and look down on the company below. Indeed, it would signify but little where he lay down; for be it where it might, assuredly he would never be able to rise up again.

If it were not that the air always comes between the surfaces of all things, the bricklayer would need no mortar, the joiner no nail and no glue; the tailor, too, would have no use for thread, and the seams of shoes would never give way. A world of that kind would be a very stable and lasting world, and the words "wear and tear" might be left out of the vocabulary. But there would be too much of stability; and there would be little motion, or change, and no life.

Thus the extreme pureness of the atmosphere, and the property that it has of insinuating itself into the very smallest openings, and pressing equally in all directions, makes it the grand pathway on land; for whatever is moved on land is literally moved in the air; and not only that, but, as the air is pressed together by its own weight, and thus heaviest nearest the earth, so that even the heaviest substances are pressed a little more upward than they are pressed downward by the air, their real weights are diminished by the weight of a quantity of air equal to their bulk. At the same time, they are held in their upright position by the pressure of the air all around them; and that pressure is so considerable as to amount to about thirteen tuns on the body of a man. That weight is, however, so nicely balanced, so perfectly the same at all points of the same elevation from the ground, and the air is so perfectly springy or elastic,—forms so delightfully soft a cushion around all nature, that its resistance to ordinary motions is not felt, and it does not ruffle the powdery plumage on the wing of the most delicate moth. Walking we do not feel it at all; and even when we run with all our speed, it is nothing but a light zephyr in our face, which fans and cools us, and really assists in speeding us on.

And it is worthy of remark how the natural coverings of many animals are "fined away" at their extremities, till they glide almost into the thinness of the air itself. Take an entire hair of any animal, more especially those that steal upon their prey unawares, and you will find the point so exquisitely fine that it is absolutely next to nothing. Painters are aware of that property, and so make their finest pencils of the hair of the sable, which admits of being made into a little brush that will hold a charge of colour, and yet all the points of the hairs united together make one point, as fine as that of the finest needle—indeed far finer. The same quality may be observed, in greater perfection, if possible, in the fur of the bat, or the fringes of the owl's feathers; and the little feathers upon the night moths are the most wonderful of any.

Creatures that are furnished in that manner act in concert with the air, as it were, while they are moving through it; and thus, though the bat be the most fluttering thing that flies, and the owls and the moths be generally far more clumsy than the day-hawks and the butterflies, yet they make their way through the air with much less noise. Many plants too have their yielding borders; and the wind murmurs in the groves when their leaves are on, and does not howl as it does among the leafless sprays in the winter; and it never roars on fertile plains as it does among naked rocks.

But the air is not merely the pathway of nature, it is the carrier, and it is as sensitive in its own motions as it is yielding to those of every thing else. The least alteration of temperature, or pressure, instantly puts the air into motion. If any thing advances, the air moves off before it to make room; and if any thing recedes, the air follows at the same time to support it. If any thing is heated above the average, the air ascends with the excess of heat; and if any thing is cooled, the air condenses and closes in upon it, not only as a protection against greater cold, but to impart positive heat. No matter how great or how small the object is, or how long or how short the distance, the air is sensible to the very smallest cause that can act upon it; and it is just as capable of obeying the most powerful. It surrounds all earthly things, and it regulates them all. If the distance is not the thousandth part of a hair's breadth, or if it is "round about the pendent world," the "viewless wind" is perfectly true to it.

The principle upon which all that is done is an exceedingly simple one. The temperature of the air, its pressure when in its natural and unconfined state, and its density, or the quantity of it in a given space, are all, by the very constitution of its nature, so nicely balanced and adapted to each other that the least change in any one of them is instantly followed by the corresponding change in the others; and its freedom of motion enables it to make an instant adjustment by motion.

There are few or no causes of disturbance arising from pressure in the air itself; because the only pressure which it has in itself is its own weight, or pressure downwards towards the earth; and the pressures of foreign substances mixed with it are considered as mere pressures, not of very much consequence. Thus the principal causes of disturbance or motion in the air are differences of heat: and, from general or local causes of heat, these are almost incessant.

When it is said that, of all substances in nature, the air is the most sensible to heat, the meaning must not be misunderstood. Sensibility to heat does not mean being actually heated, but only being put into a state of action by heat; and from what has been said about the connexion between apparent heat and resistance to motion, it will readily be understood that if the air were absolutely free to move, it would never show any increase of heat at all; but would expand and yield to the full extent of the heating cause. Nay, if it were allowed to expand faster than that cause operated, it would thereby be cooled. But light as the air is, even the smallest portion of it has some weight; and softly though it moves, still it has some friction. Both of these offer some resistance to the cause of heat, and thus the air is always a little warmed before it begins to move in obedience to the heat. The resistance is the greatest where the pressure is greatest, and the air in consequence the most dense; and that is one of the reasons why the air is hotter in hollows than on heights. If one were to ascend till the air had only half the pressure, and consequently only half the density and the resistance to friction that it has at the mean level of the sea, then it would yield twice as easily to the heating cause; and the same cause that would render it not only warm, but disagreeably hot at the level of the sea, would not bring it perhaps even to the heat at which ice melts at the great elevations. At less difference of height, the difference of resistance would be less than that; but there is a difference even for the smallest difference of height, although our observation will not reach the very minute cases, any more than it will reach the very minutest ends in any department of observation. We see as much, however, as may suffice to convince us that the law is general; and that is all which is required for the purposes of knowledge.

The daily and annual motions of the earth (and the atmosphere moves along with it) cause the heat of the sun to fall differently on every place, on every day in the year, and at every hour of the day; and the different effects of the heat of the sun on different kinds and forms of surface further increase the variety, till the relative portions of heat, at any considerable number of places, for any one time, cannot be calculated with any thing like certainty, or indeed at all.

If that could be done, we should all be perfectly "weather-wise," and should be able to tell how the sky appeared and felt in distant places, and how it would appear and feel at future times, with just as much ease and certainty as we could state the facts before our eyes. But that is an extent of knowledge which no human being can by possibility attain; and the utmost we can expect as the reward of the most careful observation is to understand what is actually before us, and make a shrewd but silent guess at what may immediately follow. In all things the past is the only mirror in which we can see the future; and if we search for knowledge of it anywhere else, we fail in our aim, and at the same time throw away the present.

When the air is heated, its tendency is to spread or expand equally in all directions, upwards, downwards, and laterally; but the actual motion is in the direction of the least resistance; and heated air ascends in the atmosphere on the very same principle that the heated lava of a submarine volcano rises through the waters of the ocean, and does not form a flat cake, or bed, at the bottom. The heated air ascends, and as it gets into air, having less resistance to its expansive force, it expands and cools, so that it at last comes to a place where it has no tendency to move unless it is acted on by a fresh cause. We can have a very tolerable notion of it in the ascent of smoke. That is really the ascent of warm air; and it is hindered, and not promoted, by the particles of charcoal and water, and other matters, which give the colour to the smoke. A chimney often smokes the most vigorously where it does not appear to smoke at all; that is, where there is a bright clear fire, and nothing but warm air ascending; and those furnaces which have their smoke so that it is hardly visible, send their currents of air to a much greater height than those which rain soot all over the neighbourhood.

Still the visible smoke of fires is one means of observation by which we can get some insight into the motions of ascending currents in the air produced by heat. When they blow all in the same direction, and soon melt into the air, it is a sure sign that the lower stratum of the air is dry, and will resist the descent of rain, even though the upper part of the sky may be cloudy. But when, without any high objects in their vicinity, some are inclined one way and some another, there is disturbance in the lower part of the air, and the probability is that it will soon rain, even though at the time there be not a single cloud to be seen. Clear skies are, indeed, at some seasons, and in some places, often more treacherous than cloudy ones: because, especially in places near the sea, or high mountains, there are clouds of day and clouds of night, which are regularly formed in the atmosphere, and again dissolve there, even in the finest weather. When the air is still, and the smokes ascend in tall columns without blending much with the air, it is a sign of rain, because it shows that the air near the earth is in a state in which it will absorb or dissolve no more moisture; and it is the under stratum of the air that keeps up the clouds; so that when these are formed and again absorbed, the absorption takes place at their under sides, and not at their upper, just as the snow showers that fall upon the hot and dry fields in the spring melt below by the heat of the earth sooner than above by the heat of the sun. Sometimes the smoke, when abundant, and when the air does not evaporate the water, and allow the soot to fall to the ground, forms a long flat stratum like a thunder-cloud; and that, like the thunder-cloud, shows that there will be showers, or rain falling from a considerable height, and therefore in large drops. The reason is, that a portion of the lower air resists the descent of the cloud, while the upper air is parting rapidly with the moisture that it contains. In these cases the evaporative, or drying power of the lower air, is often wholly occupied in resisting the descent of the cloud, so that the surface of the earth in many places, and especially that of the green vegetables, gets moist without the falling of any rain, or the formation of any dew. Growing vegetables give out a great deal of moisture to the atmosphere, because their absorbent vessels take in much more than is wanted for the addition of matter made to the plants in the process of growing. Water, or the component parts of water, decomposed and assimilated when in the aerial or gaseous state, no doubt go to the actual substance of the plant; but much of the water passes through the plant, as the mere vehicle of that part of the food which forms the nourishment: and that water is again given out to the air by evaporation. When the air is very warm and dry, more water is evaporated than is consistent with the healthy state of the plant: and in consequence the leaves become soft and feeble, and the whole plant droops. If the languishing is not very great, the plants are again recovered by the night, and next morning finds them able to bear the sun of a new day; but if it be too severe or too long continued, the delicate vessels of the leaves are shrivelled, the juices do not circulate, the light does not perform its proper functions, and the leaves lose their greenness and wither.

But when a cloud comes under the circumstances just noticed, the evaporation from the plant is suspended; and the moisture which would have been dissipated in a more drying state of the air remains and refreshes the leaves. In the banks of rivulets and the sides of drains there are often little tricklings of water, so small in quantity, that the dry air and the heated bank draw it into vapour almost before it reaches the surface; and the places seem absolutely dry. But when the evaporation is suspended by the cloud which cools the ascending air and sends it down again, so that it continues taking moisture alternately from the earth and cloud, those tricklings appear; and fresh moisture is apparent on the earth before any begins to fall in visible rain from the sky.

When the cause which heats the air is powerful, and its action long continued, the whole mass of the atmosphere may be put into motion; and the air which is moved may spring so fast upon that which has in itself no cause of motion, as to produce very grand, but, at the same time very serious effects. In the alternate halves of the year there are alternating heats of the sun in the north and south hemispheres of the earth; and these of course cause, in the middle latitudes, a shifting of all the currents and motions of the air, as the surface wind always blows from the cold place towards the warm.

The sun is no doubt the general cause of all those motions of the air that are on the grand scale; and it is worthy of notice, though of course there is no instructive analysis in it, that the young sunbeams are as sportive as the young animals. In March and April, and the early part of May, the atmosphere is absolutely wild. It is cold bleak wind: then castled clouds, and gusts flitting about; then a hail shower; after that hot sunny gleams; then fog; next cold wind again; after that, thunder and more hail showers, often in lumps in the warmer places; and after these again, weather almost as hot as that of summer. One would almost think that every spring, the prayer of the farmer to Jupiter, in the old fable, were granted to every farmer in England, and that they all had different weather for their different fields, if not just at the same time, yet all in the course of the same day.

That is the grand time for observation—the busy season with all nature in every thing that grows and lives. How countless are the millions of little buds which one of these "showering and shining" days brings into leaf! They are fresh and washed by the shower; and when the warm comes you would absolutely think that you can both see and hear them cracking their scaly cases in which they were confined and protected for the winter; and that the little green tufts were toiling, like living and rational creatures, at strife which should produce the finest shoot and the fairest blossom. Then the whisking wings and the trilling throats are apparently enough in themselves to put the air into a state of commotion. And they are all in the act of beautifying nature too: some are plucking the dry grass, so that the fields may appear green; others are gathering up the withered sticks; others again, the lost feathers and hairs; and others still are pulling the lichens from the bark of the trees. The merles and the mavises are running under the hedges, and the evergreens in the shrubbery, and capturing the snails in their winter habitations, before they have had time to prepare those hordes which would be the pest of the gardeners for the whole season. Other birds are inspecting the buds in the orchard; and picking off every one which contains a caterpillar or a nest of eggs, that would pour forth their destructive horde and render the whole tree lifeless. Yonder again are the rooks, clearing the meadow of the young cockchafers which the heat has brought nearer to the surface; and which, if they were to remain there, would soon begin to eat the roots of the grass to such an extent that the turf would peel off as easily as the withered tunic of an onion; and the labour of one hundred years (for some meadows take that length of time before they reach perfection) would be ruined in one season. Man could not do that which the rook does; because the rook goes instinctively to the places where the grubs are, just as the lightning goes instinctively to the elevated point of a metal rod; whereas man would have to learn where to find and how to catch them, and the lesson, simple as the matter appears, and is in the case of the rook, would be no easy one. Some of them come from a distance too; for there are the white sea-gulls, with their long bent wings and their wailing screams, busy in the same field with the ploughmen, and picking up the "animal weeds," while the ploughs are turning down the vegetable ones.

All the countless races of that time of labour and of love, both native and visitant, are busy following their own purpose, or rather the law of their being, for they form no purpose of their own, or they would sometimes commit errors of judgment as we do, but they do not. At the same time the fulfilment of the law of their being works for good to us, just as the law of the being of a bushel of wheat works for good to us when we cast it upon the earth and cover it with dust; and come back after a season and find ten bushels, nine for food, and one to cast into the earth, in the same manner and with the same hope as before.

At that season of the year nature has many busy labourers to feed, and many young plants, and come or coming blooms, and other previous things to look after, that her grand messenger the atmosphere requires to be on the alert; and as nothing in nature ever does that which it is not the very law and purpose of its nature to do, her messenger is always in time, and not one of her workers slackens or is palsied until it has answered the end for which the Author of nature ordained it, and the matter which has ceased to be useful in it is required for another purpose.

Those variable winds of the spring which seem to shift about and change in their rate and their temperature, in a manner absolutely capricious, are far more unerring than if the wisest man that ever lived had the management of them. That is proved by the very fact of our thinking them capricious, which is just in other words admitting that we do not understand them; and of course that we could not get one of the things done, of ourselves, or by our directions, which they are unceasingly doing for us. The most intelligent of us know but few of the properties of plants and animals, and many of us do not either know their names or themselves when we see them. How then could it be possible for us to tell what would give them the appearances that they in future are to evolve? To take a single instance, the future peach is not yet the size of a pin's head, and few can tell what it is if they do not see it taken out of a bud which they believe to be the bud of a peach-tree; and very few could tell it from the nectarine or the apricot. Now, there is no question that there is something communicated by the atmosphere to the infant peach, which gives it its soft velvety coat, and its purple and green and gold; but suppose the most skilful man were asked to "go and put the down and the colours to the peaches, so that they might be in the very perfection of their beauty, just at the time when the pulp was most delicious to the taste," what would he do? And what would another one equally wise do if he were commanded to "perfume the rose," or "scent the mignionette," or "flavour the pineapples or the strawberries?" Yet all these things have been wonderfully improved by human art; but that art has never been successful in any one case when it was not founded on the most minute and careful observation of nature.

As the Apollo of the ancients was the sun, or the image of light and heat, so Mercury, the messenger of the gods, was the atmosphere; and though the personification was a fiction or a fable, still it was a beautiful fable; and among those who have the knowledge of the true religion which God himself has revealed, and therefore are in no danger of being led into any thing like idolatrous worship by it, the fable is a most instructive fable, and gives in a few words one general and remarkable means of bearing in mind a great many truths.

Now though we cannot say positively that there is no agency but that of the sun concerned in the production of all the sweetness of the blooming year, though we cannot ascribe to solar action alone all the gentle offspring of that time which "takes the winds" with fragrance; yet we could not expect, because we have never found, that they come without the seasonal light and heat.

The *fungi* which spring up in the autumn, and come—like the vultures or the ravens of vegetation, to prey upon the dead and the dying, put forth no leaves, and expand no flowers, and they are rank. They come not up in sweetness to the humblest of the vernal tribes, from the leaves of many of which, when they are dried without heating, we have some of the sweetest of our scents. It is the scented vernal grass which gives to new hay all that sweetness which wiles old and young to the hay-field at tedding time; and the little woodruff which hides itself in the grove is even more fragrant in its decay. Yet they are both tiny and humble to look at:

VERNAL GRASS.

WOODRUFF.

All these early plants are kept fresh and sweet by the vernal showers; but as death creeps over the land, and even mushrooms and moulds begin to decay, the torrents of autumn descend; and the "wash" of the season rolls onward to the sea, bearing the corruption along with it. There the unpleasant and pernicious substances continue united with it; but no sooner has it passed the inconceivably fine but hardly discernible filter of the atmosphere, than all its impurities are removed, and the water alone and unadulterated, remains there, till, by the working of that very atmosphere which has lifted it up, it shall descend more soft and limpid than the sweetest spring that ever flowed from the rock.

It is owing to this property of the atmosphere that we have springs, and streams, and rivers. The Thames, for all its wealth, and the Mississippi and the St. Lawrence, notwithstanding their majesty and the immense volume of waters which they constantly roll to the sea, all originate in the clouds, and may be said to flow from the heavens. But the real sources of them are in those places from which the evaporative power of the atmosphere drinks them up, or rather perhaps in those natural operations by which the elements of water are loosened from other connexions, and left free to combine and form that all-refreshing substance. While therefore we cannot avoid being pleased with the bright and lively rill which dances from rock to rock to the murmuring cadences of its own music; while we cannot avoid lingering " to pore upon the brook which babbles by" the gnarled root of the aged tree, which winds round the churchyard with its gray stones, which steals through the shade of the osiers, with softer and more silent wing than the owl does through the coppice, which slumbers in the mill-pond, until obedient to the control of man it leaps in glittering pearls over the wheel to assist him in his labours; which steals through the meadows, now holding its glassy mirror to the sky, and now hidden by the bright iris and the bristling sword-flag; and which after it has run its course, the ornament and the fertilizer of its own native valley, mingles with the more copious flood of the river which sweeps gallantly by, and on the banks whereof Wealth builds his palace, and Science his temple, and Religion her sacred fane ; we cannot help regarding with lofty emotion that river when it thunders over the steep, and stuns the country round with its noise, but keeps it green and fresh with its ever-showering drops, and whose estuary tempts man to found his most goodly city, and harbour his most powerful, his most wealth-collecting, his most peace-compelling fleet; but though these powerfully draw the attention of the senses, and mightily excite and elevate the mind, there is an unseen return of the waters which outdoes them all in the wonders of its working.

The atmosphere is usually and justly styled "the breath" of every living thing; but it is something more extensive and anterior to that; and were it to suspend its general evaporative power for even a brief period of time, the very beginnings of life would be cut off and its fountains dried up. All the water which the rivers of the world roll to the sea, all that slumbers in ponds and expands in lakes, all that is caught in fountains, drawn from wells, or in any way appropriated to the processes of the arts or the purposes of life, all that supplies drink to the whole animal race, and is breath, and life, and clothing, and habitation to innumerable tribes; all that waters the fields, and sustains the existence of every vegetable from the moss on the wall to the monarch of the forest; all that enters into the structure of plants and of animals, or which bears their more immediate nourishment on its tide, or cleanses, softens, and comforts them by its ablution; nay, all that enters iuto those stones or gems which glitter so much,—is brought on the wings of the wind, mounts up through the viewless air; and the more vigorously that the countless thousands of active powers, natural or artificial, are working, the more abundantly does the air supply them with nature's most abundant, most refreshing, and most valuable production. If you would know the real value of water, ask a man when he is stretched on his couch in the heat of a fever, and when his throat is inflamed and swollen so that it will not do its office; or if he cannot answer, then ask him who sinks down under the ardours of the mid-day heat, on the wide and burning sand of Sahara, at many leagues' distance from the little dingy pool and the overshadowing palms: question him as to the value of water, and, though the charter of the world's wealth were in his keeping, he would cheerfully give it for one little cup, or even that he were sitting on the brink of one of those stagnant ditches which we shun.

As we do not see the particles of the atmosphere as a whole, the particles of its two chief ingredients, the oxygen and the hydrogen, or the particles of water which it takes up in the process of evaporation, we cannot know the nature of the agency by which any of these are held together. The cohesion of particles in the entire substance, as air, is indeed not only small, but absolutely negative, and entirely obedient to the action of heat; and not only that, but if air is let into a larger space upon which there is no pressure it will expand; and cool, that is, become sensibly cold, or abstract heat from other substances as it expands. And when the quantity of it in a close vessel is diminished by pumping a portion of it out, and water is placed in the vessel, and some substance is also placed in it which has more attraction for water than the air has, and which in consequence drinks up the vapour of the water as soon as it is formed, the remaining air in the vessel will become so cold that the water will be frozen into a cake of ice, even though the apparatus be in a warm room.

That simple experiment throws some light upon he very general and important process of evaporation. It shows us that when water passes into a state of vapour, or becomes endowed with that dispersive motion of its particles which sends it invisibly through the air, it is really changed to a state very much resembling that of the air; and thus it may ascend among the particles of the air, in consequence of the dispersive motion which it itself acquires by being heated. So that, though the vapour is invisible, we are not to suppose that it necessarily enters into chymical combination with the air, in such a manner as that the two form one compound substance; but that it is only dispersed through the air mechanically, and rises by the general law of gravitation, just because the quantity of it which is contained in any given bulk, in a gallon for instance, is less in weight than the quantity of air contained in the same.

That this is actually the case is proved by the fact that in dense air, when that air is warmed, and consequently communicates heat, not only to the surface from which the water is evaporated but to the little drops as they ascend through it, the water rises in visible vapour: and as that vapour mounts into air, containing less and less water as it ascends, and receiving more and more heat in its progress, the little drops are subjected to continual division, so that long before they have risen so high as the top of an ordinary hill, they have become far too minute for observation, and are so dispersed that a gallon of the watery vapour may not weigh one-twentieth part of a gallon of the air through which it is ascending. In that state it is not only impossible that it can fall down to the ground, but it must continue to ascend, and to ascend rapidly, in proportion as, bulk for bulk, it is lighter than the air.

And the farther that it ascends, too, it will ascend the more freely and rapidly, and spread to the greater extent; because the rarer that the air is, the farther must its particles be asunder; and the higher that the water has ascended the more minutely must it be divided, and the farther must all the parts be from each other. The action of the heat destroys the cohesion of the water with the pool, or the leaf, or other surface from which it rises, the very moment that it begins to ascend; and the cohesion of the ascending parts becomes less and less, even much faster than the diminishing size, because of the distance that they are apart, and that is the reason why vapour, which is so dense as not only to form a light floating rack, but castled clouds, with edges as well defined as if they were terrestrial solids, and even an entire covering, that extends over the whole visible heavens, and shadows the earth to very deep gloom, while yet that these formations ride buoyant on the air, and some of them are indications of dry weather.

Thus though the air is the passage of the ascending water which is to maintain the springs, it is no more the cause of the ascent than the channel of a river is the cause why the tide of that river flows downwards, and the vapour, whether it be invisible or in clouds, is obeying the laws of its own nature, and in nowise under the control of or attracted by the air. Were there an attraction, and if the air and the water actually united in their ultimate particles, and formed a new substance, as an acid and an alkali do in the formation of a salt, we should soon, from the vast extent of surface at which they constantly meet each other (which may be said to be, considering how many moist substances stand surrounded by the air, and how often the face of the water is wrinkled with waves, equal to that of the whole globe)—if they acted chymically upon each other we should very soon have neither air nor water; but a compound of the two: differing as much in its properties from either as the neutral salt does from the acid and the alkali. Common salt, which renders our food so savoury and so wholesome, is a compound of chlorine and hydrogen and soda, each of which is a poison, and when perfectly pure a very deadly one, nor are we acquainted with any real chymical combination in which the properties of all the ingredients are not suspended and new ones produced, while the combination subsists. That, indeed, is just what is meant by a chymical combination.

But the water, when in the most minute state of division, and ascending in air so very thin that the slightest cobweb would sink like a stone, is in every one of its little and invisible drops, as perfectly water as when it rolls in the flood of a river, or spreads in the ocean; and it is just as ready to obey all the laws of the water in the one situation as in the other.

The evaporability of water is the principal reason why it, and substances that are wet with it, do not become so soon hot as substances that are dry. When it is exposed to the air, it evaporates not only as long as it remains liquid, but even when it is frozen; although the evaporation of ice when it presents only one uniform surface to the air is slower than that of liquid water; because the heat has to melt the ice before it can turn the water of that ice into vapour. Thus the cooling influence of ice upon the atmosphere is much less and also more confined to the vicinity of the surface than that of water at the temperature of freezing, or even at a temperature a little higher than that, perhaps too as high as about forty-two degrees of the common thermometer, the temperature at which water has the greatest density, and at which, when it is all cooled down to it, the water in a pond or lake remains stationary, without any internal motion upwards or downwards.

The slower evaporation that takes place from ice than from water is the reason why, in walking abroad, one feels so much more warm and comfortable on a dry frosty day, a day even of the keenest frost, than on those raw days which are not exactly either frost or thaw, or even when thaw comes slowly, and the surface is covered with melting snow and ice. The hard ice and unmelting snow in the clear frosty day affect the air very little, whereas on the raw day, and when it thaws partially, the air is loaded with moisture, which takes the heat out of it: and as, on such days, there is seldom any direct sunshine to assist in dispersing the moisture up into the air, it hangs in the lower strata like a heavy fog, and abstracts heat from the human body, and forms hoar frost upon the hair and clothes: and whenever the temperature sinks a little, the water is deposited and crystallized upon every solid substance, and the more so the more slender the substance is, so that the grass and bushes and the twigs of the trees are frosted over with spiculæ of ice, which have a very pretty but very cold appearance. Those hoar frosts are most frequent in the autumn, before the waters be so far cooled down as that ice or dry frost is found. They sometimes occur late in the spring and in cold districts occasionally even in the summer.

If in the latter part of the season those hoar frosts, or white frosts, "hold," by a continuance of the cold atmosphere near the surface, they generally end in dry or black frost, and are followed by cold, but healthy and hearty winter weather. But if that air near the surface be warmed by any cause, so that the frost "gives way," or, as it is called in some parts of the country, "leaps," then, if the cause of that be general, rain is the immediate consequence, even though the general progress of the season be such as ultimately to lead to black frost, and a heavy fall of snow.

It may seem a little contradictory that temporary local heat should produce cold, but it is nevertheless true, in that as well as in other cases. How soon a person who has been in too close a room, or too near the fire, gets cold and shivering, compared with one who has been in a colder apartment, at a greater distance from the fire, or in the open air. Half the colds and coughs with which people are annoyed in the winter are owing to their winter habitations being too warm: and those complaints are far more frequent in towns than in the open places of the country. When people go hot into the cold air, the evaporation from the surfaces of their bodies is so rapid, as not only to make them feel cold and shiver, but if it be long continued, to injure the little follicles of the skin, which, in the healthy states of the body, remove much of the waste matter that is unfit for the purposes of life; and thus that matter remains in the system, and acts as a poison. Washing with warm water in cold weather has much the same effect; and they who resort to that in order to avoid the temporary influence of the cold, thereby subject themselves to it for the whole day. In summer, warm water is a luxury, and a wholesome, and almost immediately a cooling luxury: but they who would escape chilblains and frost-biting should avoid it in winter.

The temporary warmth of the air, which melts the hoar frost, acts in a similar manner. As the spiculæ of ice thaw (and very little heat thaws them, as they are in small needles to which the air has access on all sides), the water evaporates, and soon takes as much heat from the atmosphere as cools that more than ever; and the cooling influence gradually extends upward, till all the vapour in the sky, up to a very considerable height, is much colder than before. As the heat diminishes, the tendency of the particles of water to each other, which has been suspended, but not in the least destroyed by the heat, returns to action, and the particles approach each other, and form a cloud. That cloud gathers vapour from all the space surrounding it, not only while it is barely visible, but after masses of cloud have been formed. Everybody who has looked at the sky must have seen the clouds "congregating," even when there was no wind but wind of their own making; and must have observed that, true to the law of that attraction which is the real cause of their formation, the little clouds always move towards and unite with the larger one.

If the wind blows from a dry quarter, in the higher part of the air, the cloud is often swept away as fast as it forms; and if it be blown to a place where there is no such action on the surface as that which produced the cloud, it may be again dissolved by the air. But mornings when the disappearance of hoar frost denotes rain are generally calm; and in those cases there usually is rain. Indeed, a moderate surface wind, one of those "unhearty" winds which we call "raw," and which hiss in the crevices like scotched snakes, rather brings on than retards the rain; as wind always increases evaporation—even those winds that we call "moist," dry more than air at the same degree of saturation with moisture, but at rest.

When the heating cause is local and confined, the result is not rain but fog. In the evening, the land, especially where it is bare and dry, cools much sooner than the water; and as it is the change of temperature, and not the absolute temperature that produces the change of evaporation, vapour then gathers over the pools and marshes, and the courses of the rivers; and among bare hills with deep valleys, and lakes and rivers, the fog is often seen white and dense, in the hollows, as if some white fluid had been poured into them.

City fogs, such as the fog of London, which is at times very annoying, and always very offensive, are owing to a similar cause; only in the case of these, that cause is in the city. In the early morning, when the production of fog has been lessened by the slackening of the fires during the hours of rest, and the upper air, which may be very dry and tranquil without the limits of the city heat both upwards and laterally, may have melted the fog of the preceding day, the air may be moderately clear. But when the half-million of fires are lighted, and send up their heat, the whole moisture of the surrounding air is poured over the city; and that, mingling with the evaporation from the city itself, becomes so dense, that the charcoal, and the nitrate of ammonia, and all the other matters which, at ordinary times, the air disperses in great part, float mixed with the watery vapour, and produce an atmosphere approaching as nearly to the consistency of a quagmire in the air as it is perhaps possible to obtain.

But unpleasant and inconvenient as the London fog is, and much as it prevents all means of observation, there is still something in it worthy of attention to the observer of nature. The fog is a natural production, though some of the elements of it are brought together by artificial means; and thus, though they be somewhat dismal charms, it has still some of the charms that belong to all natural phenomena. It is curious to find a sort of twilight representation of London in that very substance which completely hides London itself; and yet such is the case. It is not to be understood that the wards, and cities, and boroughs which compose the metropolis, are as well represented by their several fogs as they are by other means; but still they are represented by these.

The air over London moves upwards and downwards with the tide of the river; and over rivers of such magnitude the light winds are more frequently in the direction of the tides than in the cross direction. The light winds that accompany the fog, though they barely reach the streets, and are not indeed very perceptible when so little can be seen, are usually from the east. Hence, if the tide is upward and the wind at east, the fog will be borne slowly westward, until the fog, which is produced at Blackwall may reach as far as Chelsea before the turn of the tide. That is one of the causes which produces, or at least enables a person at Chelsea to see, the "fog map."

But again, as the heat of the population and their fires, and the smoke of the latter, produce the smoke, the smoke must be most dense where these are most abundant; and though the quantity added as the moving mass creeps westward must, to some extent, weaken the shades of density as first produced, yet these are not altogether obliterated. Hence if one takes post somewhere about Earl's-court, on a morning with the wind at east, first comes the fog of Brompton, and part of Chelsea and Knightsbridge; then comes the Green Park, a great deal lighter. St. James's is not very dense, because the houses there are large, and the fires not many. It then gradually thickens to St. Giles's, and the hundreds of Drury. Lincoln's Inn Fields lighten the prospect a little; but the thick mass of buildings all the way to St. Paul's make it soon dark again. St. Paul's is but a speck; and after that it is usually dark as Erebus till you are quite tired of it. If the fog of one of the great breweries, or other works, which bountifully bestow all their smoke on the neighbourhood, happens to pass over you, it is perfect obscurity, more especially if the air which is now passing over you happened to be there when they were feeding the fire.

The London fog is no indication of rain, or, indeed, are any of the creeping fogs that are formed in the hollows. They are, indeed, the very reverse—they show that the upper air resists and keeps down the fog, so that the temperature of its own humidity is not altered. But the London fog has a rain of its own, and that rain is filthy to man and pernicious to vegetation. It rains soot and a "villanous combination" of acrid matters, which soil the people and their provisions, even while they are in the act of eating. Broccoli, and also the close-leaved vegetables, always have a nauseous bitter taste in thick fogs.

But the fog depends on the quantity of moisture there is in the earth, or mud, or whatever happens to be exposed to the air; and so the density of the fog must vary with that. Some parts of London are on a thick bed of fine dry sand and gravel, which allows the water to sink into the ground, so that it is not there to cause fog. Others are on sludge or mud, natural or artificial, and that works up between the stones of the pavement, forms mire on the surface, and converts the street into a very successful manufactory of fog; and other parts again are on an exceedingly tough clay, the surface of which is kept cold by continual humidity and evaporation.

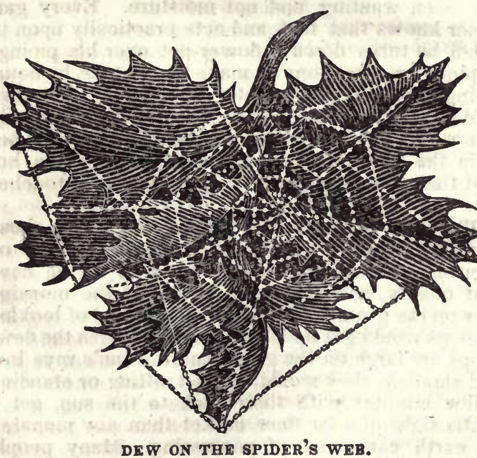
We may here find a use in observing the effects of the London fog; for it will be found, where other circumstances are the same, to be no bad indicator of the healthiness of the different places. When the air is more than usually humid, and the surfaces of the walls in consequence cold, they melt dew out of the warmer and humid air, just as the windows of a room in which there are many people melt dew out of the moist and warm air within; or as the surface of the earth and of vegetables melts dew out of the warm air of the evening, which does not cool so fast as these solid substances. The dew of the fog takes the coat of the fog along with it; and thus, wherever the bricks and stones become soonest discoloured, and the former show symptoms of decay, and the latter get discoloured with green mould, and other little plants, the place, whatever may be its height above the mean level, is always the most damp and unwholesome. Wherever the bricks lose their colour fast, and become granular at the edges, it will be found that the mortar is most decomposed, and has an efflorescence of salts of lime on it; and it will be found that the buds of the trees are black, and full of cankers, and rusty, and in some places breeding *fungi*, unless they are natural inhabitants of moist atmospheres. The flags in the pavement, and even the granite in the streets, bear marks of this humid and corrosive nature; and an atmosphere which produces those effects cannot be the most salubrious for human beings. So much for the earth fogs.

Dew, it has been said, is produced much in the same way as these fogs, and the only difference is that the dew is produced only at or on the surfaces of the objects upon which it appears, and is really a product of the atmosphere, though it does not *fall* through it; while the fog is, at least in the first instance, a product of the surface over which the air is; though, after it has cooled the air down to a certain temperature, it may, and often does, bring about that state of things which produces dew. There are instances, however, in which the fog does not bring the temperature of the air down to the dew-point, and these are usually called "dry fogs," though they are composed of water, and, according to their densities, contain as much water as those fogs which are accompanied by dew. Dry fogs are day-fogs rather than night-fogs, as, of course, the surface of the earth does not cool so fast when it is merely veiled from the sun by a fog as when the sun is down.

Simple as the process of the formation of dew is, there have been some mistakes and disputes about it. Some have written and spoken about "rising" dew, and others about "falling" dew. But the dew, as *dew*, that is, as visible drops of water, neither rises nor falls, but is formed on the surfaces; and as the air has access to all surfaces except the interior surfaces of air-tight vessels, the dew may form on the side of a substance or under it, just the same as on the top; for while the water in the air is invisible vapour, and floats in the air, it must go with the air wherever that goes; and though it is under an inverted basin on the grass, there is no reason, if the surface cools as rapidly, why there should not be dew there as well as anywhere else. If, indeed, the basin is inverted before sunset, there should be, and really there is, more dew there than upon the same surface of the exposed grass. Take a large flower-pot, and turn it down a little before sunset, and leave it a little after sunrise, on the same spot, for a week, and you will find a circle of stronger and greener grass than that around. Even if you keep the pot constantly on the place till the grass becomes yellow, you will find that it is light that has been wanting, and not moisture. Every gardener knows that fact, and acts practically upon it, when he turns down a flower-pot over his pipings of pinks or carnations to make them *strike*, by nourishing them with the gentle dew which their own cool leaves melt out of the warmer air. A shady tree will refresh a man with dew when he escapes from the burning sun, even though he be so hot that that dew is evaporated again before it touches him.

The dew forms into beautiful drops on those surfaces between which and it there is a sort of repulsion. Vegetable leaves when in action have that quality, and hence the beauty of the morning dew on the grass. If those who are fond of looking at gems would get up in the morning, when the dew-drops are large on the grass, and the sun's rays low and slanting, they would, by just sitting or standing a few minutes with their back to the sun, get a gratis sight of a far finer casket than any monarch on earth can boast of possessing. Many people make a boast of having been at court, and having seen the queen in her jewels; but if they would get up in time, they might, almost any sunny morning, see the queen of nature in her jewels, and gain both health and time by the sight.

One of the most beautiful displays of dew is that on the web of a spider; and perhaps that of the sceptre spider, or large mottled garden spider, is one of the best, as the web is large and strong, and the rainbow tints of the web are seen along with the glitter of the dew-drops, if the proper light is chosen —and any one may catch it by moving from side to side a little. At a more advanced period of the season, the drops freeze, and the main braces of the web may be taken by the ends and examined like little strings of seed pearls. The spider is not on the web in the dew, and it is dead, or in its winter retirement, before the frost.



DEW ON THE SPIDER'S WEB.

Before the heavy dews of late autumn set in, the spiders have all vanished from the gardens, but their webs remain for a considerable time after, and if the frosts are constant, they may be observed for a great part of the season, not only gemmed with the little pearl drops of ice, but absolutely bristled with hoar frost. The quantity of these webs in gardens and fields is immense; and it would be a curious inquiry to ascertain what purposes the wrecks serve in the economy of nature,—as it is part of the economy of nature that no portion even of the refuse of her works is lost. The most durable of those webs is that of the great garden spider.

There is one little matter connected with the formation of dew which is worthy of being known, because it is, in so far, conducive to the preservation of health. Every one must know that in ordinary states of the atmosphere wind very much promotes evaporation; and many must have felt the effects of sitting near an open window, or otherwise in a "draught" or current of air: and that those currents are most injurious when they act partially on the body. The reason is, that the current evaporates moisture from, and causes to shrink, that part of the body against which it sets, so that the circulation in the capillary vessels which join the arteries to the veins, and also in the small lymphatics, is more impeded there than in the rest of the body. That unnatural resistance, of course, causes an unnatural action, and stiff-necks and other local rheumatic affections are the consequence. It is matter of common observation, too, that the danger is greatest when one sits with one's back to the draught, and that it is least when the face is turned to it. The fact is, that the draught produces little bad effect, if any at all, if it blow only on the face; and one can bear to look a whole day out at a window, the draught at which would produce a stiff-neck, or even a cold, if the back were exposed to it for an hour. Now the back of the head and the neck have no means of protection against the effects of the current, except the artificial covering that may be on them; but there is self-protection in the face. The breath which is expired is heated in the lungs, and also charged with moisture. As in the operation of breathing, carbon or charcoal, which previously existed in probably a solid state, unites with the oxygen of the inspired air, and with it forms carbonic acid gas, it might be supposed that cold would be the result, as is the case when most substances pass from any more condensed state into the state of gas. Such, however, is not the fact; otherwise a common fire would cool the room instead of heating it, and furnaces would harden metals instead of melting them; for the chief process which goes forward in the burning of fuel is the conversion of the oxygen of the air and the carbon of the fuel into carbonic acid gas. There are, indeed, generally other matters in the fuel—such as hydrogen, which passes off, mixing with oxygen, in flame, and the result is water, which goes up in vapour with the smoke; and various other substances which form solid products with oxygen. In these the whole of the heat which held the oxygen of the air in a state of gas becomes free and apparent to the senses; and as the carbon which combines with the oxygen does not increase the volume, while it very much increases the density, the oxygen which forms the carbonic acid gas gives out a great quantity of its heat; and yet the gas which is formed may have a higher temperature than the oxygen. Here we may see, by-the-way, why fires burn brightest in cold weather; and why the sunbeams, or any other light, put out the fire, or make it burn feebly. The colder the air is, it is the more condensed, and of course has the more oxygen in an equal bulk. Thus it moves faster to the fire, and carries more of the element that feeds the fire. The light expands the air, and that causes it to come more slowly, and also to have less supply of oxygen in the same bulk; and the direct rays of the sun so expand the air that the current to the fire is greatly diminished, and stops altogether. We hence see how very unskilfully many persons blow the fire with bellows. They put the nose of the bellows close to the fire, and thus drive the expanded air upon all parts of the fire, except the little space on which the blast acts; and the consequence is, that that little portion is very rapidly and unprofitably consumed, and the rest of the fire is not at all improved; whereas, if the bellows were kept farther off they would blow a much more effective current of air against the whole fire. The position of the bellows should be sloping upward to the fire, because then the air is of the proper quality; whereas, if the nose of the bellows slope downward, the "burnt air"—the nitrogen and the products of the fire are blown against the fire, and tend to weaken it.

The heat produced in breathing does not approach nearly to that of flame or combustion, but still it is considerable, though it is not easy to distinguish between it and the heat produced by circulation. There is no reason to doubt that heat might be produced by resistance to circulation, and to that of breathing, among other circulations, sufficient to kindle and consume the body; for though all the recorded instances of spontaneous or inward combustion are not probably true, yet so many of them are mentioned that they must have at least some foundation. We know that when either the breathing or the pulse of the blood is quickened, either by exertion or by disease, the heat increases in proportion; so that while the temperature of health varies from about ninety-five to one hundred degrees, a diseased heat may be as great as one hundred and thirty or one hundred and forty degrees. So also when the breathing or the circulation is very languid the temperature sinks; and in those faintings, during which hardly any pulse or breathing is perceptible, the body becomes exceedingly cold.

Now, as the temperature of health is very considerably above the average of that of the air in temperate countries, and indeed above the average of almost any country, it follows that the expired breath, which, as has been said, is loaded with the superfluous moisture of the body, must have a tendency to produce dew upon the colder air against which it is breathed. In dry and warm states of the atmosphere that dew is not observable, though even then the breath will stain a mirror, if held near; but when the atmosphere is cold or moist, the breath of man and of all the warm blooded animals becomes visible; and in keen frosts, a man's own breath will cover his hair with hoar frost, and even form ice upon his face. But the same heated moisture of the breath which becomes apparent in those cases exists in every case, whether circumstances render it visible or not, and thus it becomes a protection against draughts or currents of air. These blow the warm and moist breath against the face; and that instead of parching it, as the common air would do, dews gently upon it, and protects it from injury. The effect is much greater than one would suppose; for if one stand with the head bare when the wind blows keenly, one can bear it longest by facing it. It is not a little curious that the danger of catching cold should, like all other dangers, be greatly diminished by being faced.

The mists, or dews, which are formed in the higher regions of the atmosphere, are of a very different character from those that are formed on or near the surface of the earth. The earth-mist, as we may call the lower one, before it can rise upward in the air, and disturb the state of things there, has the resistance both of gravitation and cohesion to overcome; whereas, the descent of a mist or cloud, formed in the upper part of the sky, has both of those resistances as powers acting in favour of its descent. That consideration helps to explain so many of the phenomena of the weather—phenomena which are very important for the triple purposes of pleasure, utility, and health, that every one who is to observe nature, so as either to be pleased or profited by it, should understand them thoroughly.

Water can be suspended in the air without falling only when it is in very minute drops; and as the density of the air decreases as its height above the mean surface of the earth becomes greater, the individual portions of water that it can hold without falling, at any given elevation, must be in proportion to its density at that elevation; and thus, if we suppose water to rise by evaporation from any point in perfectly still air, the vapour which arises from that point will form an inverted pyramid in the atmosphere; and however the upper part of that pyramid may be expanded, it cannot contain more water in the highest foot of its height, than it does in the foot next the point from which the vapour rises. If, instead of a point, the vapour rises from a surface—say that of a circular lake one mile in diameter,—the vapour will, as it ascends, if there is no wind or current to carry it to one side rather than to another, spread out towards all sides; so that when it comes to air of only half the density of that on the surface of the lake, it will extend nearly a mile all round; and as it ascends higher, it will spread wider and wider, till, at the upper part of the atmosphere, where we must suppose the density of the air equal to nothing, it will be diffused round the whole globe. If we could see it, it would be a phenomenon of the greatest beauty; for the slope of it would not be a straight line, but a logarithmic spiral, similar to that chosen by those consummate artists the gothic builders, by means of which the arches that spring from the columns and corbels melt so beautifully and so naturally into the roof, that all notion of one part supporting another is lost to the perception, and the feeling that we have is that the roof is self-balanced, and would float in the air even though the walls and upright pillars were removed. St. George's chapel is one of many instances of that most sublime and most natural of all styles of architecture; and there cannot be a better material incentive to religious feeling than the view of a roof which even to common observation is independent of gravitation —the test and characteristic of every thing material. The pendant drops which belong to the same style of architecture have the same aerial and floating character, just because the curves by means of which they melt into the ceilings are logarithmic curves; and it is not a little remarkable that when two pieces of flat glass are placed on edge in a coloured liquid, with their one ends touching, and their other ends a little asunder, the coloured liquid rises between them, so that its upper edge forms the same kind of curve; and that is a proof that, if we could see it, the column of evaporated moisture would have the same beautiful and self-balanced appearance.

It may seem not a little singular that the Catholic architects should have applied to the roofs of their churches that very curve, by assuming which water hangs poised in the air; and that consideration alone should teach us to pause before we arrogate to ourselves, in these modern times, the perfection of all science. Columns and an architrave, proportion them as we will, and sculpture them as we may with the richest foliage and the most graceful figures, have still all the heaviness of lumpish matter about them. The columns seem pressed by the architrave; and if that is overloaded, or the columns too far asunder, the building, however graceful the individual parts, however costly the materials, and however exquisite the workmanship, is painful to look upon, because we feel as though it were unstable, and about to be crushed by its own weight. Even if it is a circular arch, we feel apprehensions for its stability if it exceeds a certain span, though we have the rainbow and the sky to give us impressions of the stability of the circle; but in the case of those logarithmic curves, we never feel that a large span is less stable than the very smallest.

Here there is one consideration which, though it cannot be said directly to belong to the observation of nature, is yet worthy of a little meditation. It is this:—The Grecian and Roman architecture, which probably carries the proportions of material form as far as they can be carried in respect of beauty, just as the statues of their gods and goddesses carried the proportions of the human figure to a degree even of ideal perfection,—that architecture and that statuary were the art of a people whose gods were material,—the perfection of material gods, if you will; just as the architecture and sculpture were the perfection of those arts; but still the gods have the idea of material beings inseparable from them, just as much as it is impossible to separate the idea of weight and pressure from a Grecian or a Roman building. On the other hand, the logarithmic curve belongs to Christian architecture, to the true religion—to that religion whose God is a Spirit; and therefore, though the coincidence is a wonderful one, it is in perfect congruity and keeping that the roofs of the fanes devoted to his worship should be thus divested of all the apparent heaviness, and consequent fall and decay, which are the inseparable attributes of mere matter.

While the evaporated moisture is ascending in this hyperbolic form (and the wind only gives it an oblique direction, by blowing it to one side) gravitation resists its ascent, its own cohesion resists both that and its lateral spread, and the resistance of the air opposes both. It is the same with every thing that rises by evaporation, or dispersion, through the air,—with odours, with sounds, and even with the air itself, when it is heated by some local cause at the surface, and mounts up through the rest of the mass. If the air were perfectly still (which it never is), and the dense smoke of a furnace rose up with perfect uniformity (which that also never does), we should see the hyperbolic column mounting and swelling till the upper part of it became so thin as to be invisible, and it seemed to melt away into the air, both upward and laterally, with the most finely melting shade imaginable. And even as it is, although the smoke is always irregular in its quantity, and though those very irregularities produce little currents in the air, which throw the smoke into curling volumes, an eye well disciplined in the observation of forms can trace the hyperbola in its general outline, even when it is blown aside by a pretty smart breeze. The side opposite the wind is always more bent than the windward side, so that the column broadens as it gets distant from the chimney; and we have only to imagine it to be raised straight and the inequalities of the ends to be arranged, in order to have a very clear notion of what it would be if the causes of disturbance were removed.

The descent of a cloud, of a column of cold air, or of any thing else that can be so dispersed through the atmosphere, is just the reverse of its ascent; and therefore its form, if it were visible and undisturbed, would be hyperbolic, only with a downward motion, in place of an upward one, as in the former case. The motion would, however, be more rapid; and for that reason the descending hyperbolic mass would converge, or come together, more rapidly than the ascending one spreads. It is true that as it descended it would meet with more resistance from the denser air; and also from the upward current of air and of heat from the earth's surface, if the place under it happened to be warm; but still the weight of the descending matter itself, the velocity it had acquired in descending, and the attraction of cohesion between its own particles, or portions, would all act in favour of the descent and the convergence, whereas they act in opposition to the ascent and the spread Were that not the case, we should have water rising in showers, just as often as it falls in showers, or, to speak more correctly, there would neither be the one nor the other; because, wherever it happened to be, the water would remain quite stationary.

To understand well how nature works, it is absolutely necessary to have clear and perfect views of what may be called her elementary working, that working in which there is no organization of parts, and no individual substance which we can in any way distinguish and observe. That, though it is not the first we come to, inasmuch as it is not apparent to the senses, is the true beginning of observation; and unless we comprehend it, we lose the greater part both of the pleasure and the profit of the observation of individual things.

The cause of descent is gravitation; the cause of aggregation, or bringing together, or condensation of any kind, is cohesion; and the only force which we know that can act in opposition to, or overcome, either or both of these, is heat. Gravitation is, as it were, the tie of all matter, without reference to any thing in particular kinds of matter, but just their quantities. Cohesion is the particular tie which holds together the several kinds of matter, and it is perhaps the ultimate foundation of all their differences. The motion of heat overcomes gravitation only by loosing cohesion,—by so dispersing the parts of a substance as that they shall rise upward through a substance, specifically lighter than that which their form was before they were dispersed. Thus, when heat acts so as to expand, and thereby to elevate, it has always two resistances to contend with; whereas, when heat is diminishing, and concentration and descent are taking place, these two act jointly against the heat; and both of them act with vigour, increasing inversely as the squares of the distances from their centres of action.

Even admitting that moisture floats in the atmosphere to the highest elevation at which that is estimated to have sensible weight, which is about fifty miles above the mean surface, that is only one-eightieth part of the distance of the mean surface from the centre, so that, from mere gravitation alone, the same quantity of water, when it reaches the surface, will have only about one-fourth more gravitation than it would have at the height of fifty miles.

It is very different with the cohesion, or, as it is called, when the substances are not touching each other, the attraction of cohesion, because the centre of that is in the body itself; so that, whenever from any cause, and that cause may be generally, if not invariably, said to be a cooling, or suspension of heat, the moisture in any part of the air becomes more dense than that in the surrounding parts, the centre of that part instantly becomes a centre of cohesion; and those particles of water which are situated at half the distance have four times as much tendency towards that centre, and so on for all other distances.

Thus we see that the tendency of moisture in the air to form a cloud is much greater than the tendency of that cloud to fall after it is formed; and that it is so without reference to any thing else than the three principles of gravitation, cohesion, and heat,—principles which, in themselves, contain the abstract of the whole philosophy of matter. It is not unusual to call in at this stage of the business the assistance of ideal causes, much after the same fashion as those who know not the true God worship idols, or those who are ignorant of the truth give currency to any untruths; but the careful observer of nature should be especially on his guard against false causes; for it is in them that all error in the knowledge of nature lies. It has not been unusual to delegate the process of cloud-making to electricity, to magnetism, and to the aurora borealis; but in all probability, though there may be other and accompanying appearances of those states of the atmosphere that precede or accompany rain, we have no more reason to believe that they are primary or active agents than we have for believing that a Lapland witch can raise wind, or fairies prank the sward with circles. Those last-mentioned causes were once in as high repute as any of the witch and fairy superstitions of philosophy; and though those who know better have discarded the witch and the fairy, there are people who still bow down to the other idols.

Electricity, and the other supposed disturbing causes of the atmosphere that have been mentioned, are mere appearances which matter under circumstances, some of which we do and some we do not understand, puts on; and as it is contrary to the whole tenor of our observation to believe that a mere appearance can act, in any way whatever, we should treat those appearances as sensible people treat all appearances—that is, we should say nothing about them which we do not understand. That which we call a substance, or matter, is not mere appearance, or even an accumulation of appearances, it is an inference from those appearances and the relations in which we observe them; and as that inference and the perception of those relations, are acts of the mind subsequent upon observation by the senses, we may conjecture and speak of it, and make discoveries with regard to them by the mind only, even though all our senses should become obliterated; but with regard to mere appearances they can be known only through the medium of the senses; and beyond observation every attempt is an error. Nor is there any necessity for inventing new powers or principles, for the three that have been stated, are perfectly sufficient to produce every appearance and every change of appearance that we can ima gine—for we can rationally imagine nothing but a modification of something we, by the operation of mind, have seen altered in its relation ; and it is no more violation of propriety to suppose that the same heat which keeps the body warm in life, which labours in the furnace and cooks in the fire, and which brings us the beauty of summer and the abundance of autumn, can sport in the aurora borealis, guide mariners in the needle, or blaze in the lightning, than it is to suppose that the never-thawing ice of Mont Blanc could be a river or part of a tree, or a human body, or that its component parts might become the fuel of the most intense flame that is known, and that they are the chief materials in the flames of our common fires.

At whatever place of the atmosphere water remains in a state of rest, the heat is always such as to balance to the utmost nicety both the gravitation and the cohesion; and it is only the air which at the same point admits of variation. The others are, compared with it, dull and passive properties; and they act only when heat is suspended, though when once begun, they increase at the rate which has been mentioned; and, as their action goes on, and water has no solid cohesion at a temperate heat, the result is most conspicuous as gravitation.

The extreme mobility of the air favours the action of all these principles; and that is the reason why the aerial state is to be regarded as the elementary state in the formation of all material things. Easily as the air is moveable at the surface of the earth, it must become more and more so as we ascend above that surface, till at its upper limit we can hardly imagine that it offers any resistance at all. We, indeed, know nothing about absolute limits in nature; but where there ceases to be any resistance is the limit to our observation, and therefore there can be no knowledge, and need be no speculation beyond.

As, from its utmost density, at the bottom of the deepest pit or crevice in the earth to which it can reach, to its utmost degree of rarity in those elevated regions where, if we could ascend to it, it would elude the observation even of our muscular feeling of resistance, which is our primary as well as our ultimate test of the existence of matter, the atmosphere in all the compounds of which it is made up, stands in the same perfect equipoise between heat and those other principles which are the antagonists of heat, it follows that its susceptibility of change must be everywhere in the inverse ratio of its density; and that a difference of temperature will produce, in the upper or rare and delicate regions of the atmosphere, very great degrees of motion and disturbance, although it would produce no sensible effect in the denser portions near the surface. Those upper parts of the atmosphere may be regarded as being sensibility itself, just on account of the inconceivably small portion of matter which there is in any assignable space. If we could suppose that the last space of the atmosphere, taken even to a mile in thickness, could weigh a grain, or even the millionth of a grain, we should still be on the ground of observation, and not have arrived at the limit. At the limit both gravitation and cohesion are in the very article of entirely losing their dominion, and heat is beginning to be all-powerful. At that boundary, therefore, there is really nothing measurable, or even moveable, that can retard motion:—and so it is perfectly consistent to suppose that the air moves, or, which is the same thing, the wind blows there with a rapidity equal to that of light itself, if not greater, and yet that, though we were exposed to its current, we should be no more sensible of the impact of that current than we are of the impact of light, which comes to us without any difference of temperature from that of the body, and falls not on the eyes.

As we descend downwards from that limit of extreme atmospheric rarity and gravitation, and cohesion becomes more and more sensible, the motion produced by the same variation of temperature must gradually become less and less; but the atmosphere is so rare even where densest, that it is probably more sensible to changes of heat than even our sense of muscular resistance; and therefore we cannot even feel it to any thing near its boundary.

Thus even at moderate elevations, elevations not greater than the summits of our loftiest mountains, the atmosphere may be thrown into very great action by very slight causes; and the very first pencil of the morning light which streams upon an atmosphere thick enough for dividing that light, and sending down the extreme violet of the spectrum in a glimmer of dawn to us, may, in the red and more energetic part, give to that light air a degree of motion which shall send it completely round the atmosphere, before the other part of the ray can reach us from probably not the thousandth part of the distance.

But though, in those upper parts of the atmosphere, there is the least matter in the same space, we must not on that account suppose that nature is there least active. We have noticed, again and again, that matter is the clog of motion; and as the most active substances that mingle with the atmosphere have the greatest tendency to ascend in it, we may properly suppose that they occupy the upper parts of it; and that their motions and oppositions are not only perfectly adequate to the production of all the luminous meteors that appear there, but also of forming out of the scattered materials which float at that airy height, the meteoric stones of which so many are recorded as having fallen to the ground.

Lower than that, but still in air so fine that it will float nothing that can be visible to our sight as matter, whatever it may be in appearance as light, there may be a perpetual formation of clouds, not one of which may be able to find its way through the denser and warmer air below. In those high regions of the air there must indeed be an action of heat in the atmosphere much greater than that which takes place on the earth, otherwise there could not be snow on the summits of the loftiest mountains. On some of those mountains there is continual frost, except in the direct rays of the sun, and even a lower temperature than that at which, under ordinary circumstances, water freezes. It is true, that as the whole, or at least the greater part, of the sunbeams is reflected back into the atmosphere by the white snow, the air around those lofty summits must be warmer while the sun is shining than air at the same elevation over plains. That is the reason why travellers who have ascended the Andes and other mountains of great elevation have described themselves as being above the clouds; and they no doubt have been above the clouds of the plain and the valley, just as a man on Highgate Hill or Hampstead Heath is often above the London fog; but if they had dwelt for months at even the highest point that the human foot has trodden, they would have found, though they might not have survived to tell, that they were not above the clouds and storms of the mountains. The inhabitants of South America, of Chili in particular, have roads, and also work mines in the Andes, far above the limit of perpetual frost. But elevated and cold as they are, and rare as is the atmosphere upon those dreary heights, they by no means enjoy a peaceful sky. The "temporales" which rage there are perhaps more violent, both in the fury of the wind and the thickness of the snow, than in any other part of the world,—as the number of crosses set up at death-spots, and the number of bones (of those who have been blown over the precipices) that lie bleaching in the desert, but too truly and emphatically proclaim.

But though the clouds which form there produce effects so disastrous and fatal, it is probable that they could not find their way down through the mass of atmosphere that lies between that elevation and a low plain; but they show that the atmosphere can act as powerfully at those heights as in any other situation, more so indeed than upon the surface of a level country, and more especially of a country covered with trees or other tall vegetation. There is a resistance to the wind by friction, as it passes over these; but the swell of the air comes full and uninterrupted upon the mountain, and as those temporales prove, the loss of weight may be more than made up by increase of velocity.

There is also little doubt that the mountain draws the atmosphere and the atmospheric moisture towards it, notwithstanding that it is cold, and that the general motion of the air on the surface is towards the warm place. Over white snow, the air when the sun shines is warm,—very warm as compared with that over a vast and black surface at a much smaller elevation. Of course the air ascends in consequence; and the very snow on the mountain has a self-maintaining property, though it is continually refreshing the lower places with springs and streams.

But though the atmosphere over high mountains, warmed as it is by the heat reflected from the snow raises moisture higher than the atmosphere does over plains, yet it is less able, in cases of change of temperature, to sustain that moisture. If the mountain is so high that the air has only half the density that it has at the mean level of the earth, then the same volume of it will support only half the weight, whether of cloud or of any thing else. Thus the very same texture of cloud which is a fog over the city, or a creeping and even a dry mist in the valley, may be a very wetting rain on the mountain. Every one must know the saying that "a Scotch mist will wet an Englishman to the skin;" and the fact is correct, both as to Scotch and to all other mists, provided they be mountain mists, and at a sufficient height. A stranger, when he sees a light white mist trailing in detached parts, among the crags and hollows of the mountain above him, lighter to all appearance than the lightest "sea-rack," which plays by the beach on a May morning, so dry that it will not "dew" on a cobweb, heeds it no more than he would heed that. But when he enters it he finds his mistake. The drops are no doubt much smaller than those of "lowland" mists; but they are three to one at the least, and they do not hit and dash off by means of the force with which they strike, as the large drops do. They all adhere; and when it is quite calm, as it often is when they are falling, and when the cloud just obscures but does not hide the sun, the stranger has a chance of being "wet through," before common notice has made him sure that it is raining. The minuteness of the drops not only allows the solar light to come dimly through the cloud, but it causes that cloud to look white at a distance, which increases the deception.

Nor is it only when they form around mountains that these elevated clouds produce rain, or lead to its production, for they have similar effects when they form in the atmosphere. The "curl-cloud" which appears streaky in the uppermost part of the sky, and the circle of vapour which is often seen round the moon, are much more certain indications of bad weather than much denser clouds that lie lower. A cloud that just floats is as ready to fall at any one height as at any other; but the higher up that it is the less action puts it into motion downward. The higher cloud thus, as it were, commands the whole atmospheric action; and though the heat and drought of the earth and lower part of the atmosphere may resist it, and dissolve it again and again, if the cause continues to act in the upper part of the atmosphere, the earth and the lower part must, in the end, give way, and rain must be the consequence. The cloud, too, or the "gum," as it is sometimes called when it is merely a tinge of colour without any definite and limited shape, intercepts part of the light and heat of the sun, and thus lessens the resisting power of the lower atmosphere and the earth, and that hastens the coming of the rain. The gummy appearance is probably even more suspicious than the curl-cloud, because it shows that a region higher, and therefore more sensible, is affected, and it also shows that the cause is more widely extended.

The quantity of water which the air can sustain in a state of vapour, supposing the air to be of the same density, diminishes more rapidly than the temperature; and thus when two currents of air of different densities meet, a certain degree of precipitation of moisture always takes place; and if the difference of temperature be considerable, and the currents, or any one of them, rapid, instant rain may be the consequence, and continued rain may be the consequence of their continuance. Spring and summer showers come on far more suddenly than the rains of autumn and winter; and the wind always shifts before the continued rains begin to fall. The upper current may be considered as the one which more immediately produces the rain; although clouds may be borne across the horizon by the under current long before any rain actually begins to fall.

But the currents of the air do not always blow the one above the other, or the one in opposition to the other. Air moves with equal ease in all directions, whatever they may be, if the impelling force tends that way. So that there are often many currents, moving in different directions and with different velocities within a very small space. These give rise to innumerable compound motions, the causes of which it is impossible to separate, or in any way to understand, unless when they produce some specific effect upon visible substances.

When different currents set obliquely against each other they produce a double motion, one circular, and the other progressive. The circular motion is a whirlwind, and it may have any degree of force, from that which just twists the finest blades of grass, or stirs the lightest dust on land, or dimples the water with faint revolving circles, to that which twists up trees by the roots, or wrenches off their boughs, and raises them in the air, or wrenches the masts of ships, or twists up the sea itself in water-spouts. As the two winds which produce the circular motion of the whirlwind are seldom of equal strength, the whirling follows progressively the motion of the more powerful; and as winds, more especially land winds, where the surface is much varied, blow in gusts, the centre of the whirlwind, whether it be shown by a column of dust on land or a column of water at sea, is very seldom a straight line, or the same curve for two successive seconds. The first whirlwind is often taken in another circulation as it moves along, and thus it is made to describe circles in its progress. The same thing may be observed in the water: a little revolving dimple often floats down the stream, till it is taken in the eddy of a reach, and there it will keep whirling for many revolutions before its own motion be overrun by that of the eddy.

Many of the whirling motions of the air never reach the surface of the earth; and so the only means that we have of judging of them are the clouds. These are often in very wonderful commotion; and especially before thunder-storms, it is no unusual thing to see them moving in twenty different directions at different rates, while some are whirling round horizontally, others tumbling in a vertical manner, and others again moving backwards and forwards between the larger masses, as if inviting them to come together.

Those currents and commotions are always most conspicuous when the clouds are congregating before thunder-storms; and when they appear in several masses of strata, the one above the other, there are as many currents of air of different temperatures, moving in different directions, and mingling together. In these cases there is often no general motion of the mass of the atmosphere, in all that part of its height which the masses of cloud occupy; and it is frequently, generally indeed, a dead calm on the surface of the ground, while the motionless state of the thin white curl-clouds that appear through the openings shows that there is not much apparent agitation in the upper air. Nothing is more deceptive, however, than the apparent lightness and cleanliness of these white curls. Theirs is the region of atmospheric sensibility; and their great height diminishes to our view both their magnitudes and their motions: and though they appear to be above the gathering storm, the probability is that they are the real agitators in the whole,—unless there be some cause in the surface of the earth, such as one place scorched to almost absolute dryness, while another retains its average degree of moisture. A large city, a barren moor, or an arid down may, in very hot weather, which has been long continued, be the means of producing those motions in the air, the result of which is a thunder-storm; but thunder-storms that have that origin are generally very local, and of short duration.

If the storm has its origin in the upper regions of the air, its primary cause must be at a greater distance, and consequently more powerful, as it can propagate its action through a greater volume of air. The storm itself is therefore more widely extended, and of longer duration; and indeed it generally brings a change of the weather. In those cases, it is of no consequence to the motion of the storm whether it be that the disturbed air comes from the distant place, or a steady current comes from that place, and acts upon disturbed air at the other. But there is a very marked difference in the change of the weather; for if the disturbed air come, it brings broken or rainy weather; and if the steady current come, it drives the bad weather away. If it has been a tract of dry weather, and if curl-cloud appears, and then a thunder-storm follows, we may be sure of a tract of bad weather; and if after continued alternations of showers and warmth, and cold bleak winds, thunder ensues, we may be equally certain that the weather will clear up. The former case is, however, in the temperate latitudes, by far the most frequent. The dry air in fine weather is a much quicker conductor of heat than the moisture in broken weather; and when the earth is dry it both reflects and radiates heat, whereas the wet earth produces cold by evaporation. Besides, there is no attraction of cohesion between the dry earth and the water that forms a cloud; while between the wet earth or water, and that water, there is the very same attraction of cohesion by which clouds are accumulated in the sky. The cloud thus comes down to the moist surface, and avoids the dry; and even those thunder-showers that have their causes on the surface of the earth follow thick leafy woods and the courses of the rivers. Even in mountainous countries, though the local thunder-clouds do sometimes strike the peaks, they much more frequently plough up trenches in those elevated heights which abound in moist peat earth, and are always saturated with water. That (as indeed all the occurrences which are perfectly natural are when we once understand them) is highly beneficial. Where the cloud strikes it usually falls, and the water which falls upon those heights does not so soon run to waste as if it fell on the peaks.

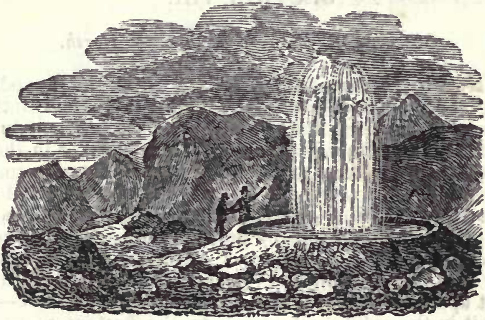
When the thunder-storm is followed by fine weather, it is said, in common language, that "the thunder clears the air;" but though the fine weather follows the thunder, it is no more the cause of that fine weather than the battle in which one party is vanquished is the cause of peace. The thunder is the battle, the resistance made by the bad weather in opposing the good; and the good weather takes possession of the atmosphere only after it has vanquished and driven off the bad.

When the bad weather *invades* any place in a thunder-storm, the appearance is often very grand. The wind may have been blowing steadily from the same point for weeks; and some peculiarly bright day (for the first sign of an invasion of the horizon is commonly unusual brightness) the wind may keep its point all the morning, till about twelve o'clock, without a particle of curl-cloud, or any one suspicious appearance, save the unusual fineness of the day and purity of the air. Now although those treacherous days were known and named "halcyon days," by the ancients, and are still well known to the northern fishermen by the name of "*weather gāās*," that is, worn, weak, or cracked parts of the weather, yet they are not much heeded by ordinary observers. Well, about twelve or one, on one of these days, when it is delightfully clear, and at the same time most intensely hot, in consequence of there being no evaporation to cool the air; and when, in consequence of there being no evaporation, the leaves do not languish, as they do in a dry atmosphere; a little cloud, with an edge as well defined as if it were a perfect solid, makes its appearance in the point of the horizon just opposite to the wind. If it happen to be in the point opposite the sun too, and in some places it is generally from that point, it is at first as white as snow, and might pass for the summit of a distant snowy ridge. There is no light cloud strewing before it, as there generally is in the case of those clouds that ride quietly on "their own wind." Its whiteness is a proof of its density; for it shows that it has body enough to reflect the entire light of the sun, and so the shady side of it will be as black as the sunny side is white. [It is the same kind of treacherous appearance which we have in the white curl-clouds,—they are white, not because they are rare, but because they are dense, and the whiter the denser.]

The firm outline is occasioned by the resistance which the cloud encounters, and the pressing of it between the two winds would bring it down in rain, only that the opposing wind blows under it, and the heat of that and of the earth repels it upwards. The top projects the most, but both that and the under side are turned back in a sort of head, like that of a streamlet when it rolls before it a stone which its force can barely roll, and no more; so that, long before it reaches the zenith, there is a deep shade upon it, all but the front edge, which, as it pushes on in curved scallops, shows white sometimes on one, and sometimes on another. When its edge is about the zenith, it appears to move with greater velocity, as it is then nearest to the eye. As it approaches the place of the sun, the edge becomes very splendid; and as there are places which admit only the red rays of the sun and the heating rays to pass through, some of the tints are dismal. The red light through the thinner parts of the cloud, mingling with the reflected green from the earth, gives the cloud and the air under it a very smouldering and murky appearance, as if the sky were about to be on fire. If the cloud is to break where the observer is, the lightning usually begins about that stage; the first flashes being in the cloud, that is, through the dry air that separates the different strata, and the thunder is low and growling. But every flash brings some of the strata together, and the collected mass descends towards the earth with increasing velocity;

but if the surface of the earth is flat, the lower surface of the cloud also continues flat till it is near the earth; and then its approach is not without danger, as the longer that the cloud holds together, the stroke is the more violent; but then, although more powerful, the flashes of lightning are fewer than if partial discharges took place. When the discharges from an equal accumulation of cloud are partial, there is little action between the different strata of the cloud, until there has been action between the lower stratum and the earth; and in those cases each stratum of cloud descends and thunders to the earth. At such times the curlings of the different parts of the cloud are very striking, for they are so dense that they all seem solid, and as there is air between them, the openings appear to penetrate many miles into the sky, and yet it may happen that the most distant cloud is the blackest; as the lower ones, that have discharged their thunder, are melting in rain, and as they then allow a passage to the red light, the lower sky is exceedingly murky. The fall of the rain is often as fantastical. After each peal, which reverberates as if a stone arch were rattling down in pieces, the rain falls with the headlong rush of water when it bursts its barrier; but the rain is often over before the last echo of the thunder-clap has ceased. Yet the silence and cessation of rain are of very short duration; for it is barely fair, when another black mass descends, discharges its thunder, and lets fall its rain; and that is succeeded by another, and another, till the whole cloud is exhausted. Sometimes those splendid clouds sail majestically over without disturbing the atmosphere through which they pass; but when they do break, there are no atmospheric phenomena so sublime, or that imbody so much of varied information in so short a time. The impressiveness of thunder-storms renders them among the best studies for beginners in the observation of nature. There is often a sulphureous smell accompanying thunder, just as there is accompanying earthquakes, which shows that there are other atmospheric ingredients acted on by the commotion of the water and the heat.

When water remains on the ground in the liquid state, its operations are more open to unguided observation than when it is on its aerial passage from the sea to the land; and its natural uses there are much more profitably viewed in connexion with those substances and productions to which it is useful. But on the earth's surface, and even in cavities within the earth, heat has the same kind of effect upon it as when it is in the atmosphere. Boiling springs are among the most curious of these phenomena; and one of the most remarkable is the great Geyser in Iceland, which is a sort of natural steam engine, which, like some of the high-pressure engines, blows its steam into the air.



THE GEYSER.

Great part of Iceland is volcanic, and there is no doubt that there are many curious caverns that have been formed below ground, as there are in all volcanic countries. The Geyser appears to have a boiler, which opens downward into the well or pit that supplies the water; and, whatever the heating cause is, whether warm air or warm earth, it converts the water in that boiler into steam. The steam is confined by the pressure of the column of water in the pit or well, which is open to the air. But when the steam reaches a certain heat, the pressure of the column can no longer resist it, and it forces the water up in a high and powerful jet. The steam, and most likely also heated air, escape along with the water, and the water is cooled, so that it sinks down in the pit, and again enters the boiler, so as to shut the opening till the steam be sufficiently powerful to drive up the column of water.

SECTION VIII.

Observation of the Water and the Earth.

Notwithstanding the length to which the preceding section has extended, it contains only a few hints on an exceedingly limited number of those conclusions relating to the agency of air and water in the economy of nature, to which even the most common observer must arrive, if he reflects as well as observes. There is scarcely any thing natural that happens in which one or both of these substances are not concerned, either as materials, or as media by means of which other substances are enabled to act upon each other. Thus, whatever we observe—be it in the solid earth, down to the bottom of the deepest mine—be it in the ocean, "deeper than plummet ever sounded"—be it in the atmosphere, as high as a foot can climb or a wing cleave, a vapour ascend or a meteor be formed—be it at any time, or at any place—be it in plants, from the little moulds of which the *sporæ* or seeds probably circulate viewless in every current of the air, every rush of the water, every motion of sap in the plant, and every pulse of life in the animal, to the giant pine of Western America, which stands proudly in mid-air, towering over the forest, as some tall cliff does o'er the pebbles at its base; or the Indian fig, which extends its ever multiplying stems over acres of space, and braves the vicissitudes of a thousand years,—or be it in the animated tribes, from the small tenants of water tinged with sour paste, to which a single drop is the same for space and scope as an ocean to a whale, to that giant of living creatures:—be it in any or in all of these, or in any thing within their limits, or any limits to which the most discursive fancy can extend, even in its farthest flight, there is not a thing done, not a pulse of life, not a hair's breadth of growth, not a tint of colour, not a trace of motion, not a shadow of change, in which air and water (or one or other of them) are not present, and contribute to the result.

The observation of Nature is, therefore, very little else than the observation of air and water, simply or in their combinations. So far as we are able to judge, that has been the case in the formation of all the solid and permanent parts of the earth; for even the oldest mountain rock bears distinct evidence that its parts have been crystallized from a watery solution; and though in many places we can discover rocks that have been molten by fire, yet these are merely *changed* rocks that had previously existed; and, if we wish to trace them back to the first working of Nature's hand upon them—to that mysterious boundary where creation is creation still, though our present capacity will go no further—it is in the waters we must take our farewell of them. So true, even literally, is the declaration of Holy Writ, "He hath laid the foundation thereof upon the waters."

The softer and, as we may say, the younger strata of the earth have the traces of their aqueous origin still more legible, except in cases where we can explain why they have been obliterated. The lava of Etna, Vesuvius, and various other mountains, which still continue to burn—that of many others which are now extinguished, or have been so since the commencement of history—the sea of glass in Iceland—and all the other productions of fire with which we meet in large masses—are no more original or primary formations, than the scoria and cinders of an iron furnace, which are nothing but certain parts of the ore, the lime, and the coal, after the iron has been taken out of them by the process of melting. The power of those fires cannot be doubted; and, indeed, it would not be easy to find words by means of which their effects could be overrated. Every mountain on the face of the earth may have been reared by fire of that description; and where they are of rock, and not accumulations of fragments, which can be explained by mechanical causes acting at the surface of the earth, if we do not consider heat as the agent in their elevation, we cannot at all account for the fact of their being elevated, any further than by saying, "God made them;" and though in all cases we must come to those words some time or other, we should never do so at the beginning of an inquiry. That is one of the most obvious, as well as one of the most undeniable truths, to any one who thinks even slightly on the subject; but it is a truth too general for guiding us to the knowledge of any particular in nature; and therefore, unless for the effect which it has on the feelings and conduct, there is no need for repeating it. Indeed the repetition of it is a species of fraudulent idleness; if we go on with an inquiry in the proper manner, we are always sure to come to it; but if we begin with it or resort to it before the proper time, our inquiry is at an end, and our ignorance of that subject is sealed.

Rocks are proverbially associated with barrenness, though there is no rock but which, if left at rest and watered, will produce its plants—nay, a succession of races; and if the climate were favourable, and we could wait long enough, there is not the least doubt that we could water a rock till it became so fertile on the surface that we could sow it with grain, or plant it with vegetables. Pebbles in a brawling stream, or rolled on the beach by the waves, are unproductive things certainly; and not merely that, for they wear one another; but examine the very same kind of pebbles in a shallow standing pool, or on a part of the beach where they are left at rest, and you will find that they have their plants and their animals. The mountain rocks, even in the coldest places, are covered with lichens, some of which are of value in the arts, and others as articles of food. Many dying materials are obtained from those curious productions, some of which are in themselves not easily distinguished from the rocks on which they grow.

The common people in the northern countries have long been in the habit of dying their stuffs with these substances; and in their hands the colours that are produced are very durable, though not very brilliant. The orchal, or French rock-moss (*Lichen parellus*, of Linnæus), which forms a very white, rough, and warty crust on the rocks, and might, by a careless observer, be taken for a patch of mortar, produces very beautiful shades of crimson and purple; and cudbear (*Lichen tartareus*), which forms grayish patches, is found so valuable in giving a bloom to colours, that there are manufactories for the express purpose of preparing it, and people who resort to the rocks and earn their living by scraping it off. Hard as it is, it grows much faster than would be supposed; and the cultivator of it (if he can be so called) has little labour compared with other cultivators, as he has merely to come and scrape the rocks once in every five years, when he finds as much as repays his labour. Those hard and apparently useless productions of the rocks are not only useful, as may be seen from the two instances that have been mentioned, and of which there would, no doubt, be many more instances, if those who are much in the wild places where lichens are most abundant would look at what is around them, and find out what it is good for; but imagining that a place must be barren in every respect, because it is barren in those productions which abound in places of quite a different character, is a folly by means of which we are left without much useful information with regard to nature, of which we might otherwise be in possession, and deprived of the use of many things in the arts of which we might otherwise be in the enjoyment. That folly is as absurd as it is mischievous. No man would think of taking hounds to sea in order to course game, or propose going to the moors with boats and harpoons, or white fish-lines. Now, though in many cases the absurdity is not so striking as it is in these, yet so far as it goes, it is just as absurd. And it is far more dangerous; for, just as at sea there is more to be dreaded from the sunken rock than from that which stands high and gives warning, so in the case of error, there is ever the more peril from that which is the more concealed, or has the nearer resemblance to truth.

We find that very frequently the case in matters connected with the study of nature—more especially those parts of nature which do not appear to bear immediately upon the common concerns of food and clothing. In those very lichens, which we have mentioned as being useful in dying, it is not the people who live where they grow that gather them, but strangers who find it their interest to go there in the season: so also it is not very long since the people of Britain depended mainly upon the Dutch for supplies of the very fish which are most plentiful on the British shores.

In matters connected with the earth itself, the want of common observation, and the loss occasioned by that want, are still more striking. If coal, or iron, or any other useful mineral, is found for the first time in any district, it will, in general, be found that the discoverer is not a native, but some stranger. There is a case in point. The greenstone rocks which form a considerable portion of the lower valley of the Tay contain vast numbers of veined agates or Scotch pebbles, and in some places the rock has, to a considerable depth, crumbled into mould, well fitted for agricultural purposes; but the pebbles, containing less clay than the stone in which they have been formed, and being of a close texture, do not decompose so readily. In consequence there are whole fields and farms where, excepting where the ground has been opened for quarries, every stone that can be picked up is an agate, just as in the chalk districts of England every stone that can be picked up is a flint. Some years ago, those pebbles were fashionable, if not valuable (and except in durability, size, or some use in the arts, fashion forms much of the value of any stone), and they were consequently esteemed. The proprieter of one of the estates, on which there is really nothing but pebbles, was in London on some business; and as he did not often visit the metropolis, he resolved to purchase some trinket for his wife, as a memorial of his journey. He went to a jeweller's, and was shown all the varieties of gems and pastes, but he rejected most of them on account of their smallness, and made his election of a necklace, &c. of large and strongly-marked Scotch pebbles. So much did he admire these, that he began to question the jeweller (who was also a lapidary), what part of the world was so rich as to furnish jewels so splendid. With utter astonishment he heard the name of his own estate as the place where in one day each season a sufficient supply had been collected, during the time that the stones had been in fashion. The owner of the mine of so much beauty, and as it appeared to him, from the price that he had paid, of so much wealth, would have been glad to exchange his purchase for something that he could not get at home; but still he was pleased that the mine was his freehold. Home he returned; the present from London was duly seen and admired; and the very next morning, taking his mole-staff with him as a divining rod, he was early at his rhabdomancy. Three days he consumed in diligent and laborious search, keeping the secret of his wealth with great care, until he should astonish the world with its amount. In the course of his labour he picked up many stones, but, as they were all very rough and unpromising to look at, he cast away as fast as he gathered, till the third day and his patience were nearly at a close together. When he had nearly reached his home, he took up one of those nodules of which he had previously taken up and thrown down so many, and dashed it upon the rock with all his force, as if in vengeance for the deception which he had practised on himself. The stone broke in pieces, and in the fractures he found the colours, but not the lustre, of those disks which had so pleased him in London. He soon began to reflect that his uncut pebbles were not saleable trinkets, any more than the soil of his farm was saleable quarters of wheat; so he prudently resolved to follow his farming, and leave the pebbles to the lapidary as before. The purchase, too, retained its value, as the pebbles that were collected from the fields as an encumbrance, and used in paving the court and filling drains, could not rival it; and he even boasted that the trinkets were the produce of his own estate, and spoke with admiration of the art and skill of the Londoners, who could make a few ounces of that which was not worth sixpence a tun where it was found, worth several pounds in the market.

That is a homely anecdote, but it is a useful one, as it points out one of the reasons why those whom we would, without reflection, think should study natural substances the most, yet actually study them the least. It shows, too, that that is especially the case with minerals. The occupation of the people of any district runs in a train; those who are not required for the working of that train migrate to other places; and if any one betakes himself to the study of nature, he is branded as an idler, or wizard, according as the current of popular belief and feeling sets,—and whether it set the one way or the other, he is equally certain to be ejected from the companionship of the district, and must either associate with those at a distance, or be an idler in reality.

It is only in what may be termed sublime or romantic places, such as mountains, and crags, and ravines, or bold and caverned shores, that stand beetling over the flood, that we can observe the grand features of the earth; because it is at such places only that we can see sections of the strata of rocks, sufficiently deep and extended for enabling us to judge in what order, and guess by what means, those which we may term the living rocks—the skeleton of the globe—those gigantic masses, which can have been produced and arranged by no surface action, but are the result of energies which, whatever they may have been, have had their origin and their place of action within the globe itself, whether the influence of that action was more general or more local—whether it went to the uplifting of a continent, or the building of a chain of mountains, or merely raised the point of a volcanic cone above the waters of the sea.

There is no knowing how much land and how much water,—including, under the term "land," all substances which are neither water nor air, whether they be in solid masses or in fragments, in powder or melted, and whether they belong to the animal, the vegetable, or the mineral kingdom,—and under the term "water," all of that substance, whether solid or liquid, or whether pure, or where it forms so much the prevailing ingredient in any compound as to give its own character decidedly to that compound, as in the case of sea-water, or of mineral springs; there is no knowing how much of these, as thus distinguished, may have existed at any period of the globe's history; and there is no knowing how they may have changed and shifted from time to time. Water may, however, be decomposed and again reproduced in so endless a variety of ways, and both the oxygen and the hydrogen which, in the present state of our chymical knowledge, we consider as its elements, are so active, and enter into combinations, as mixtures, with so many substances, that we have every reason to believe that the relative quantities of land and water, according to the sense in which the terms have been explained, are not for any two successive moments exactly the same. Very many of the metals exist in the earth in the state of oxides, or combinations of the metal with oxygen; and not a few of them have a third ingredient, or are triple salts. The alkalis, and many of the earths, have been proved by experiment to be hydrates of metals, or compounds of those metals with the other ingredient of water; and it is probable that, when more powerful means of chymical decomposition shall have been discovered, all the earths will be found to contain hydrogen, as well as all the alkalis and most of the salts. No man could, therefore, though he could gauge all the seas and lakes, measure all the rivers and streams, and weigh all the clouds, venture to give even an approximate estimate of the quantity of water and its elements, even for one time.

The seasonal changes of it are also considerable.

In England it is in fogs and fens in the winter, and in the crops on the fields, and the leaves, flowers, and fruits of other annual and deciduous vegetables, in the summer. In climates farther to the north, it is during winter piled up in snow and ice: and in summer it is either at work in the more scanty vegetation, or it has ebbed away to the ocean in the spring "freshes" and floods. The action of gravitation distributes it equally in the ocean; and when it rises in vapour, the action of heat disperses it in the atmosphere.

What these causes may from time to time produce we cannot calculate; but within a very long period of duration—one as long at least as we have any thing like authentic information, it does not appear that the great collected quantity has varied much. Now, according to the estimates, which on such a subject must be vague, if the solid parts of the earth—those parts that we have denominated land in distinction from water—were in the form of a regular spheroid, the form which gravity and the revolution and rotation of the earth (the only external causes that we know that could act upon principles that we understand in moulding the earth into its form),—the water would cover it with a crust (if the term may be used), or shell of water, something about two miles in thickness. That would give a pressure of more than two tuns on every square inch of the solid nucleus, exclusive of the pressure of the atmosphere,—or a pressure equal to the weight of the whole navy of Great Britain on a surface equal to the floor of an ordinary-sized room.

When we reflect upon that immense resistance of pressure which the internal powers of the earth that elevated the mountains had to overcome, we may cease to wonder at the results that have been produced; nor need we be in the least astonished when we go to mountainous countries, and find strata of firm stone many miles in extent, and many fathoms in thickness, bent and twisted as if they were pancakes, or turned on their edges as if they were ice-brash of but one hour's formation before the roll of the ocean, or the wing of the morning gale; or when we find granite moulded as if it had been dough. As little need we wonder when we find a "dike" of different or more modern formation, or a "lode" of spar and metallic ore, cleaving sheer through a mountain ridge, or extending many degrees on the girdle of the earth. To a power that could overcome such resistance we can set no bounds.

But vast as that resistance is when we bring it to the test of numbers—the only one by which we can get an accurate judgment—it is really nothing as compared with the resistance farther down; for go but one-fourth of the distance to the earth's centre, and the pressure on a single inch would make the greatest mountain, nay, all the land which stands out above the mean level of the sea, kick the beam.

Now, as we have stated the mean depth of the water at rather less than it would come to, according to the guesses of the most eminent and eminently cautious men, who have calculated as far as they could, and then speculated on that most extensive subject, it must follow that whenever some parts were elevated so as to be at a less depth, other parts must have been depressed so as to be at a greater. Thus the very pressure of the water, which resisted the powers by which the continents and islands were elevated, would assist those powers in their progress, after the elevation was begun. Whatever of matter was forced upward by the heat (for if heat was not the instrument, we know it not, and heat is fully adequate to the task), there would be no vacancy left, because the superincumbent pressure would send down the remaining parts with more energy and effect than it resisted the ascending; so that, as the mountain reared its head, it would continue to do so with less and less of the original propelling force; and when it came to the air and the sunbeams, its labour would, comparatively speaking, be at an end—at least, compared with the first struggle in the deep.

To those who have been accustomed to look at nature only on the small scale, and as conducive to the puny possessions of man's little life, those speculations may appear to have but little to do with the "popular" observation of nature; but, in truth, they belong to the popular, and not to the systematic part of natural history: for they come upon the popular student in his very novitiate, nay, they probably force themselves more or less upon the attention of all young people, learned and unlearned, when they are permitted to think for themselves. There is not a child but will break its toys almost at the moment that it gets them into its hands—and certainly the instant that it has seen their external novelty, which is soon seen; and it takes a great deal, both of precept and example, and sometimes chiding and chastisement, to break the child of that habit—so perfectly painful and unnatural to it is possession in which there is no enjoyment. To defend either the natural propensity of the child, or the lesson of early care which is inculcated by means of the rattle and the penny trumpet, is not our business. It may be that when the toy is saved, the desire of knowledge in the child is broken; and it may be that frugality is produced by the lesson. If it be the former, "the whistle" is, indeed, a costly one; and if it be the latter, probably the best way would be not to purchase the toy at all.

But all that we contend for is the fact, and that must be admitted, as it is one to which there is no exception, if it has not been produced by teaching. Now if a desire to know the structure of every thing that comes within its observation be irresistibly natural to every child, until that child is flattered or forced out of it, how much more irresistibly natural must it be to speculate about and wish to know the structure of that world which contains, circumscribes, and is every thing that can in any way be perceived by the senses.

And perhaps there never was a human being that stood gazing and admiring, even for five minutes, upon a mountain ridge, whose thoughts did not turn to the grand subject of the formation of the mountains; and thence glided away to the primary separation of the land and the water. Certainly there is no subject more inviting; for it brings us immediately to the grand questions of "whence we came," and "whither we must go?" and in such places it almost seems as if the rich and the tempting of the small of nature were kept away, in order that our meditations may be on the sublime of the great. It is true that we do find traces of recent times even in those situations: the waste occasioned by the last winter, the last thunder-storm, or the last flood; and though they are few in number, and not in general very high in usefulness, there are animals and vegetables there, and their states indicate the state of the season and the weather, upon the same principles as others do in other places, though not to the same degree.

But still those characters are characters of the mere surface, and they and all that belongs to or is connected with them might be taken away without much alteration of the grand mass of what is before us. Deep seashells, imbedded by countless thousands in the solid strata near the tops of high mountains, are good quotable proofs of the sea's having been there,—when we are arguing the point on the plain with probably not an inch of native rock within our horizon; but to appeal to so small, though satisfactory, testimony on the mountains would be about as unnecessary as to prove the presence of the sea from the shells upon the beach, on which we were standing, and looking upon the expanse of waters, curling in pleasant waves, and wafting into port the richly-loaded vessels from the opposite hemisphere.

The animals, the plants, the mud, the broken stones, the water of the springs and rills, and some of the wearing of the rocks, and the formation of little patches of meadow in the turns of the mountain gullies, and larger ones in the valleys at its base, are all explainable by causes that can perform their action in the present state of the mountain, and at the present elevation. But, though all these were removed, the substantial character of the mountain would be very little altered; and the taking of them away would, in fact, be nothing but digging and clearing away those ruins which, in the course of ages, have concealed and disfigured a little, and but a little, of the mountain itself.

Even the dells and gullies, to say nothing of the larger valleys, and the basins and hollows of large dimensions, all of them with only a small portion of water in them, and many of them with none, cannot have been formed by water above the sea-mark, any more than the ocean can, by its tides and currents, have formed its own bed. Nobody will contend that there is any natural action at the surface of the earth that can build up solid inorganic matter, whatever there may be to cast it down. But, although the casting down may have done a great deal (though much less than is supposed), it is just as impossible to imagine a surface power capable of scooping out all the hollows, as it is to imagine one capable of elevating all the hills and mountains.

Let any one take the map or the model, or, better still, go to the place of any of the considerable rivers in Britain, that have wide valleys, with mountains, or even hills of rock, at the sides; and then let him ask himself whether, in the nature of things, the water of the river could have made that valley. Take the valley of the Severn, from Plynlimmon to Shrewsbury, or that of the Dee from Bala to Wynnestay, to say nothing of the lower part of either, and it will be found much nearer to the truth to say that the valley is the cause of the river, than that the river is the cause of the valley. If the lower parts of the valleys were taken, the accumulation of debris might perhaps be accounted for; but what could the Severn do towards the hewing out of the Wrekin, or the Dee to that of Beeston rock?

In places which have more of an alpine character, the formation of the valley by the river, even though that river had been running for a million of years, would be, if possible, still more puzzling. The Tyne and the Tiviot never could have excavated their dales; and even if they had, what stream paused on its course, and altered the whole system of its working, in order to find basins for "the lakes?" The Tay and its branches may have cut through a pass or two, at Dunkeld, Killiecrankie, and some other places; but to suppose that any of the valleys was altogether formed by the action of the stream is an absurdity. The most conclusive instance (if any can be more conclusive than another, in a case where the very simplest affords demonstration) is the great valley of the Scotch Highlands, from the Moray Firth on the east, to Loch Linnhè on the west. There is a little dike of stone, which crosses that valley somewhere near the midway between the two seas; but much of the rest is in alluvial formations, and in the basins of lakes absolutely lower than the bottom of the adjoining sea, to which the Ness, the largest river of that singular valley, runs.

Nor are the proofs confined to the mere forms of surfaces, for they are to be found in the very rocks themselves. Where the schistose, or stratified rocks meet the granular ones, they are twisted and bent in all directions, as they would have been had they been upheaved by some action from below; and at many of the lines of junction one of the rocks is melted as if the other had come to it in a state of ignition; and we know of no action from above, even if we suppose a depositation from any imaginable depth of water, which could have given the plates, or strata, the inclinations which we observe. In a basin of coal strata, or any of those that have a hollow, of which we can obtain the section, so that the several layers "crop out" all round, we can perhaps imagine how they may have been formed by successive growths and deposites above. But, even in those, the coal, which is vegetable matter, and matter which must have grown, not in the sea, or in any other way under water, but in the air on dry land, as it contains the remains of land productions, often lies under other formations, which must just as clearly have had their origin, not merely in the sea, but in deep water.

The granular rocks, which have no appearance of plates, or strata, but are great lumps, and lumps having their upper surfaces very much resembling what we would expect from matter forced up from beneath, are perhaps the most striking proofs that the mountains and valleys of which the principal part is native stone have been elevated from under water. In the mountains of granite and porphyry, there are also precipices and cliffs, the formation of which cannot be attributed to any known cause that can act above the level of the sea. That cannot have been produced by the action of water that has fallen in rain, or in any way run in streams; because there is not only now no water at all equal to the producing of the effect which we see, but there is no channel in which water could at any time have run. Many of our highest mountains—those which overtop all the country round—have horse-shoe precipices in their sides (often in the north-east side), the tops of which are higher than any thing within many miles; and therefore we cannot suppose them to have been formed by the action of water above the level of the sea, unless on the absurd supposition that the water ran up one side of the mountain for no other imaginable purpose than that it might run down the other—that it acted contrary to the law of gravitation on one side of the summit, just in order that it might the more readily and effectually obey that law on the other side.

Even in plainer cases than that—those in which there is only a gradually inclining dell, with a rivulet meandering along—we cannot give the rivulet the merit of making the dell, at least not out of the hard strata of primary rock; because, unless we have the dell at the beginning, we cannot explain why there is a rivulet there; even rivulets, if they are to be permanent, must have permanent causes; and, unless where there is a spring supplied with water from a store farther up, the sloping sides of the dell are necessary to provide the rivulet with water. In rivers of longer course, that is more striking. Take, for instance, the Thames; the quantity of water that rises up in the springs, though much magnified in the pictorial representations, is in reality considerable: but look at the distance to the sea, and think whether, instead of that infant stream having excavated the goodly valley of which it is now the wealth and the ornament, it must not have been evaporated before it could have reached Windsor or even Oxford.

That a river can cut deeply even into very hard strata is proved by many instances; but in those instances there are always slopes above to send down in a flood, during rains, that water which, if it fell on level ground, would sink into the earth, and not form any flood at all: so that there could be no cutting through even the softest materials. These cuttings are, in general, the secondary strata, or even collections of rubbish; and there is perhaps no instance of a dell formed by the action of water wholly in the solid granite, though in many places there are little notches. The cutting of the rubbish may go on very rapidly, so that a large excavation may be made in a year, or even a day; but the solid and seamless rock is quite another matter, and we find that even a considerable river, with the assistance of a valley every way well adapted for the producing of powerful floods, makes but little impression on such strata in the course of ages.

The North Esk, which discharges its waters into the British ocean, a few miles to the northward of Montrose, and the Isla, which flows by the castle of Airlie, from the southern slope of the Grampians to the valley of Strathmore, are perhaps two of the most striking instances of rivers cutting the soil that are to be met with in Britain. Both rivers drain mountain valleys, the sides of which are steep, and the autumnal rains fall very heavily on both. There is no lake on the Isla to regulate the waters when the rains fall, and on the North Esk there is but one small one (Loch Lee), which is far in the mountains near the source of the river, and has little influence on the whole stream, because a great part of the water of floods comes into the channel lower down.

Each of those rivers has cut a dell, or den, several miles in length, and very deep in proportion to its width. But gravel and red sandstone (which in those places is a soft crumbling stone, together with pudding-stone, very weakly cemented) are the principal matters through which these rivers have cut. Even now the cuts which they have made are little more than sufficient for containing the flood water during the rains. Gannachie bridge is thrown across the dell of the Esk, among the very picturesque scenery at "The Burn;" and though, in common states of the river, the roadway on the bridge be at least fifty feet above the water, the floods rise so high that a tall man of the village, locally named "Lang Gannachie," could reach over the parapet of the bridge and fill a bucket of water. The strata through which the Isla has cut become hard more gradually than those at the Esk; so that the floods in the dell at Airlie do not rise to such a height as those in that at the Burn; though in late harvests, which are generally those that are more than usually rainy, both rivers do considerable damage to the crops and fields in the plains below.

But those rivers, notwithstanding the headlong impetuosity of their floods, and the traces of their devastation in those channels, have done very little within the period of their recorded history; and probably the "linns," or cascades, where the hard strata have resisted the action of the water, are nearly in the same places as they were when Agricola led his Romans through that part of the country. Those linns, too, do not fall over granite, but over secondary rocks of some description or other —partly hard pudding-stone and partly schistus; so that in the formation farther up, whether of the stratified or the granular stone, the rivers could have had very little to do.

Even in cases where there are no rock foundations with which to contend, it is quite impossible to account for the form of the present surface, by any action of the waters now existing, or by any action not carried on entirely under water. Any situation in an alluvial country will suffice for enabling one to understand that. Go, for instance, to any of the heights near London, which command a view of that part of the valley of the Thames, examine the position of the gravel and clay hills on both sides, and then say whether, trifling as they are, they could have been formed by any action of the Thames and of the ocean jointly, working at the surface, even when the sea may have flowed as far in as Teddington, or even farther. What action of the river, and of the resisting sea jointly, could have raised up Richmond Hill, and all the successive swells or "caps" of gravel, by Wimbledon, Clapham, Brixton, and so onward till one comes to the chalk formation near New Cross? So, also, the heights of Ealing, Kensington, Primrose Hill, Hampstead, Highgate, Pentonville, and the other swells, towards Finchley common and the flats on the river Lea. It is true that where the estuary of a river so meets the set of the tide as to form a constant eddy in the waters, and a permanent whirlwind in the air, hills of sand are in some instances collected, as high as any that have been named, or even higher. There are instances of them at the mouth of the Tay, below Dundee; and at that of the Findhorn, below Forres; and on some of the sandy shores of the Continent. On that of Jutland, for instance, they are very numerous, and formed without any river, by the action of the sea-eddies alone. So also in the sandy deserts, there are hills of sand formed by whirlwinds or eddies of the atmosphere, without any assistance from water, for there is no water there. But these cases will not explain the formation of the eminences in the valley of the Thames. These contain flint pebbles, which are rather too weighty for being built into hills by the winds; and they also contain beds of clay, a substance which imbibes too much water, and forms too much in the state of a paste, for drifting much with the winds. Besides, the "London clay" is obviously a gradual deposite from water which has stood over the highest points where it is found; and even though we consider the flint gravel as the debris of chalk rocks, out of which all the lime has been washed except that which suffices to give a binding quality to the gravel, we must allow it to have been rolled about in the water till the flints abraded each other into smoothness, and the dust thence produced formed the connecting powder of the gravel. It is impossible to say how long it may have taken to round the nodules and produce the powder: but the period necessary for that, and also for the depositation in the places where it is found, must have been considerable; and nothing but an action of the sea could have given the surface the form which it still has, notwithstanding all the action of art and of the weather.

But though we could explain by the action of river and estuarial resistance, aided by the winds, all the formation of these alluvial strata, we are not a jot nearer the formation of solid rocks than ever. Nay, when, as we must, we have recourse to the action of the sea, even though that sea had constantly outraged the angry monsoon at the Cape, or out-eddied the Bay of Biscay, the whole process would be change rather than formation—the destruction and breaking down of rocks, and not the consolidation. Even if the chalk is sea-shells, and the flints are sponges, a goodly pressure must have been required to bring them into their present state; and therefore to seek for their origin, we must examine downwards into the deep.

What the condition of the sea was, when it covered all the land,—for, whether all at the same time or not, the sea must have covered all the land, and covered it to a great depth at some time or other,—we cannot say. The mountain limestones would lead us to suppose that it contained shelled animals of some kind or other, long before one foot of the dry land appeared above its surface; and the oolites, and many other formations, leave not the least doubt that they were under the waters, inasmuch as they contain shells, and skeletons, and entire fishes, which are adapted for the deep water.

The mean level of the sea may be taken as the line of greatest fertility both in the water and on land, and both in the animal and the vegetable kingdoms, because it is the line of the greatest action of both the sun and the air. It is probable that the sea sinks down as much below that line in proportion to the extent of its surface, as the land rises above it; and it is also probable that the fertility of the sea diminishes as the depth increases, just as that of the land does with increase of height. But it is probable, nay, it is certain, that the fertility of the sea cannot diminish so rapidly as that of the land; because, as we descend there are pressure and condensation, which are sources of sensible heat, while, as we ascend, there are elasticity and expansion, which are sources of sensible cold. Thus it is neither improbable nor unphilosophical to suppose, that though the inhabitants of the sea vary at different depths, just as those of the land do at different heights, yet that the sea may be well replenished with its peculiar plants and animals at depths measuring more than the height of the highest mountain. Consequently, if we carry our imagination backward to the time when the uniform solid spheroid was covered with the two miles of water, we are upon legitimate ground when we say that the surface of that spheroid under the water may have been abundantly stocked with plants and animals, and the water itself as abundantly as any part of the ocean is at present.

We cannot know what was the condition of the water at that early stage of our globe's history—whether it was fresh, or impregnated with saline substances as at the present day. Many of the plants, the remains of which are found in the strata, have more the character of fresh-water aquatics than of plants now found in the salt sea. The fishes also have, many of them, the characters of fresh-water fishes; and as for many of the shells, though we know but little of their inhabitants, perhaps they are as much adapted for fresh water as for salt. When we take all those circumstances into consideration, we may perhaps be warranted in saying that the sea which, in those primal days, rolled over the whole globe, was water in a much more simple state than the sea of the present time, and that as new actions began to be carried on over the land, the sea became the receptacle of new products.

Bearing all those things in mind, we can carry our speculation back to the period of the first internal action of the earth,—the time when the first mountain ridge (that ridge which was in time to become the centre and spine of a continent), began to ascend from the bottom of the deep. We have already spoken of the great pressure which must have opposed its ascent; but we must bear in mind that that pressure was exactly balanced by the resistance of the bottom, so that, mighty as were the weights, both upward and downward, so nice was the poise, that a single grain would have given it either the one direction or the other. It is one of the beauties in the arrangements of nature, and one which, though man must admire, his art can never imitate, that the great and the small are both equally susceptible to impressions. Thus, though the weight of a continent was upon the surface which was to be elevated by the internal action, a few pounds would put it in motion; and whatever was the state of the substances when they began to ascend, the two pressures were quite sufficient to bring them to that state of cohesion which we find in rocks.

In those parts of the ocean which may be regarded as covering the slopes of volcanic ridges, there are still occasional displays of the action of those vast powers; and there are in many places decided proofs of that action having been at some time carried on in situations where it had ceased before the records of history began. It is important, too, to bear in mind that the formation of large tracts of alluvial land so as to remove the sea to a distance, occasions the internal action to cease. In that ridge of mountains in France which stands nearest to the Mediterranean, on the right bank of the Rhone, there are many extinct volcanoes; and the plain of Languedoc, which lies between those mountains and the sea, is alluvial, composed in many parts of sand, in others of gravel and stones, and in others, again, of shells,—the whole giving the clearest evidence of having been under the sea, or formed by the action of its waters upon the shores.

The farther part of Italy and the island of Sicily are still volcanic countries. Vesuvius and Etna burn continually, and often pour out eruptions of melted matters; the whole of Calabria is subject to earthquakes; and fires are continually burning in the little islands which lie nearly in the line between Vesuvius and Etna.

One of the most recent displays of submarine action, extending above the surface, which has appeared in those seas, is

HOTHAM ISLAND.

That island, or rather the symptoms of its formation were first observed on the 10th of July, 1831; though on the preceding day quantities of charred sea plants and dead fish were observed floating on the surface; and sounds resembling that of thunder were heard. Shocks of earthquakes had, indeed, been felt by ships passing the same spot on the 28th of June; but there was then no appearance at the surface of the sea. At about eleven o'clock on the 10th, Captain Carrao, who commanded a Sicilian brig, and was then about twenty miles off Cape St. Mark, observed the water, at the distance of a gun-shot, in a state of agitation. A portion, more than a hundred fathoms in diameter, rose up to the height of sixty feet; and discharged volumes of sulphurous smoke. The elevated mass, as there is no action of the atmosphere mentioned that could sustain a column of water to that height, must have been steam. That steam, however, from the supply of a whole sea of cold water, and the powerful action of the fire under it, may have had the colour and apparent density of a mass of water. Indeed, the external part of it must have been condensed, and descending in a thick fog, which fog would be kept from spreading on the surface of the sea, by the wind which must have set towards it in all directions, to supply the air which was constantly rarefying and ascending over it. The smoke mentioned by the Sicilian captain was, most probably, the hottest part of the steam, because if the heated strata had so broken under water as to allow volumes of real smoke to escape, the solid matters would not likely have reached the surface. It appears from the observations made by other vessels, that the immediate bottom was mud, and that the depth, *after* the island was formed, was one hundred and thirty fathoms, at the distance of one mile. That was nearly three hundred and thirty-eight pounds (say three hundred weight) on the inch, from the mere pressure of the water, without taking into the account the condensation, the weight of the mud, and the resistance of the strata, which there are no means of ascertaining; but they, in all probability, exceeded the simple pressure of the water.

Now, if we suppose that the surface, acted under by the heat, was only a circle of about one hundred and twenty fathoms in diameter, we shall form a rude estimate of the power employed. The surface is about 11,310 square fathoms, or 407,160 square feet, or 56,631,040 square inches, which at three hundred weight on the square inch, gives a pressure from the weight of the water alone of the vast amount of 8,794,656 tuns. But as there were other, and probably greater, resistances to overcome, the force exerted at that single spot must have been far greater than would suffice to blow all the navies in the world into the air. That spot, too, was but a mere point on the surface of the globe; so that it is utterly impossible to imagine any material weight, or material strength, which those powers could not overcome.

It is only under the pressure of a depth of water that such a phenomenon could take place, as the water both supports and consolidates the upper part, and so enables the crust to rise in a mass, which, in the air, would burst and discharge the melted matters in an eruption, as is the case in those volcanoes that are on land.

The second observation of Hotham Island was made on the 13th, two days after the first; and the account was,—the appearance of columns of smoke, the hearing of a sound like that of the paddle-wheels of a steamboat; and dark matter rising up to a height, and then falling with force into the sea: all those appearances, which we have stated in nearly the words of the eyewitnesses, agree in establishing the same fact; namely, that by that time the volcanic matter had reached the surface, and been broken when it came in contact with the air, or even when so near the surface that the pressure upon it was much diminished. The smoke was a sure sign that the surface was reached, the hissing was the solid matter coming in contact with water at a lower temperature; and the ascent and fall of the dark solid matter was a direct confirmation of the other two.

The young island having thus attracted attention, Vice-admiral Hotham directed Commander Swinburne, of the sloop Rapid, to examine it. The commander discovered the island at four P. M. on the 18th of July. It was then about forty miles distant, and had the appearance of a column of white smoke. Advancing about thirty miles, he saw, at fifteen minutes past eight, bright light mingling with the smoke. The column then became black; but immediately "eruptions of lurid fire" shot up; and then the whiteness of the smoke returned. The same succession of appearances continued till five in the morning of the 19th, when they again steered for the island.

Whether Commander Swinburne did or did not see the very first eruption, he must have been near the time of the commencement, for early in the morning he saw, in the intervals of the eruptions, only a small hillock, a few feet above the level of the sea; but as the discharges of dust, and stones, and steam were frequent, the progress of the island could not be seen. At the distance of one mile north the depth was one hundred and thirty fathoms; and when the commander took his boat and rowed towards it, twenty yards of the weather-side, there were eighteen fathoms water. For two or three miles round, the sea was discoloured with dust and cinders; but at the distance of only twelve yards, the sea was but one degree above its ordinary temperature.

The island then appeared in the form of a crater or cup, seventy or eighty yards in diameter, twenty feet high in some places, six in others, and broken on the south-west. Through the break was seen muddy water in a state of violent agitation; from which hot stones, and cinders, and immense volumes of steam were incessantly ascending.

That was but the tranquil state of the volcanic action; for, at short intervals, the crater became filled with stones, cinders, and dust, which were volleyed upwards to the height of several hundred feet with loud noise; and when they again fell down and converted the surface of the surrounding sea into steam, the noise was still louder. So powerful was that steam as it rose, that it carried the dust with it, so that the whole had a brown colour, and a solid appearance; but the steam became white as it ascended, and the mud fell down in showers. These volleyings and descents were so constant that one was often up before the other had fallen; and amid the columns lightnings were continually flashing, and thunders roaring, as if all the sublime and the terrible in nature had been collected at that one little spot. Commander Swinburne's description is so circumstantial, that we shall give part of it in his own words:—

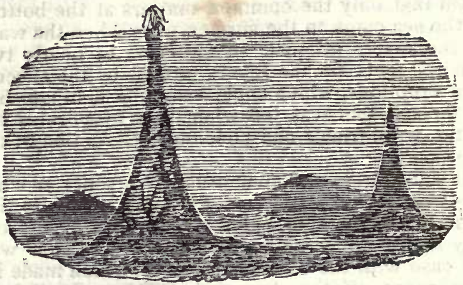
"Renewed eruptions of hot cinders and dust were," says he, "quickly succeeding each other, while forked lightning and rattling thunder darted about in all directions within the column, now darkened with dust, and greatly increased in volume, and distorted by sudden gusts and whirlwinds. The latter were most frequent on the lee-side, where they often made imperfect water-spouts of curious shapes. On one occasion, some of the steam reached the boat; it smelt a little of sulphur, and the mud it left became a gritty, sparkling dark brown powder when dry. None of the stones or cinders thrown out appeared to be more than half a foot in diameter, and many of them much smaller."

During the whole time the wind was steady at north-west, and the weather was serene, so that the action, violent as it was within its range, was very confined in that. Confined as it was, however, it brought all the elements into play. Its smallness is indeed an advantage to those who study it, because it comes as near to being an experiment in the making of islands, by the action of fire as it is possible for any thing in nature to come. The internal action, when deep below the water, was sensible only in the motion communicated by the quaking earth to the water over it; and as the heat was only one degree above the common temperature at twelve yards from the island, one can hardly suppose that any smoke or even steam could come to the surface, or be produced, until the solid matter had risen very nearly to that. On the 28th of June, when Sir Pulteney Malcolm and his companions felt the shocks, the action had begun, but was going on quietly under the water. It may be indeed that there is always an action under that part of the Mediterranean, as shoals are laid down near the place in some of the charts; and the Maltese have traditions about a former island there. But Swinburne found no bottom with a line of eighty fathoms, till he came within twenty yards of the island, and there as has been said, it was eighteen fathoms, or one hundred and eight feet. That is an exceedingly abrupt slope, and would meet the bottom of one hundred and thirty fathoms deep, at little more than one-twelfth part of a mile, if we suppose the slope uniform. The rapidity of the slope, and the depth of the sounding are not very consistent with the supposition that a shoal in any way tended to the formation of the island, though it is true, that with the same external action, the bottom would rise more readily in shallow water than in deep.

The island was subsequently visited by various persons, and the nature of its materials examined. Ashes, a substance resembling cake, scoria of iron, and burnt clay were the chief ones; and there were not many of the substances that are usually discharged in the eruption of volcanoes. It should seem that only the common matters at the bottom of the sea came to the surface, even when the walls of the crater attained an elevation of nearly two hundred feet; for the layers formed by the successive eruptions, which could easily be distinguished by the salt that was left when they evaporated the water, were friable and yielding to the action of the waves.

It seems to be not an unusual occurrence, in what may be called volcanic seas, for small islands to rise up in that manner, and afterward to disappear, probably by the mere action of the water. That was the case with the island of Sabrina, which made its appearance off the Azores in 1811, and attained nearly the same dimensions as the one in question. It has now disappeared and there are eighty fathoms of water in the place where it stood. As those instances are well authenticated, and as others have been mentioned, it is by no means unlikely that they occur frequently in the sea without producing any appearance at the surface. It would be contrary to the general economy of nature, in which there is no thing or power out of the connexion, to suppose that those depths of the sea, which we may conclude are too far from the action of the sun and atmosphere for supporting life, lie idle. They are very extensive, and the power of water pressure in them is vast. It therefore agrees with the analogy of nature, as well as with the observed facts, that in them are placed the grand laboratories of nature, in which new lands are prepared; and that the action of those smaller submarine volcanoes, which shoot up their columns of charred and granular matter, to be strewed over the bed of the ocean by the currents of its waters, is the process by which the strata are mixed and tempered, so as to fit them for their purposes.

The following cut will give some idea of that action:



HILL-MAKING UNDER WATER.

That hypothesis is not only in strict accordance with the whole of nature, in all its kingdoms, and in all their productions and phenomena, but it explains many things which otherwise are puzzles in geology; and it enables even those whose means and opportunities are the most limited to turn even the progress of the most common labour into a means of instruction and pleasure. The digging of a quarry, or even the cutting of a drain, may be made a study of nature, and the hand that works may work with more ardour and success in consequence of there being instruction, and consequently pleasure, in the working.

The coal mines, from the extent and depth to which they have been worked, are perhaps the best places for observing the traces of that working. The coal itself has been vegetable matter, for there are vegetable impressions in it. It lies generally in basins, and there are in most cases many seams, and some of them deep below others, so that the "coal measures," or strata in which the coal is found, have been formed gradually. They consist chiefly of limestone clay, iron stone, and sandstone;

the accumulation of which must have required a long period of years. But they also show traces of volcanic action, in the "dikes and cutters," by which they are intersected, and which often throw the strata out of the plane, so that the coal is higher on one side of the dike than on the other. Those dikes are frequently "whinstone," or allied to basalt; and there are cases in which the basalt has issued in quantity and formed "caps" on the top of the other strata. The coal-field in the south of Fifeshire is remarkable for those caps, which there form very beautiful conical hills, locally termed "laws." The top of one of these, "Kellie law," is, under the green sod, as regular a basaltic pavement as the top of Staffa.

We may, by the observation of what we see going on at the surface of the earth, understand how a bed of sand, clay, or gravel is formed; and there are instances in abundance of the formation of peat-bogs. In those cases we can also in general tell whether the bed has been formed in a pool, or by an occasional fall of rain, or flood. But when we look at even a very limited portion of the tamest country, we are utterly unable, by any power of which we can see or imagine the working in the air, to account for the form of its surface. The gravel and clay hills, near London, again occur as the most familiar instances, though they are far from being the most striking ones. Water, whether of the sea or not, must at all times have preserved its level, because that is the very constitution of its nature, and without that it could not have been water. The currents of the sea may have done a little, but it could be only a little; for it does not appear that even the Gulf-stream of America rolls stones before it; and the little coral insects are quite competent to the task of erecting a wall from the unfathomable depths, sufficient to stay the roll of the wide Pacific, even in its most stormy latitude, and with a tide-run of several thousand miles. So that those minor operations of these internal fires of the earth are necessary to account for the inequalities of the surface, which are not formed of rock but of accumulated fragments.

They also enable us to account for the formation of beds of chalk, and shelly limestone, and marble in all their varieties of form.

SECTION VIII.

Observation of organized Beings.

In the former sections, an attempt has been made to call the attention of the reader to the objects and phenomena of the creation around him, in their general appearances and properties as matter, and without any reference to the particular forms of individual subjects.

Light is nearly the same wherever it may fall, or from whatever it may be produced; and though the light which comes to us from one substance is often very different, in colour and intensity, from that which comes from another, the portion that does come to our eyes is still a part of the same specific light, which is entire and undecomposed in the beams of the sun. When the fields send us back the green, and, as we suppose, drink up the red, that red wholly disappears in the leaves and the grass; and, in like manner, when any other colour is given out to us, the remainder is absorbed, and we cannot, by any scrutiny in which we can engage, find out what becomes of the portion which is retained by any substance, or how it affects the other properties of that substance.

As we can, by means of the prism, decompose the sunbeams into all the tints that are necessary or even possible in the colouring of nature, we can have no reason to doubt that the colours of nature are all produced by the sunbeams. But, in consequence of the great rapidity with which light moves, we must not confound the manner in which we see painters make up their shades of colour by mixing variously coloured substances, with the mode in which the colours of nature are produced. The light *reveals* the colours, but we are not warranted in saying that it *makes* them; for though, by means of a common triangular prism, we decompose a beam of light into the most perfect spectrum, and keep that spectrum ever so long on the identical piece of white paper, or any other surface, whatever may be its colour, we shall never be able to find a trace of the spectrum on the paper, or other surface, after we remove it out of the light which the prism decomposes.

Now it is evident that, if the remaining colours of the sunbeams did not in some way act upon the surface, which gives out any particular colour, the surface that shows any colour under the spectrum would show the same whether the spectrum were there or not, and as the same colour remains on the surface after the spectrum has been removed that was there before the spectrum was thrown upon it, it is just as evident that every coloured surface must have some peculiar state or property which disposes it to show its particular colour.

Hence it is evident that colour, and that which we usually call light, is not a being or thing of any kind, but merely a relation between one surface and a reflection from another surface; that being the case, we cannot regard light as in any way forming a part of, or otherwise affecting, the quantity of matter in bodies; and, therefore, all such speculations as, "whether the quantity of matter in the sun be diminished in consequence of the light which the sun gives out, in the same manner that the oil in a lamp is consumed by the burning of the lamp," are absurd. The *light* of the lamp does not consume the oil, and as little does the light of a fire consume the fuel. The light is, in these cases, only one of the appearances attendant upon the decomposition of matter, and if it measure any thing it measures only the rapidity with which the decomposition takes place. Further, as light is reflected from surfaces, and reflected from them though it be invisible previous to the reflection, the light of the sun may be a reflection from the sun, or the sun's atmosphere, which comes invisibly to that luminary from some far distant source. The colours which we observe directly in nature are not visible, and therefore do not exist at any point between the coloured object and the eye; and reflected colours, such as those of the face in a mirror, exist nowhere between the face which is reflected and the eye that sees the reflection.

So also, in the case of heat, we can never observe it as any thing else than an accompaniment of some action, and intense in proportion to the intensity of that action. From what we can observe and judge of the other appearances attending cold and heat, even heat up to the most intense combustion, all that we can say is, that absolute cold appears to be but another name for absolute rest; and absolute heat, absolute motion and conflict.

To speak of "parts" of light and heat, in any sense of the word, is, therefore, to speak that which has no meaning, even if we consider those parts as the mere results of mechanical division. To speak of the half, or the quarter, or any other fraction of light, is absurd; and one of those absurdities which, having crept into common language, tends to confuse our understanding of things, even in their very simplest elements.

Air, water, and solid matter we can conceive of as divisible into parts, mechanically, or into pieces in all their various forms; and, chymically, into their constituent parts or elements, in all kinds of matter except those which we consider them, and we consider them simple, just because we have not been able to divide them chymically.

Our means and methods of decomposition have been much improved since the time when fire, and air, and water, and solid matter under the general name of earth, were considered as the four elements of all created things. And as we find in every case of decomposition that the constituent or elementary parts have all different qualities, and that the compound has qualities of which we could have had no knowledge or even suspicion, if we had known the elements only in their separate states, we are enabled to say to what the properties which we observe in different kinds of matter are owing. But, as every new combination is attended with new properties, we have strong grounds for believing that every property of matter, and every change in the appearance of any portion of matter, is the result of combination: that the property which we find originally in any substance is the result, or effect, of a combination which took place before we examined that substance; and that every change which we find to take place in any substance is the result of a combination immediately preceding that change. The combination may take place in two ways, because it may, in the case of the individual substance, be either an adding to it or a taking away from it; and the addition or the subtraction may either be that which we can obtain and examine in a separate state, or it may not. It may happen, also, that those two modes of change are combined, and the combinations of them may be varied,—it may consist of any two of them, or of any three, or of all the four.

Removing a spot of tar is a familiar instance of that. Common soap will not dissolve the tar, and neither tar nor grease will dissolve in water; but the tar and grease combine and soften; and when soap is added, the compound is soluble in water, and the spot is removed.

Limestone or marble may be heated in the dry fire, till it become quick-lime; and while that lime is hot in the kiln, it has an increased action of heat in it; and it parts with water and with carbonic acid. After it is removed from the kiln, the action of heat is communicated to the surrounding atmosphere, till that and the lime have the same temperature; and if the atmosphere is moist enough, the lime takes water back again out of that. So also some vegetable substances (such as the *Jatropha manihot*, of the tuberous roots of which the Indians of Central America make their *cassavi* bread, and which in its raw state is a poison) may, by moist heat, have both the water and the poison, or other offensive ingredients, boiled out of them.

CASSAVI (JATROPHA MANIHOT).

If, in these cases, any quality which the substance had previously shall disappear, we may always conclude that that depends on the combination; but if we find it in any substance that has been separated by the process, it is either an original quality of that substance, or it depends on a combination which has not yet been discovered: but which we may find upon further examination.

It is thus probable that there is no permanent quality of any thing material; but that all distinctions which are apparent to our senses are the results of combinations, all of which may be dissolved; and when that takes place, the old qualities vanish, and new ones become apparent.

We find, too, that there are many states of matter that have the power (as we call it) of extending themselves. Combustion, from a match or spark, soon spreads over a vast quantity of combustibles. Fermentation is produced in brewing and baking, by adding yest to the dough, much in the same manner as a crop is obtained by sowing seeds. Canker, begun at a little hurt, will spread till it destroys a tree; rot from one place will consume an entire beam of timber; a spot of rust will in time destroy a bar of steel; and a puncture with the fang of a serpent, or a needle merely stained with the corrupt matter of the dead and dissolving body, will breed corruption in the living one, which no surgery can arrest.

But these and all the analogous cases are really destructions, and when the process of destruction is over, the *power* of destruction, as we call it, is nowhere to be found, and all that we can say of it merely is, that it is a *state* of matter, and no more a kind of matter, or matter as independent existence at all, than light, or heat, or gravitation.

The tendency of those decompositions, so far as they go, is to reduce all matter to one state—to bring it to the dust—to prepare it as materials, just as the active operations which are carried on in a populous and busy city, reduce streets, and houses, and furniture to dust, and prepare them for the brickmakers and the builders; so that the city may partly do in fact what was fabled of the phenix—arise again out of its own ashes. If the brickmaker and the builder were to stay their hands, the city would soon become uninhabitable; then it would be a ruin; and then, again, and not very long after, it would become dust, and dust not to be known from the other dust of the earth. The places of many cities, of which the histories are fully recorded, are now matters of uncertainty even to the most believing of antiquaries; and in cases where they are determined, it is not done by that which has been ruined, but by that which has escaped from ruin. When we speak about seeing "the ruins" of Rome, or of any city or edifice, we speak about that which we cannot see. What is left is what we perceive, not what is ruined, and to find a former city in the dust is about the same as to predict a future one in the quarry. And even that which we find tells us of nothing but itself; and when we come to a brick or part of a broken altar, we are no more warranted in coming to the conclusion that "here there has been a city or a temple," than that nearly extinct race of hunters for marvels were warranted to conclude, upon coming to the scoria of the old "beal fires" at the "vitrified forts," that "here has been a volcano." But it is with ancient cities as with their inhabitants; they cannot rise out of the dust and contradict any thing that may be said about them, however imaginary or incorrect that may be; and thus the antiquary, like the historian, gets credit for telling the truth, simply because nobody can contradict him by an appeal to observation.

Those remarks may at first view seem foreign to the purpose of these pages; but that is by no means the case; for it is highly probable, nay, it is certain, that, because the word "History" has been made part of the name of the description of nature, the observation and knowledge of nature have been vitiated. The saying is common, even to a proverb, that the history of any period, whatever may be the events of which that history is to give an account —even if they are the occurrences in the life of one individual, cannot be properly written, till many years after the period has elapsed. We shall not inquire why that should be the case, because the result of the inquiry might not be very satisfactory; but if it be true, as it is very generally said to be, that the events of history are the better understood the further the study of them is removed from actual observation, most assuredly the reverse is the case with nature; for in it, nothing but immediate observation can be relied on; and that which, it seems, is philosophic truth in the successions of human conduct, is error, and nothing but error, when applied to the knowledge of things.

If there were nothing in nature but the properties of matter, the agencies of light and heat, and those actions of substances upon each other, which can, wholly, or even in part, be imitated in the laboratory of the chymist, then nature would altogether be in progress towards destruction. The tendency of all those powers is to produce *inorganic* masses —masses of which the one part is not necessary for the operation of the others; but of which any portion may be considered as a whole, whatever may be its form and magnitude. The heat of a burning taper, though not the same in degree, is just as entirely heat as that of Etna during an eruption, and the light of the same taper is just as completely light as that of the mid-day sun. So also, if the water of a pond were to be divided into countless millions of drops, each of them would be just as much a whole as the entire contents of the pond, and as perfectly water as the ocean. It is the same with all the metals, stones, earths, and other substances which obey no laws but those which, to some extent or other, we regard as common to all matter. But there are also peculiar laws, which act in opposition to the common laws of matter, and within the sphere of their action overcome them, at least for a time.

These are the laws of that mysterious relation which we call LIFE; and which, though we never can tell what it is in itself, or how it and the general properties of matter act and react upon each other, yet furnishes by far the greater part of the usefulness and pleasure of nature before us.

Fanciful men, who have lost sight of facts, have sometimes supposed and said that there is a regular gradation through all the productions of nature, from the simplest substance up to man, and even higher; and these have been called the gradations of nature towards perfection, and held up as especially worthy of our admiration. But, in truth, we observe no such gradation; and we ought never to know any more about nature than we can observe. There are differences, and very great differences of appearance; but still we are not warranted in saying that one production of nature is more perfect than another. When we have any purpose of our own to serve, we may find that one thing more perfectly answers our purpose than another does, and we may say so; but when we put our own purpose and use to us out of the consideration, and come to speak of "use," and "purpose," and "perfection," in nature generally, we speak words which either have no meaning at all, or one which is very presumptuous and impious, as well as very absurd. That we always understand our own purpose is very doubtful; and it is certain that we can never find out any purpose in nature. If we did, we should penetrate the secrets of the Almighty; and as we cannot do that, it is a silly as well as an impious vanity to say that we can. The real fact is, that we know what we have observed, and not a jot more; and if we think that we do, we are in error.

Now, when we carefully, attentively, and without any visionary theory—or notion formed previous to knowledge, and therefore groundless and delusive—look at nature around us, we find two great classes of natural productions. The one class perfectly passive to the operation of the laws of matter, having in themselves no principle of change, suffering no alteration though ever so long kept apart from other substances, and altering only when they are affected by something external of themselves. Those substances we can, in many instances, resolve into their elements, or constituent parts; and we also can, although not in so many instances, reproduce them back again out of the very elements into which they were previously resolved. If we cannot do that, we always can account for all the parts, and say into what other substances they have been compounded; and scatter them as we may, through any number of combinations, not one of them is lost either in its quantity of matter or in any of its qualities; but in all cases in which we can bring the ingredients together under the proper circumstances, and these all observable circumstances, we get the original compound, unaltered and undiminished in any one of its qualities.

These are the substances of which, it has already been mentioned, no part, mechanically considered, is necessary to the existence and perfection of another. If we cut them with a sharp instrument, break them by a blow, or otherwise divide them by any mechanical operation, all the parts are, size and weight excepted, just the very same substance that the larger mass was before the mechanical division.

And as we cannot make them smaller, except by taking away a part, and the part and what is left still make up the whole, so we cannot add to their quantity in any other way than by adding matter of the same kind. Neither have they, in themselves, any principle by which they can increase their quantity out of other matter. It is because the smallest portions into which we can divide such substances suffer nothing but in quantity of matter by the separation of the other portions, that we call them *inorganic*, the different parts of them not being *instruments*, useless out of their place, but in it conducing to some general purpose which they would not accomplish if out of the combination.

All chymical compounds have properties different from those of the substances of which they are compounded, but then the chymical compound is not organized; for all parts of it are alike, or if there be any portion of the mass which has different qualities from the rest, then that is no organ, nor even a part of that compound in any way; it is a different substance.

Wherever there is organization in a state of activity there is *life;* and perhaps the best definition of material life, taken in its most extended sense, is the faculty, or power, of producing or maintaining an organization,—a system of local parts performing different functions, but all conducing to some effect which is never, in any instance, produced by inorganic matter, how active soever that matter may be in its own way. Organized substances have not the permanence of inorganic matter. That remains unaltered if kept from the action of every thing but itself; but organized substances, if taken out of those situations and circumstances which are favourable to them, die: and, so far as we know, they are all subject to natural death. When one of them perishes, either from natural decay or from accident, that same one is gone for ever, never to return; and there are no artificial means, nor do we know of any process in nature, by which it can be got back again.

But although that may be regarded as universally true of every organized being as such, yet the matter of which that being is composed is not lost by the death of the organized being, any more than if it had been matter in an inorganic state. That alone would suffice to show that there is something more than matter, or the common properties of matter, in the organized being. But there is further proof; we know of no instance in which an organized being is produced, unless from a former organized being. It is true that beings of that kind often appear under circumstances where we cannot trace the steps. When any organic matter begins to be disorganized, or, as we say, begins to putrefy or rot, we always find that, if it is exposed to the air, or if the air has access to it, under circumstances favourable to the growth of organic beings, those beings, varying in kind with the decaying substance, are found upon it and supporting themselves on its substance. Some of these, even when they have attained their full size, are so small that the eye cannot distinguish the individuals; and they are often found in places to which we can trace no visible opening. But still they never make their appearance except in situations favourable to their growth. When the bodies of large animals are left dead upon the surface of the earth, or buried at a small distance under it, in warm weather, they are very soon found full of maggots. But even with that small difference in the circumstances, there is a difference in the maggots. Above ground they are the *larvæ* of air-flies; but if below ground, they are the *larvæ* of beetles. If, too, before they have been affected by any thing else, the bodies are buried to a great depth in the earth, or if they are far in the sand, or covered with quick-lime, or coated with any of the pungent resins, which are hurtful to most of the minute animals, maggots do not make their appearance. As little do they appear when the body is under water; for, so far as we know, though there are many small animals that will prey on the carcasses of land animals when deposited there, there are none that place their eggs in those bodies for the purpose of being hatched. In deserts of hot and barren sand, where there is not, upon ordinary occasions, food for any of the insect tribes, and where recent animal remains are very speedily dried up, such remains are found without any insect ravages; and the same may be said of places which are intensely cold. So far, therefore, from even those that are called inferior animals, being produced out of inorganic matter, they are not produced out of the remains of other animals, unless other circumstances besides the presence of those remains be favourable to their production.

It is the same with vegetables. The fungi and moulds which come upon these in their decay do not come upon them equally under all circumstances. The common *rot* (*Serpula distruens*), which comes upon, and no doubt hastens, the destruction of the timber of houses, comes only in damp situations, and then only on the ends of the timber that are near the walls. So also the *dry rot*, or oak-leather (*Xylostroma giganteum*), which chastises ship-owners so severely, for using oak before it is properly matured in the tree, and dried after being cut down, and also for keeping their vessels damp and foul, and without ventilation, never makes its appearance, even on bad timber, if the air play around that timber with sufficient freedom. The fungi, and other parasitical plants which come upon timber, and almost all land vegetables, when in a state of decay, and hasten their destruction, are, generally speaking, encouraged by moisture; but, at the same time, none of them grow naturally in the water; and thus, however rapidly timber may decay under water, fungi never appear on it there. Various aquatic plants adhere to the surface of submerged timber, but they do so, not for subsistence, but for stability;

and though the course of a ship through the water may be impeded by the seaweed on its bottom, that weed does not tend in any way to injure the timber. As there are no sea animals which breed maggots in the dead bodies of land animals that find their way to the sea, so there are not in the sea any parasitical plants which hasten the decay of land plants there.

There is another proof in the peat bogs: when trees fall through decay, in damp and rainy situations, and it is only in such situations that they decay at the surface of the ground, there are generally, if not always, successions of fungi around the root of the tree for several years before it becomes so weakened as to yield to any thing but a flood or a tempest. When the tree does fall, it is usually covered with fungi on those parts against which the water forms a damp, but not where it forms a pool. In that case, the fungi will be at the surface of the water; and if the trunk is altogether under water there will be none. But even where the fungi do appear, they are not of long continuance. Their soft glutinous substance, which is soon gone in the ordinary seasonal crop, unites with the mud which the rains of autumn, after the season of the fungi is over, collect, and the two form a water-tight paste by which the slope towards the tree is converted into a little dam. There are abundance of the germes of the fungi, in the matter of these dams, although, in that stage, even those of the larger species are not visible until they have arrived at that period of their underground growth in which those of the esculent mushrooms are known by the name of spawn. Yet though they are there, they never germinate, if the water continues, nor would they do so if the place were to become quite dry. But the water brings another tribe, the mosses, the germes of many of which are as invisible when alone (and when with the plants their existence may be said to be inferred rather than seen) as those of the fungi; and they carry on their labours, growing at the tops summer and winter, and decaying at the bottoms, till they form a soil often many feet in thickness, and sometimes rising higher than any of the neighbouring grounds.

Those invisible seeded plants, as well as some of the animals which are minute in their size, peculiar in their situations, and widely different in their forms and habits from those quadrupeds and birds with which we are most familiar, and which have become, as it were, the types of animals generally, in common language, have given occasion, not only to a belief that there is organic matter in so neutral a state as that it may *of itself* become a land or a water plant, according as it falls in the one situation or the other, but also that there is inorganic matter so nearly approaching to vitality that it not only can but actually does, become alive of itself. That is a doctrine which is not only believed among those who have no pretensions to natural knowledge, but it is always now and then appearing under different modifications among those who have; and therefore it is one against which beginners in the useful study of nature should be particularly on their guard. It is as much as saying that certain kinds of matter can, without the agency of any thing else, give themselves new qualities—qualities which were not merely previously unknown, but which actually did not exist. Now if that be true of any one kind of matter, be that what it may, there is no denying it to any and every kind of matter; and if that were the case, we should have all the species of matter confounded and jumbled together; and that is a conclusion against which we should most especially be on our guard, because it would unhinge all our natural knowledge.

When we come to examine plants and animals, and reflect upon the immense variety which they present, in size, in structure, and in habits, we cannot easily avoid putting the question, "Why they should be thus or thus." But, though a tempting question, 't is a dangerous one, and we must presume no more than we see. From what was formerly said of the germes of the oak, we may form some notion of how impossible it is to trace backwards through annual successions, and often through successions of several races in the year, plants which, in their full-grown state, are merely or not at all visible to the eye, and animals which are equally or even more minute.

Yet why should we trouble ourselves about those minute points? There is enough to be seen in such a manner as we can understand it, in both kingdoms of living and organized nature. And as the members of those kingdoms are more susceptible than matter deprived of life, we have them more varied both by place and time.

There is not a more beautiful study than the climatal variation of the vegetable tribes, in their gradation from the extreme north, where they are few, to the luxuriance of the tropical forests and groves, in which they not merely cover the surface of the earth, but are suspended by thousands in the air, without any immediate connexion with it.

We may begin our survey at Spitzbergen, where the summer is only a few weeks, and the number of plants is of course very limited, or at the extreme north of Baffin's Bay, where it is doubtful if there be one land plant, unless we are to suppose that the "red snow" is a living vegetable. But even there, or at least as far in that direction as man can inhabit, there is some substitute: and where the land ceases to afford any thing but a place to rest on, the sea still abounds with wealth. The seal and whale tribes, though warm-blooded animals, and requiring to breathe the free air, contrive to summer and to winter there; and in the extreme north of America, the Esquimaux, who migrate a little southward in the summer, and seek their subsistence by hunting and river-fishing, return northward in the winter, build their habitations of ice, feel warm in them, just because the cold is too intense for allowing any of the ice to melt, even by the smoke and heat of the lamps, which serve at once for light and culinary purposes, and watch the seals at their breathing-holes for fresh provisions.

Even farther to the southward, the plants are few; and such as do appear are of the most humble appearance. In Iceland there are a few stunted shrubby bushes, but none of them of size enough for a hop-pole, or even for a substantial walking-stick. Notwithstanding, the Icelanders have plentiful supplies of timber, wafted to their shores without any trouble or expense of importation. Great part of North America—that is, the northern part of it, was once one continuous pine forest, and notwithstanding the "grubbing" by the Europeans who have settled there, much of it is a pine forest still. In those forests which have stood for ages there are of course trees in all stages both of growth and decay; and as pines, in swampy places, are generally assailed by fungi at the surface of the ground, as soon as they have ceased to vegetate, many of them are thrown down every season; and when the "freshets," or floods of the spring, set in, they are rolled onward to the sea. Those who live in places where there is no flood, but where the surface of the earth is clear,—and every porous soil absorbs part of the water which falls from the clouds,—can form but little idea of the violence of a flood over a frozen surface, where the earth absorbs not a drop, and the melting of the snow is added to the rain that falls. The combined violence of these is very great, and by means of it vast quantities of drift-wood are every season, though not in all seasons equally, rolled down the rivers of Northern America into the sea, and thence distributed by the sea currents, along the shores of all the dreary islands that lie near the margin of the polar ice.

These pine forests form the characteristic vegetation of the verge of the northern polar zone, and the northern part of the temperate one. There some of the species are found far to the south—as in the island of Teneriffe, and the mountains of Mexico, and some of the West India islands; but it is a curious distinction of the two hemispheres, that though there are trees in the southern that are called pines, and have some of the characters of the tribe, there is not a true pine found native to the southward of the equator.

Even in the north, where they are found in all the three quarters that abut on the Arctic Sea, there are peculiarities in those pines. Towards the east of Asia they are of small dimensions, but the timber is heavy, and very hard and durable. As one advances westward, they increase in size; and the tallest that are met with on the old continent are in Norway. In America they are very tall; and towards the shores of the Pacific they are giants of from 300 to 400 feet in height, and 18 or 20 in diameter.

Another peculiarity is, that though some species grow in the peat-swamps, the majority follow the directions of the rocky mountains, those especially which are composed of granite, while the debris and secondary strata are covered with trees which shed their leaves.

Few plants, except fungi and mosses, thrive under the shade of pines, though in all the pine districts there are numerous species of wild berries and other sub-shrubby plants in the vacant spaces. In those forests there is, accordingly, but little to attract notice, except the gloomy grandeur of the pines themselves. There are no climbing and twining plants; and flowers are few, and by no means interesting; while of native fruits there may be said to be none.

Those pine forests, though the species are not the same, follow the lines of the mountains to nearly the southern boundary of the temperate zone; and there are some lofty situations where pines are met with within the tropics. But oak, and the other deciduous trees, form the chief characteristics of the forests in the temperate countries; and the box and holly are found among the evergreens. About the same time the ivy and the honeysuckle are found native; and in proceeding from the regions of the snow they may be considered as the first plants which hang their festoons upon other trees. The honeysuckle is not, however, a parasite; and although the ivy certainly does destroy trees, it is more by strangulation than by any other means; for when the roots which connect it with the ground are divided, it soon withers.

As we advance still farther to the southward new trees make their appearance, and give a new character to the scenery; but as the continents become more and more separated from each other by the great ocean, their vegetable productions become more and more dissimilar. The pines of Siberia, and Norway, and New-Brunswick, are not quite the same; neither are the junipers and other evergreens of more humble growth; but still they have a considerable resemblance. But when we advance to about the latitude of the Mediterranean we find far more dissimilarity. The deciduous cypress (*Taxodium disticha*), which is so majestic a tree in the lower valley of the Mississippi, is not found either in Europe or Asia; neither is there in America any plant resembling the cork oak of Portugal and Spain, nor the cypress or cedar of the Levant.

Somewhere about the same parallel we meet with particular spots which set all arrangements at defiance, and forbid us to attempt tracing any general connexion between latitude, or almost any thing else, and the vegetation which is predominant.

Thus, Japan is a temperate and in some places even a cold country; and some of the plants which have been introduced into Britain from Japan stand the winter not only better than the plants of southern Europe, but better even than some of the native plants which are found on the bleakest places. The *Aucuba Japonica*, which makes the shrubbery so gay with its large and handsome leaves mottled with green and gold, actually bears the rigour of an English winter much better than a furze bush on the common; and of a variety of evergreens, many of them reckoned of the most hardy kind, that were exposed to a snow-storm in the winter of 1826, a *Camellia Japonica*, was the only one that survived. There is therefore very little doubt that by due care the camellia might be made a common shrubbery plant in all the warmer parts of the country, and might flower there to greater perfection than it does in the conservatory. The *Dahlia* never came to its full beauty till it was cultivated and allowed to flower in the open air. When we recollect that the colours of flowers, and indeed of all plants, are chiefly owing to the light of the sun, and that the light never comes through glass entire, unless when it falls on the surface at right angles, which can only be for a very little while of the day through the same piece of glass, we may have at least some notion of the fact that plants in a situation so contrary to their natural habits must fall off. There are, indeed, not a few of the vegetable productions of the tropical countries which naturally inhabit places not very unlike our hot-houses: they are surrounded by thick trees, so that the wind does not blow upon them, and when they get rain they get it in torrents.

Another singular anomaly—if it is to be supposed that the characters of the vegetable tribes are to follow the latitude, or even the latitude and elevation—is to be found in the Himalaya Mountains, and their continuation to the west. At their lower slopes those mountains have the vegetation of tropical Asia; but as they are ascended, the vegetation of Europe makes its appearance; and the progress has much resemblance to one from Italy to Lapland, in forest, orchard, and every thing.

But the genuine tropical landscape is a curious sight to those who have been accustomed to nothing save the seasons of England and their succession of productions and phenomena. These productions are tempered to great peculiarities of weather; many months without a shower or any moisture except the dew; and then pelting rains of the utmost violence. One year of such weather would, if there were no help to be obtained from any other quarter, cause a famine in England, and go far towards converting the entire country into a desert. No doubt many parts of the tropical regions are deserts, and some are deserts now which have traces of having been once fertile. It is not so much, however, to any alteration of the seasons that that is owing, as to alterations in the earth itself,—to the fact that the lakes have been emptied, and the rivers have cut their channels so deep that they no longer continue to irrigate and fertilize the soil.

There is protection against excess both of drought and of moisture in the surfaces of most of the tropical plants. Their epidermis, or external rind, is very compact, and in general highly polished and shining. Thus the light and heat of the sun are reflected from it in the hot and dry season, so that the internal parts are not excited to more than ordinary action. Then the compactness renders the evaporation far less than it is in the common plants of Europe, with a very inferior degree of temperature. In like manner, as the peculiarly smooth and close epidermis prevents evaporation to parching in the dry season, it prevents evaporation to chilling in the humid; and so, notwithstanding that intense action of heat and light which produces so much beauty and fragrance in the tropical fruits, the germes in the plants there have certainly a more equable temperature throughout the year, and probably not a higher one than they have in Lapland. In all tropical countries the fruits are delightfully cooling, even when they are gathered under the burning sun; and as the pulp of fruits has accomplished its purpose, and is about to be yielded up to the general doom of materials, if man do not appropriate it to his use, if that be found to retain so very cool a temperature, much more so must the common juices of the plants, many of which outlive the oaks and the chestnuts of temperate climates.

The whole of the orange tribe, and the orange itself in an especial degree, show how well the tropical vegetables are, by a very simple provision of nature, protected from the vicissitudes of temperature. The volatile oil which is contained in the pellicles of the rind absorbs and flies off with much of the heat; and the soft white substance of which the body of the skin is composed is almost as good a barrier against both heat and cold as the fur on an animal or the down on a bird. In consequence of that, the orange tribe, where they are uninjured when picked, and kept out of the circumstances which resemble those in which an orange would prepare for growing in the soil, can be carried uninjured to greater distances, and into a greater variety of climates, than any other fruit. It is very different with the northern berries; none of them will keep their flavour, and few their form, for a week; the strawberry is vapid the second day if fully ripe when gathered, and the raspberry is injured in an hour—even in shorter time if the weather is very warm. All those are covered by mere pellicles, as tender and easily ruptured as they are thin; and more strength is not required for them, as the term of their existence is very short, and the season is mild and comparatively uniform all the time they are passing from the blossom bud to the ripened fruit. Not so with the tropical fruits. The trees which produce them have no winter of repose, and therefore the progress of their fructification is much less rapid. Generally speaking, they remain two years on the twigs, and thus they enjoy both the dry season and the wet; and in all cases where they do so, we find that they are provided with means of protection from the intense action of the sun; and even when they come more rapidly to maturity, we still find the shining rind or capsule. Even if there is a shell, and that a hard and tough one, we find an external protection, as in the *coire* which is between the external rind of the cocoanut and the shell; and, thus protected, the milky juice of the nut is very cool and refreshing.

Even in the cold countries, if the leaf or the fruit has to bear both the summer and winter, we have generally the shining epidermis and the shining rind. The leaves of all the evergreen pines, and cypresses, and yews, and the whole tribe of the *coniferæ*, are smooth, while those of the deciduous larch and taxodium are not. It is true that the leaves of many of what we call evergreens are just as unusual as those of the lime and the mulberry, the latter of which is the last to come and the first to go; but still they summer and winter on the tree: there are always two successions wholly or partly upon it; and the fall of the leaf with such trees is in the summer. The common juniper is almost the only native berry which we have that lasts more than one season upon the bush, and it has the firm rind and some of the other characters of those that remain for two seasons in warmer countries.

The water-melon is perhaps one of the most remarkable instances that we have of the power of tropical vegetables to obtain moisture in the extreme of drought, and cold in the very violence of heat. In the Indian desert between the valley of the

Indus and that of the Ganges, there are many places where the surface, with the exception of here and there a crumbling stone, is nothing but sand; there is no water, except what has to be drawn from the depth of several hundred feet, and the rainy monsoon sometimes passes over without refreshing the surface with one drop of water. Yet even there the water-melons, planted in the dry sand, not only vegetate, but attain to a size unknown in the most fertile places of Syria and Egypt. The diameter is often from a foot to a foot and a half, and the crops are very abundant.

WATER-MELON IN THE DESERT OF AJMERE.

But though we sometimes find a plant thus flourishing in the desert, and collecting cooling juice in abundance where, to our observation, there is nothing but dry air and burning sand, it is not in such places that we are to seek the characteristics of tropical vegetation. As little is it in the fields and meadows; for, in one sense of the word, fields or meadows there are none. If the grasses are in the marsh, they resemble reeds, or even forests; and if they are in dry places they disappear for the greater part of the dry season, unless they are preserved by artificial watering. So that in them there is little beauty. But the woods are truly splendid. Not merely the palms, though many of them are gigantic, and almost all of them have a simple grandeur of character which belongs to no other tribe of vegetables, but the other trees, be the species almost what they may, are, in the undisturbed but often impenetrable forests, the very excess of vegetable action. Bright as is the sun, the trees are so thickly matted, that their shadow turns mid-day into twilight; and the branches are full of monkeys gambolling and chattering in the most fantastic manner; and of parrots and other *zygodaclytic*, or yoke-footed birds, of the most brilliant plumage, scrambling and screaming everywhere. The earth, too, whenever a beam of the bright sun breaks in, is glistening with lizards, and the light is all radiant with humming-birds; so that all the fancies of the northern romancers, whose pictures are of course limned only with the colours which they knew, about fairy-land, are outdone by the plain and simple reality.

Then the *epiphyteæ*, or parasitical plants, are perhaps even more wonderful. The greater number of them belong to the *orchideæ*, many of the British species of which attract, by the singular forms of their flowers, the attention of even those who are not habitual observers of nature. The "bee," the "fly," the "spider," and many other names, have been given to them from resemblances to the animals they are named after, which are not altogether fanciful. The more curious of the native species are most abundant on the dry chalky heights; and those soils, in Kent especially, are worthy of a visit in April or May for the spider, a month later for the fly, and a month later still for the bee. But they are not confined to the chalk districts; for some are found in bogs, others in woods, and others again at considerable elevations on the cold and steril mountains.

The British ones are all bulbous herbaceous plants, with annual stems, and they annually produce one or more bulbs at the root. The roots of all contain a very soft and glutinous matter, which makes a wholesome light gruel, under the name of "salep," and is, in some of the foreign species, made into a kind of vegetable glue. But curious as some of the British ones are, they are nothing compared with those that are natives of the tropical countries. It is difficult to imagine a whimsical figure that shall not have a sort of likeness in one or another of them; and in the forests there, some of the monkeys and some of the flowers of the *orchideæ* so much resemble each other that if it were not for the motion and the chattering, a stranger would hesitate a little before deciding which were the face of the animal and which the flower.

In their tints of colour they are most brilliant, and the contrasts are perhaps the finest that are to be met with in all the pencilling of nature. Nor are the plants so diminutive, or of so short duration, as they are with us. Many of them are perennial; and though there are perhaps none of which the roots and stems can be considered as wood, yet they continue to endure and to grow where wood never grew. It would be impossible, however, in any description that could be written, to convey a popular notion of their forms; but there are some of them that, in point of absolute beauty, and in as far as flowers are concerned that is utility, are entitled to take the lead among the whole of the flower producing-tribes.

The following is a *black* outline of part of the flower of the one which may perhaps be regarded as the foremost of the tribe, and in point of floral beauty, the foremost of the whole vegetable kingdom, though it is almost an absurdity to attempt any sort of representation of the gem of flowers in a little wood-cut.

RHINANTHERA COCCINEA.

Rhinanthera coccinea is perhaps found in the greatest perfection in the woods of Cochin China, though it is common in China, and much employed there in the ornamenting of apartments. But in its native woods its dimensions are more splendid. It not only climbs to the tops of the most lofty trees, but it rises over them; and it so interlaces and festoons them, that the whole forest is hidden; and when it is in flower the whole is one mass of crimson and gold, of so intense colour that the eye can hardly bear to look upon it. Then, different from some showy flowers, the scent is as fragrant and refreshing as the colours are brilliant. Nor does it seem that, splendid as this plant is, it is very difficult either to cultivate or to flower. Cochin China, though from the difference of their latitudes a much warmer country than Japan, yet resembles it in some particulars, and as even the fine plants of Japan are very hardy when put to the proof, it is natural to suppose that those of Cochin China should be moderately so. It is true that this Rhinanthera has hitherto been treated only as a stove-plant, and perhaps it may require to be always so treated till it comes into flower; but after that it may be brought into the house, and suspended from the roof in a porcelain vessel, after the Chinese fashion, and it will there display its beauty for several weeks; for the flowers are as lasting as they are fine. If left in the dry air, however warm that air may be, it does not flower; but the method of bringing it into action is to surround the stem with moss, and keep that moss constantly moistened with water.

But, in order to find pleasure and profit in the observation of the vegetable tribes, it is not necessary to resort to the tropical forests, notwithstanding the splendour of their appearance; for the vegetation of every place is so beautifully tempered to the soil, the climate, and the weather of that place, that though some may be more novel than others, it is impossible to say which is the most interesting. If in one place there is more continual action, there is in the other more activity after the season of repose is over; and where there are the flowers of summer and the fruits of autumn in perpetual succession, we look in vain for the buds of spring which are at once the most beautiful and the most inspiring of nature's productions.

Even the leafless groves have their charms; and he who has never studied it in the winter has no proper knowledge of the beauty or even the form of a tree. There is fully as much character in those permanent parts as there is in the leaves or the flowers. There is a character of species in the bark, and there is a character of age. In the young shoot it is smooth; but as the tree gets old it is rifted and thick. Except it be some of the sycamores, and they are not natives, there are not trees that with us annually cast their bark. In some countries it is different. In New-Holland, for instance, all the species of Eucalyptus, and they compose the principal forests, cast their external bark down to the white *liber* every year; so that, though the leaves are evergreen, there is a "fall of the bark" answering to our "fall of the leaf."

When we compare those two operations, and then consider the difference of the timber, we gain one point of knowledge in the economy of vegetation. The dismantling of the leaves is a protection to the plant as a whole. It presents a smaller surface to the wind, and the whole of it is wrapped up in a close mantle from the cold. The juices which, during the summer action, were liquid, become firm in their consistency and diminished in their bulk. The bark is elastic, and not only follows the lessening of the stem, but co-operates in bringing about that lessening. This condensation in the wood of the tree, and it extends to all the wood which is in a state of activity, necessarily generates heat, for heat is produced in all cases of condensation; and thus, the colds of early winter, which would destroy leaves, unless those leaves had the glossy epidermis of evergreens, has no injurious effect upon the stem. Indeed, the epidermis of an evergreen leaf has more resemblance to that of a twig of the first or second year than to that of a deciduous leaf. The cold acts in it in nearly the same way, and it becomes rigid; so that there is little or no action of any kind in it during the winter. And, as even the evergreen leaf is but a temporary organ, which accomplishes one purpose and then decays, the leaf of the evergreen does not revive in the revival of spring.

If, after the winter is over, the leaves of a common evergreen—those of the laurel, for instance—be tried by a proper test, it will be found that their vitality is gone, although their colour remains. The very best test of life in vegetables, as well as of health in animals, is the thermometer. The living thing, be it what it may, has always one temperature which is the most favourable to healthy action, and it struggles to preserve that; but when the principle of life fades, the mere matter obeys the laws of matter; and thus, when the evergreen leaf has ceased to perform its functions as a leaf, it has no longer the uniform temperature of the growing plant, but gets heated in the sun and cooled in the shade, in the same manner as though it were a portion of inorganic matter.

If the experiment is made after the young leaves are expanded, but before the old ones show any discoloration or other symptom of decay, and made when the sun shines brightly, the contrast is very striking; so much so, that an instrument is quite unnecessary; for the young leaf feels cold, and the old one warm. This shows that all action in the old leaf has ceased; because it is the action, the evaporation of moisture at the surface of the leaf, which preserves its coolness.

In all cases where there is an annual leaf, there is also an annual plant. In trees which last for years that is a very beautiful study; and if we could separate the oak which has stood a century into the hundred oaks that have been produced in the suc cessive years of that century, there is nothing in the museums half so curious. But we can trace them in the cross section of the bole, and so virtually arrive at all the rest. When the infant oak sprouts out of the acorn, it is nothing but pith and pellicle, the former a small portion of jelly, and the latter very soft and tender. Even then the oak is an organized being, from the moment that we can discern it; and, previous to that, there is nothing but conjecture. The vital principle of the plant is not a quality or property of the pith, or of the pellicle, for both of these are mere matter, and neither of them could of itself originate an oak any more than the soil in which the acorn is set. The life consists in the union of the two, the action of the one upon the other; and that action takes place at the surface where they meet. During the first year that action converts the food of the plant (derived at the first from the cotyledons, or lobes of the acorn, and then from the soil and the air) into a new substance, the *cambium*, or "changeable matter." That begins to be formed as soon as ever the little plant puts out a leaf, but the nature of the substance which is formed depends not a little upon external circumstances; and the quality of the timber which the tree is to produce is, in all probability, determined by the circumstances under which the young plant performs its very first action.

We know from observation, that no plant will live without air, or be healthy if the air is not pure and good; and we know, from the same source, that if the plant is shut up from the light, it is colourless, and contains little or no charcoal. If, therefore, the young plant be in air that is tainted, or too deep in the ground, its action must be vitiated, and it must, as one may say, "start with bad timber." Now, if a taint is given at the commencement, that is a constitutional taint, and must remain with and vitiate the tree, how long soever it may live, or what size soever it may attain.

Complaints are every day made of the badness of the oak timber now, as compared with what it was formerly; and these complaints are well founded. What with dry rots in confined air, and rots in water, and slow decomposition in the atmosphere, modern oak, which is, generally speaking, planted oak, is absolutely less durable than even some of the inferior species of pine, and far inferior to the native pine of the mountains. A piece of heart of oak, chosen by the king's builder for royal purposes, had been seasoned and prepared in the most careful manner; and after that, it had been kept dry in the centre of a trussed beam for more than twenty years. It is not easy to imagine how a more desirable specimen of oak timber could be procured; and it certainly appeared well. The colour was good, the grain close, and the texture very hard and firm to the tool. Well, a piece of this same oak was let into the ground, in a dry soil, and so situated that no drip fell upon it, or trickled down it; and it remained between three and four years. Upon its being taken up, all that portion of it which had been in the ground was in the same condition as the alburnum, or sap-wood, of very old oak piles when they are taken out of the water,—more like compact clay than timber; and when dried, it "broke short," and crumbled into powder. In colour it was more like rotten pear-tree than rotten oak, for there was no blackening, and yet the soil contained a great deal of iron, so that the timber must have been deficient both in tannin and gallic acid.

It was not, as has been said, the sap-wood, but the very best part of the tree, and from inspection of the cross-cut, the tree had not grown with any very extraordinary rapidity. As little was the injury done at the "weather line," just by the surface of the earth, where the durability of timber is put to the severest test; for the decay extended, not only to the entire portion of the part that was in the ground, but also to a cross piece, which was nearly two feet below the surface, and which, of course, had no weather line, from which its decay could originate. Some pieces of American white pine, which is considered to be the worst timber of the whole pine tribe, were put down for the purpose of keeping the durable "heart of oak" steady, till the earth should be consolidated about it. When taken up, these were entire and merely wet, while the said heart of oak was completely gone!

But that was not the case with oak of former growth; those oak posts and beams, in the earth and out of it, in all sorts of situations with regard to damp, confined air, and all other circumstances which are usually charged as being the causes of rot in the modern oaks. There are old piles drawn out of foundations in the water, where they must have been for upwards of five hundred years; and though the sap-wood of them is in a state of decomposition, and the heart champs when too suddenly exposed to the drought, yet the heart of those, properly treated, is as sound as when it was put down. In the peat-bogs, and other submerged forests, too, there is abundance of oak; and if care be taken in the drying of it, that oak is as hard and durable, at the same time that it is as black, as ebony.

But our modern oak will not last as many years, in some instances not as many months, as the old oak lasted centuries. The specimen upon which the above experiment was made was of chosen oak, picked in the royal forest, and, therefore, presumable to have been the very best that could be procured, and yet, had it not been protected by the pine beam in which it was cased up, the probability is that it would not have lasted any longer in its first situation than it did in its last. To build houses of such oak is mockery, to build ships of it is cruel;

for while they have the external appearance of soundness, they may go to pieces with the least strain, and bury all on board in the deep. Only that the fungi are not of the right species, such timber would answer the purpose of the mushroom-grower far better than that of the builder or the ship-carpenter; for the timbers go into their places loaded with mushroom spawn, and, in fact, progress to the state in which that generates; and so, in as far as oak is concerned in their structure, we have mushroom houses and mushroom ships.

What is the cause? Why should it be that when navigation is every day increasing in extent and value, the grand engine of navigation should be deteriorating every day? "The dry rot," is he answer. Well, be it so: what is the dry rot?

DRY ROT. (*Xylostroma Giganteum.*)

"*Xylostroma giganteum*, which grows in the timber, like a thick broad patch of dull yellow leather, or *serpula distruens* in other instances, which is smaller, redder in the colour, and whitish at the edge; but that last is as often found upon other timber as upon oak." Well, that is not a point worthy of much dispute; the timber is destroyed, and, generally speaking, these are fungi; but it is just about as sensible to call those fungi "dry rot," as it would be to call flowing blood "a wound," or the worms that consume the body "death." Why come the fungi there? There was a time when dry rot was unknown; and as long as the beams of houses were of good oak, or chestnut, or red pine from the north of Europe, there was no information laid against serpula. Besides, there never appeared a single fungus of any species upon or near the piece of oak in the experiment, and yet it passed from what may be regarded as the best state that it could be in for duration, to absolute uselessness, in so short a time, that if a ship were to decay as fast, the whole freight that could be obtained would not pay for the treenails. How is the same dry rot to be got rid of? "Oh, wash the timbers with sulphate of iron, and other saline solutions, and let the ship, or the house, as it may be, be well ventilated." The old story. "Call in the doctor, apply a lotion, and exhibit a bolus," under which the diseased have continued to die ever since medicine was a science. Are ships kept less clean now than they were before the dry rot was heard of? or are they or houses worse ventilated? Truly not. If there be any difference, the ships must be kept sweeter, else the chlorides, and other powerful fumigations, have been invented and applied to little purpose. The crews certainly keep their health better than they did formerly; and it would be somewhat wonderful, if air which were more wholesome for human beings should be more deadly for oak timber! As for the houses again, there are certainly more under-ground apartments than there were once, and possibly more than it is wise to have. It may happen, too, that the tax upon windows has impaired the ventilation by those apertures; but in many of the modern houses, and those especially where the rot appears, the loss of ventilation by windows has been more than made up in ventilation by walls, many of which are so thin, and of materials so in-firm, that, in as far as air is concerned, the fabric is ventilator all over.

But fungi, by what names soever they may be called, are not locomotive destroyers; they do not, full-grown, career over the land and the waters, to prey upon sound timber, as hawks do to prey upon birds, or wolves to prey upon sheep. The *sporæ*, or whatever else the small, and generally invisible germes of the fungus may be called, are perfectly passive, and of themselves can do no more harm to an oak beam than could be done by a mustard-seed. The soil in which alone it can germinate, or *begin* its action, is rotted wood. If it meet with that, it will germinate; if not, it will remain inactive. There is no doubt that the increasing quantity of rotted timber has increased the number of those plants; but that it has in no way altered the law of their nature, which is to grow in rotten wood, but not in wood which is sound. The only rational view of the case, therefore, is that the timber must be rotten before the fungus can act even in the slightest degree; and that, consequently, the fungus is produced by the rot, and not the rot by the fungus; and though the fungus is destroyed, the rot will go on probably as fast as if the fungus were not there; only as the fungus has a great attraction for moisture, and as moisture, though not the cause, is an instrument in producing the rot, the fungus may, when it appears, hasten the destruction.

It has been thought advisable to go into this case at some length; first, because it is a highly important one—one of the most important to which the attention of a maritime people can be turned; and, secondly, because it shows how dangerous it is to proceed upon mere human opinion, however learned the holder of that opinion may be, if it is not borne out by facts which have been found out and established by a careful and thorough observation of nature, in every way in which nature can bear upon the point at issue.

Imported oak has been blamed for this decay, and it is true that the imported oak, and more especially the oak imported from America, is inferior to the oak which *once* grew in the forests of England. But the deterioration is not confined to the imported oak; and however bad that may be, it could not inoculate the oaks of the forest with its deleterious qualities, any more than the species of insect called American blight, which infests apple-trees, could take its departure for Hereford or Devon, immediately on the landing of a cargo of American apples at Liverpool. The rot is in the timber itself,—*that* is of an inferior quality; and the cause why it has been allowed to degenerate is, that they by whom oak-trees have been bred have not been careful in the observation of nature, but have proceeded in their operations by means that had no natural foundation. The object of the grower has been to get goodly trees—trees that pleased the eye, without any regard to the quality of the timber; and the object of the nurseryman has been to rear up his seedlings and get them to market as soon and in as showy a condition as possible.

It has been said that the wrong oak has been cultivated, and that may be true, for the very same circumstances which led to the wrong mode of treatment may have led to the using of the wrong plant. The collector of acorns would naturally proceed upon the joint principles of "the most easily obtained and the most saleable." I do not know that it is in all cases a positive fact, that the worst kinds of oak are the most prolific of acorns; but it is a sort of generally-observed law among vegetables, that where there is a great deal of fruit, the wood is soft and perishable. And that has reason on its side; trees do not work miracles any more than men do; and, therefore, if their action is more turned in any particular direction, it must be less in any other. Fruit trees are often killed *in the wood*, by excessive bearing; and therefore it is natural to suppose that a similar excess must injure the wood of an oak. Now, it generally happens that in the same species, whether in the same or in different varieties of the same species, the productions run largest when they are most numerous. Hence the acorns of the oak having the inferior timber are the most profitable for the gatherer both to gather and to sell; and those two circumstances are quite sufficient to bring them to the market in preference to, and even exclusive of, the other,—more especially as the purchaser is to grow seedlings and not oak timber. The question of the timber is, indeed, a question seventy years hence with those who deal in acorns and seedling oaks, and as they have small chance of hearing any complaint that may be made about the quality, they of course give themselves very little concern about it.

But still granting that the acorns are those of an inferior oak, and that there are those mercantile considerations in favour of their use, that is no justification of the breeder or the planter of the oak. An acorn is not an oak; there is merely that in it which will, in time, make an oak out of other materials, if it is put properly in the way of so doing. Nor is there any reason that an acorn should not be made to produce a better oak, than the one upon which it grew. "Improving the breed" is constantly done by those who rear domestic animals, and has been done in the case of cultivated plants, more especially those that are used as human food, from the beginning of history,—and before it, for we meet with the names of those cultivated plants which have separate types in a wild state, in the most ancient histories; and those plants must have been cultivated out of something. The most learned botanists of the present day cannot be absolutely certain about the original potato; various species or varieties of the cabbage tribe are sufficient to puzzle a novice; and after a while the wild plants from which we have bred the Camellia Japonica and the Dahlia will not be a matter to be settled at a glance. It is not very long since the wild roses of Scotland were bred double and so deep-coloured as some of them are; and yet, to people that have some little knowledge of plants, their relations to the ones still wild are, even now, fully more matters of testimony than of ocular proof.

Now, if people have been able to cultivate animals into greater size and strength and beauty, and also to make them have better flesh and finer wool; if they have been able to improve by culture the beauty of flowers, and the nourishing qualities of all manner of esculent roots, stems, leaves, and fruits, it would be passing strange if their culture could do nothing for an oak-tree, but make it more worthless timber. If all the earth were given to man for improvement, and he had improved much of it—as he actually has done,—it would be a perfect anomaly, if timber, which is so very useful, should be the single article on which he could not lay his hand of culture without doing it an injury. It is impossible to believe that such an anomaly can exist in nature; and therefore the only way is to catechise the man who makes the attempt; and if he does not understand what he is doing, send him back to nature to inform himself as to what he should do.

There is a custom, and a very inveterate custom, which we have, and that is the custom of generalizing analogies. If there be a way in which one thing answers very well with us, we are apt to think that same way will do as well in all other things, even though the things are, in their nature, quite different. We go about to persuade ourselves that the way of doing one thing is the way of doing every thing, just as Lord Peter, in Swift's "Tale of a Tub," went about to persuade his two brothers, Martin and

Jack, that the brown loaf was beef, and mutton, and venison, and custard; and, as we are always very willing to believe ourselves, we are far more ready believers than Lord Peter's brothers.

Now, in all our cultivations of vegetables, there is none save that of timber trees in which the quality of the wood is any consideration; and there is, perhaps, none of them in which the wood is not actually deteriorated by the culture. In the grain plants that is decidedly the case. Straw is very inferior to hay, in strength, in flavour, and in every quality. The more highly, too, that the grain plant is cultivated, and the more abundantly it produces seeds—the grand object of the culture—the straw is always the worse. In the cold districts, where the crops of stunted oats are barely worth the gathering in, and would not be worth it at all in a place where labour was high, the straw is rich and sugary, whereas the straw of barley or wheat grown upon land in high condition is perfectly insipid. The former, too, is tough and firm, the latter soft and brittle, with little or no substance in it of any kind.

It is the same with all the plants. Our object is to obtain a certain part of the plant more abundantly, and in higher perfection, than it exists naturally, and we can obtain that only at the expense of the other parts. Compare a crab-stick with a similar portion of an apple-tree,—a hazel-twig with one of filbert, a black-thorn with a plum (if any or all of these be respectively the wild plant and the cultivated of the same species), and see how inferior the wood of the cultivated tree is to that of the other. "The wild wood" is just as superior in life as it is in strength. We have difficulty in keeping the cultivated plants "rooted in," and we have as much in getting the wild ones "rooted out." A very little observation of nature, and a few very simple reflections on that observation, might have shown us that that must have been the case; and had we taken that trouble, and very small trouble it is, we should never have gone about to cultivate timber in one plant, by the very process whereby we destroy timber in all other plants. Yet we have done and we continue to do that; for, grafting excepted, we breed oaks and peaches in the same ground, and much after the same manner. We may make some difference in the mould in which they grow; or we may choose that which we fancy will be the best for each; but we do not even that as observers of nature, at least as very attentive or close observers; for our good soil for oak is that on which we have seen large oaks growing, whether the timber of those oaks happened to be good or bad.

Let us return to our acorn and our embryo oak. That embryo plant, we shall suppose, is just beginning to be independent, by which time it may have stricken its root six or eight inches into the ground; for the oak remains much longer on the cotyledons than many other trees, and has also a root and rootlets ready for action in the earth. The cotyledons do not rise and partially take the form and probably perform the functions of leaves, as in many other plants; so that the action of the air is confined to the rising plumule, and the true leaves which it puts forth. When the acorns are sown by nature, they are sown *on* the surface, not under it. By looking back to figure A, on page 93, it will be seen that the sprout tends downwards, as if to reach the ground, while the acorn lies on its side upon the surface, though even then the little tubercle which is to become the tree keeps its apex upwards. It is evident, therefore, that that part of the process is *naturally* done in the air; and, though seeds are better to have the light excluded during what may be called the "fermentative" part of the process of germination, which is the earliest stage of it; yet in the case of the acorn, that is over before the shell is ruptured. The acorn from which the figure was drawn was taken from under the earth, not above an inch or an inch and a half indeed, but still under a firm covering, so as to exclude the light from it altogether, and the air nearly so, at least the free action of the air; and, unless by some effort, which it is not easy to see any agent capable of producing, the first leaves must have been formed, and the character of the oak determined, before the light could possibly have had the smallest effect upon it.

Now it is very much to be suspected that it is at this early stage that the mischief is done; and I am the more inclined to that opinion from the fact that the practical men seem to know very little about the process of germination, even in those seeds which they are sowing by thousands, nay, millions, every year,—there is not much, indeed, in the professed writers on vegetable physiology. The agency of light was not understood in the days of Grew and Malpighi; and though that agency be better understood now, there has not been *very much* added to the other branch of the science. Besides, the buried acorn does appear to make some sort of effort to come to the surface, and when it is there the cotyledons acquire a greenish tinge, which they do not acquire when buried; and that clearly shows that in their *natural* state, they give to the food with which they supply the young plant some of that preparation which vegetable matter receives from the action of light. The condition of all blanched and etiolated plants, compared with that of the very same species freely exposed to the air, clearly shows that *carbon and astringency*, the very things in which the perishable oak timber is deficient, are among the principal results of the operation of light. These additions appear to hinder rather than forward mere growth at the time, for an etiolated potato will rise thirty feet in the dark, whereas it would not rise as many inches if exposed to the light; but in the case of timber there is a gain in consolidation, and that is the main point.

The way in which the parts of the oak "come" farther shows the importance of light to it at the very instant the plumule begins to move. By that time the root has penetrated to a considerable depth, and is furnished with absorbent rootlets. The nourishment which these procure cannot be acted on by the light in them, and the plumule, being just beginning to move, has no leaves, so that if the cotyledons are buried in the earth, the oak must begin life with all the weakness of an etiolated plant; and if it begins without the carbon and astringency that are necessary for good oak timber, the timber of it must be bad, how long soever it may stand, or what size soever it may attain. Future treatment may make it grow faster or slower; but no future treatment can change the character with which it starts. If it starts good timber, it may be stunted or deformed, but it will be durable; and if it starts bad timber, it may be showy, but it can never be good.

Too rich and stimulating a soil may also injure the timber, even though the acorn, ruptured as it is, be exposed to the light; and if the acorn is buried, and the soil too rich at the same time, they will jointly injure the quality of the tree.

Cultivators sometimes forget (and it is often an unfortunate forgetfulness) that the healthy condition of a plant does not depend on the soil, the moisture, or the heat; that it does not depend upon all three jointly, or on the proportions that they bear to each other. To that part of the plant which naturally lives in the air there must be light; and although their artificial heat without light *may do* for those roots that are naturally under ground, it is extremely doubtful whether any substitute can be found for the beams of the sun. So, if there is artificial heat applied to the leaves, its action will be imperfect, and the quality of the plant deteriorated, if there is not the light of the sun along with it.

The soil, the humidity, the air, the heat, and the light must, like all causes which work jointly in producing an effect, be duly proportioned to each other; and when, in any combination of that kind, there is any one of the causes over which we have no control, we must regulate our measure of all the others by that. Now the light and heat of the sun are the only causes of the growth of vegetables which are without the control of man as to quantity, and the light is most exclusively so. We have not the smallest power over it, either in respect of duration or of intensity. Perhaps something might be done by means of mirrors, but they have not been tried, and they could not be used on the great scale. Indeed, it is probable that any attempts to increase the intensity of light by artificial means would do mischief rather than good. On sunny days, any additional concentration up, even to that which would burn the plants if dry, and boil them if moist, could be obtained; but then, as there is no calculating when it shall be sunshine and when cloudy, the transition from the artificially increased sunbeams to the natural shadow of clouds would be destructive. Thus the safe plan is to regulate all the other matters by the natural light.

Here a little fact presents itself, which is not wholly unworthy of notice. The first necessary that man has to find, by skill and artificial means, is food; and light, the agent in vegetation over which he has the smallest control, appears to have less to do in preparing vegetables for food than in preparing them for any other purpose. Succulent, pulpy, and farinaceous matter, the kinds which are most nutritive, are best when prepared out of the immediate reach of light. When part of a potato is above the surface, the light turns it green, and the taste is unpleasant. Allow it to be formed, and to grow altogether in the light, and it is not edible, neither will it make into starch. Its qualities approximate those of a leaf or a stone. Celery, and the other plants which are generally made use of in a blanched state, are unfit for being eaten if the light has free access to them; and generally where mere nutriment is the object, it is best attained in the shade.

Forest trees of which the cotyledons rise above the surface, and perform the functions of leaves, are not so much deteriorated by the nursery mode of sowing, as those of which the cotyledons remain below, but still they are all injured less or more, so that no planted tree forms timber equal in quality to that of naturally sown timber. The planted pines are a very striking instance of that; for in those districts where the natural pines afford very excellent and durable timber, the planted ones, even when the cones have been taken from the natural trees, are spongy and soft; and the "hearty" wood of them does not last much longer than the sapwood of the natural trees.

Want of the proper action of light at "starting" is not the only injury which timber trees sustain, by the way in which they are grown for the market. They are sown so close, that while they remain in the seed-beds they want both air and light. A seed-bed of pines, in the early stage of their growth, resembles a plat of moss more than any thing else; and when it is considered that, in the situation where they are native, the pines stand singly and are exposed on all sides to the action of very keen air, it must easily be seen that they cannot acquire their due strength when huddled together to the number of many hundreds on a square foot. Those who are familiar with pine forests, or pine plantations, must be aware that the seeds of the cones never germinate under the thick shade of the trees, and grow up so as to form an underwood in the forest.

Cones in abundance are produced every season, but they contribute chiefly to the food of the animal inhabitants, and it is only where a blank occurs, from the decay or the casual destruction of a tree, that young plants rise to fill it up. There are, indeed, few or no trees of which the young plants grow and form underwood, while the old ones remain filling the air above. Nor would it be in accordance with our general observation of nature if they did. The young of no tribe, vegetable or animal, are the destroyers of the old; they merely come on, in succession, when they are required; though the germes of all are exceedingly numerous, so that there never is room on a fit soil at the proper season, without the plant appearing to fill it. But man comes in with his nursery-bed; and though he cannot be said to overstock the country (for there can hardly be too many trees—and there are numerous and wide wastes in England, where it is disgraceful that there are not millions), yet the nursery-bed is overstocked, and the consequence is, the dry rot in oak, and general rottenness and want of strength in all timber.

The inferiority of planted timber is often attributed to the act of transplanting; but though that may have a considerable influence upon the growth, it cannot have so much on the quality of the timber. Trees that have long top-roots, as the oak has, cannot be transplanted without injuring them, and injuring them often to a considerable extent; but still that is only a mechanical injury, and can affect only the size and appearance of the trees.

The economy of vegetables has not been carefully and extensively enough examined, for enabling us to say what effects variously tainted atmospheres have upon forest trees, or even upon vegetables of any description; but enough is known to let us see that they must be very pernicious. The air of the sea is very hurtful to all plants that contain potass, though there are some trees that grow in the salt water, and actually invade the ocean. The mangroves that abound so much on the muddy shores of tropical countries, and form a sort of soil like the *Ultima Thule* of the ancients, neither land nor sea, are a remarkable instance of that, and the maritime pines of the Mediterranean shores are another. Metallic fumes are very hurtful to vegetation, more especially those that contain lead; and the trees near lead mines are few and sickly. Saline efflorescences upon the surface of the ground destroy vegetation; and works where sulphur is burnt into sulphuric acid, and those at which Prussian blue, and various other colouring matters are prepared, are, if possible, more so.

Now it is evident, whatever substance has an injurious effect upon trees in an advanced stage of their growth must be much more injurious to them at the very commencement. But the commercial advantages of having nurseries for forest trees, as well as other plants, near great towns, are so many, and so much more obvious than the injuries that may thus be done to the trees, that many of them are in very tainted atmospheres. Ground there is high rented, and the plants are in consequence huddled together as closely as possible, both in the seed beds, and after they are transplanted. Still, with the rich soil and skilful management in such places, the trees rush up quickly and look well, so that they are more "taking to the eye," and fetch higher prices, than if they were to produce better timber. Indeed, those plants, inferior as their timber must be, are actually the most acceptable to the immediate planter. Most species of forest trees are so long in coming to maturity, that the grand incentive to the planting of them is ornament, and not use. Even the man who accumulates for posterity, in reality seldom does so in his own feeling of the matter; for he who leaves the most to others when he quits the world, did not collect it for them, but for himself—for the gratification of his desire of possession. The man who plants wishes to have something to look at, and to have it as speedily as possible, and that, with the other circumstances that have been noticed, conspires to cover the rich districts of the country with growing rubbish, which, when it comes to be cut down, is fit only for firewood, and very inferior for that. To obtain good timber by cultivation appears then to be very difficult, if not altogether impossible; but still it is highly necessary that the causes should be known. But let us return to the merely descriptive part of the subject: "the hundred oaks in a hundred years."

Well, the plant of the first year continues to send down a root, and push out rootlets, and to elevate a stem, put out leaves, and show the germe of a bud or buds, until it has attained a certain size, and then it pauses for the year. During the whole time of its growth, the whole consistence is soft and juicy, and though there are vessels in it, they are not very easily seen by the naked eye. But when the enlargement of bulk ceases, a new action takes place, the whole gradually becomes more firm, and if it is cut across, the pulpy substance will be found separated into a central piece and a ring, with an intervening ray of pellicle, as well as another on the outside.

The centre piece is the pith, which, as the season advances, renders up its moisture to the other parts, becomes spongy, and shrinks in bulk, as if its object were accomplished. The ring of pellicle next to it is the young wood, which may be observed shooting as the season advances, the external ring is the bark, and the pulpy matter between is the substance furnished by the roots, and prepared, and also in part furnished, by the leaves out of which the wood and bark are forming. All these parts are exclusive of the epidermis, or mere external covering, which merely serves to protect the other parts from external interruption or injury. [By-the-way, the possession of a protecting epidermis is one of the best popular means of distinction between organic and inorganic beings, in those obscure species in which they resemble each other the most.]

At the close of the season, the whole of the *cambium*, or changeable pulpy matter, is formed into wood and bark, which adhere firmly to each other at the line of separation; and when that is accomplished, the leaves are of no further use, and they change colour and fall off; for though there are vessels apparently of a woody texture in the leaves, they are not the product of the same action as the wood of the tree. That action extends only to the base of the *petiole*, or foot-stalk of the leaf, and as a pellicle of epidermis gradually forms upon that, as it becomes complete, the leaf separates without a wound. Whenever indeed the action of a tree ceases, whether naturally at the season when it passes into repose, or in consequence of an external check, such as transplanting it while in leaf, the last action of the tree—the effort of nature by which it preserves its vitality—is the formation of that epidermis between the twigs and the petioles of the leaves. If the tree succeeds completely in forming that, and the withered leaves fall off spontaneously, or can be removed by a touch, the tree may be considered as safe, though it may remain a long time before positive action again begins; but if the withered leaves remain firmly on the twigs, it is a sign that the tree is affected in its general action, and that it will "die down" in those parts to which the withered leaves adhere, if it does not perish altogether.

When the action of the leaves ceases, that of the absorbing rootlets ceases also, because the matter which is taken in by them is not convertible into wood or bark without the co-operation of the leaves;

and if the leaves are stripped off, or eaten by caterpillars, or destroyed by any other means, the only effort that can be made by the food from the root, is the pushing out of new leaves and buds; and if these are picked off as soon as they make their appearance, no more wood is added to the tree. It is by availing themselves of this property of trees that the people of China contrive to get several successions of leaves from their tea-plants in the course of the season. But as the first crop comes after the winter's repose of the tree, and when the roots are in the greatest activity, that crop is fine and more highly flavoured than those that are gathered later in the season.

As in most trees the roots are put out before the stem at the commencement, in each year's action, the rootlets, or absorbent vessels of each year, are formed before the leaves of that year. For that reason, the autumn or winter is a much better season for planting trees than the spring, provided those trees are intended to show leaves in the ensuing summer. Indeed, if the transplanting is delayed till the rootlets are fully formed, the tree is in as much jeopardy as if it were completely in leaf, or even in more. The action of the rootlets ceases sooner than that of the leaves, so that they pass into the state of winter repose at an earlier period of the autumn.

During the first winter after it issues from the acorn, the oak of the first year, with the loss only of its leaves which have been cast off, remains inactive till the return of the season. When that comes round, the elaboration of the second oak is begun.

The growth of that oak, though still an interesting operation, is not quite so wonderful as the first, for there is a basis of both wood and bark for the second one; and the vegetable action is expanded over the whole surface where they come in contact; whereas, the first year, the wood and bark were not begun, and the vegetable action is confined to a mere point. Still the exciting of the former oak, so that it shall produce the new one, is a very wonderful matter; nor is it easy to understand how, or possible to tell why, it takes place. The cause is beyond human scrutiny, but the mode is well worthy of observation.

When the return of the genial season has brought the tree to a certain degree of heat, it begins to act; and the longer that the tree stands in the autumn before its ripening of wood is completed, and the leaves are shaken off, the longer must the spring in general advance before the part of the tree above ground comes into action. There are exceptions to that, but they are characters only of peculiar species

The underground action begins first, and rootlets, which have the same period of action as the leaves, though it begins and ends sooner, are formed to a considerable extent before the tree itself shows any signs of reviving. The rootlets of the former year are not cast off like the leaves, but are converted into "root wood," which, from the circumstance of its being covered from the light, does not contain so much charcoal as the stem and branches. The sap ascends through the vessels of the wood, and in all probability dissolves the peculiar matter which is in the cells, and takes it into the current; for that matter is soluble in water, and as there is less and less of it in the wood as that gets older, it is probable that it is a sort of store prepared towards the end of each season, to assist in the action at the beginning of the next.

As the spring action begins in the lower part of the tree, if any part of the trunk offers more resistance than another, from the bark being tightened or what is called hide-bound, or any other cause, the tree, if it be of a species which puts out lateral buds, is apt to throw out suckers at the roots, or new shoots on the stem and large branches, and these very much injure both the growth and appearance of the trees. These are very apt to appear on fruit trees, and indeed on all trees that are cultivated out of their natural habits. But when the tree is uninjured, as it has every chance of being in a seedling oak of the first year, the whole tree soon comes into action; the buds are expanded into leaves, and lengthened into twigs. After the tree has begun to act, and thence till the leaves have attained their full size, the juice or sap of the tree is in the wood, and the bark is comparatively dry. But after the leaves have attained their full size, and are in complete action, sap appears in the bark as well as the wood. The sap which then appears is not however the same as that which was in the wood before the leaves came on. The air, heat, and light have all had an influence upon it in the leaves, and fitted it for the composition of the new substance.

In the young shoots, those that have been prepared the same season, the process is the same as it was in the first oak; but in the other parts, the prepared juice spreads itself between the wood and the bark. First in a state nearly fluid, but it gradually becomes a little granular, then fibrous, and it ultimately divides into wood and bark in the same manner as that of the former year; and when that has been completely performed, the leaves are "healed off," and the tree passes into its repose as before. The result of the annual action has been to case the former tree, roots, and all, with a new layer of wood and bark, and to lengthen it by a twig at every bud. If we could by any means separate the two trees by pulling the first out of the second, as an instrument is pulled out of its case, we should have a sight of two years' progress of the oak, and only the leaves would be wanting to give us the whole of what had grown from the acorn during those years.

The third and every succeeding year is merely a repetition of what took place during the second, only the action of each year is on a larger scale than that of the preceding year; and the additions become gradually greater and greater till about the middle period of the tree's duration, and then they gradually become less and less every year, till at last the action ceases, and the tree dies. After that the remains of the tree continue for a longer or shorter time in the organic state, but they at last yield altogether to the laws of inorganic matter, and mingle with the general mass of materials for new productions.

But there still remains the most curious part of the whole matter, and that which forms the grand characteristic of organized beings, when viewed, not momentarily, but as existing in time. However simple the organization may be, it is so constituted that it leaves a memorial behind it—a monument of its living action, as well as of its material substance; and thus, though the individual yields to that dissolution which is the law and the destiny of all created things, and yields the more readily the more numerous that its parts are, and the more delicate the operations which they have to perform, the life is continued. Not that it is absolutely secure—proof against every contingency; for nature can separate every thing that nature combines; and as the succeeding race is intrusted to the world in the state of an embryo, and depends upon the action of external causes for its development into the matured being; a suspension of these causes, or a change in the mode of their operation, may cause the embryo to remain inactive; and if that happens in every instance, the race may perish, either from any particular country, or from the world altogether.

Those causes of more than ordinary dissolution of organized being, whether vegetable or animal, are very obscure portions of natural history. We are unable to see them in operation, and the dead remains have no story to tell, excepting only that they have been living at some time or other. It sometimes happens that trees of a certain species will perish in a district all in the same season, though no difference between that and other seasons can be observed. One year all the specimens of the dark-leaved American beech in the plantations of a district in Scotland died simultaneously, while there was no apparent injury to trees of any other kind. Seals have also in some seasons been observed floating dead on the sea in incredible numbers; and their dead bodies were so thickly strewed on some parts of the north coast of Scotland and the northern islands that they tainted the air. Many analogous instances of mortality in particular tribes, for which no cause could be, or at least has been, assigned, are recorded; and because nothing is known of the means by which they are produced, those mortalities are, in the case of animals, called EPIZOOTY, that is, "on the life;" because they, as it were, fall on the life itself, without any apparent derangement of the organization, or other disease of which the symptoms can be observed.

But there is also a gradual wasting away of races, with just as little apparent cause; though that must not be considered as extending to all cases in which tribes diminish in a country. The wolf is now extinct in the British isles, and the eagle is rare, excepting in the very wildest districts; both of these have been hunted, and besides that, lonely places are their natural haunts. Heath, too, has diminished upon the uplands, and rushes by the swamps; but that has been before the plough.

One of the most remarkable instances of gradual decay which has taken place in these islands is that of the forests, more especially the pine forests. It has been said that these have been cut down, or set on fire by invading armies, or gradually consumed by the workman's axe in times of peace. But though reasons such as these satisfy those persons who wish for nothing further than to have something to say upon a subject, they cannot satisfy the attentive observer of nature. Those decays of the forests have taken place in situations where no invading army ever was or could come. Then as for the conflagration—it would be a powerful flame that could reach from Caithness to Orkney, or from Skye to the Long Island; nor would it be an ordinary fire that would burn across the summit of a lofty ridge, and down the other side, especially when, as must have been the case when the hill-sides of Scotland were close forests and the bottoms pools of water, the summit of that ridge was clad with perpetual snow. Besides, if the trees had been burnt, the charcoal would have been found, for charcoal is one of the most indestructible of substances. The charcoal of the fires at the signal posts already alluded to, remains in great quantity—indeed, it is that which most simply and effectually confounds those who will have it that these trifling fusions of stone by common fires and wood-ashes at the surface are volcanic operations that have long ago taken place in the bowels of the earth; and if the ashes of a few billets fetched from its skirts have remained, it would be passing strange that the charcoal of the whole *Sylva Caledoniæ*, the conflagration of which, if it happened, must have been more recent, should be entirely lost.

But the fact is, that the pine forests both of Scotland and the Scottish isles, and of Ireland, have been buried, and not burnt. The remains of them are in the bogs of both countries, so abundant as to serve in many cases both as fuel and as a substitute for candles; and so sound and fresh as, in not a few, to answer the purposes of domestic economy.

In the natural history of vegetables, those facts are important in two respects; first, they show that there are certain periods at which forests fade off, both by the old trees dying and the seeds ceasing to germinate; and secondly, that death is not owing to any gradual deterioration of the timber, in that of one succession becoming weaker than another, till the last is so soft and spongy that the weather breaks it up; for the remains of the trees in the peat bogs, and they are met with many feet below the surface, are not inferior to the very best of those that still remain at a few points on the surface, and even provide a succession, though with comparatively small and, as it is said, gradually diminishing additions. No matter what the trees are, they are perfect in their interment, according to the known durability of their species. The sweet woods, as they may be called, from having little pungency, or astringent matter, such as the birch, the alder, and the hazel, have form down to the minutest twig, but they have no consistency, while the oak and the pine, although consumed in the alluvium, in proportion to the time they may be supposed to have lain, as well as to the peculiar nature of the accumulation over and about them, are perfect in the hearty wood.

That latter fact is of some importance with regard to the *rot* in the planted timber; for, if it could not be shown that "the last race" were as sound and good in their quality as any of the others, the nurseryman might meet the strictures of the observer of nature, by charging the rot on the trees, and not on the mode of treatment,—by saying that the weakening of the timber is one of the symptoms of the fading of native trees from the British soil. But the facts render such a plea nugatory.

As little can it be said that the forests perished because the trees became barren—ceased to bear fruit after their kinds; for the remains of fruit, in all cases in which they are of such an imperishable nature as that they can last in the cold and humid bog, are as well preserved as the trees. Nutshells are in some bogs, the only memorials of the hazel coppices; and they are found in thousands in places where there is not now a native hazel bud for twenty miles in any direction, although there is abundance of room which has never been disturbed by cultivation. At one place, in the parish of Monikie, in Forfarshire, there stands a lonely fortilage, the Hynd Castle, upon a mound of its ruins, and surrounded, or nearly so, by a peat-bog, which, from the immense number of nutshells in it, must once have been a hazel copse,—or rather it has been a wood with hazel underwood—the demesne, or park of the fortilage, perhaps, for there are the remains of large forest trees in it; and from the remains of vegetation, the form of the surface, the keenness of the air, and the purity of the water, there is great reason to believe that it has once been a very beautiful place. Tradition carries the history no farther back than the reign of the last ghost, and it had abdicated before the beginning of the present century. The eyes of the most prying antiquaries can trace nothing but the marks of the chisel in the squared stones with which the fragments of the walls are cased; but that is something, inasmuch as there is not now in the neighbourhood, or even in the county, a freestone of the same colour (old red sandstone) that will show the marks of the chisel so perfect after one century. The walls have been grouted in the central parts, but whether they are Roman or not cannot be determined. There are camps of many paces about, some square, with the usual traces of the Romans, and others oval, or round; and there are (or used to be) abundance of flint arrow-heads, which the old women sometimes described as flying about in the twilight and killing the cows, but they have lain still for some years.

The fields around are now mostly under tillage, and yield a scanty and precarious crop to a most laborious culture; but their natural productions were on the humid places bent, and on the dry, brown heath and white moss, or white moss and brown heath, according as the soil was less or more bad. These were symptoms miserable enough to have succeeded to forests and groves; and if we could fill up the chasm in the succession, we should have at least one satisfactory portion of the history of vegetation; but we want the facts, and so conjecture would be useless.

The mixture of lime in the fallen part of the castle had nursed the henbanes and hemlocks, and other lurid plants which love such places, and the decay of these had brought on a coat of soil. About fifty years ago, the little mound was enclosed and planted, chiefly with Scotch firs, but with a border of deciduous trees, and a few interspersed among the Scotch firs. For a time they all grew luxuriantly; the firs made shoots of a foot to two feet every year; the laburnums hung out their racemes of golden yellow, the mountain-ash made the summer fragrant with its flowers, and the autumn gay with its berries. The thrush and the blackbird came with their mellow songs, the little birds with their more lively notes, and the wood-pigeon moaned from the deep covert of the pines. The magpie and the jay, too, came to take account of the spare eggs; and weasels, and even a polecat, made their appearance. In short, the place became a little oasis in the desert,—a thriving miniature world, both vegetable and animal; and the promise that it gave led to the planting of many square miles of the moors. Meantime, an impulse was given to agriculture, by the farmer being pulled on to activity by high prices, and spurred in the same direction by high rents, so that the marshes were drained, the wastes improved, and a more kindly appearance, and certainly a more mild and uniform climate, obtained.

Now it was generally supposed, and anybody but a very attentive observer of nature would naturally have supposed, that matters were in the fairest train for a well-wooded as well as agriculturally improved district; and so it seemed for some ten or fifteen years. But, alas! the *epidendric miasma* (as those who believe in aerial infections would probably call it) was in the air, and the epidendric poison was at the roots; and never did dry rot consume a beam of bad oak more certainly, or even more rapidly, than all the fair promises of future forests were swept from those moors. In a whole mile a clown cannot now find a rude walking-stick; and even the little grove by the ruined fortilage has departed without axe or fire, and the ruins are as bare as ever.

Innumerable instances of the same kind might be given, all tending to show that we have "much to learn," and therefore must observe much before we come to any certain general conclusion, about the germination and the growth of vegetables. But vegetables are, as it were, the foundations of our whole cultivated productions, as without them we could neither have animals nor implements. Hence, if we are to have any claim to the title of useful observers, we must so observe as to keep those general relations always in view. It is not enough that we see a beautiful flower, or any other attractive appearance; and that we give it a name, local or learned, and set down every particular in the form and arrangement of its parts, the tints of its colour, its taste, its odour, the time of its appearance, the length of its continuance, and the period at which it is gone. All that is but an amplification of the name—a resolving of that into those parts of the sum of which in their union it is the sign; for, if we *understand* the name, it will bring all those particulars to our recollection. To take a simple instance, the name "daisy" will suggest to the mind all the observable properties of that flower, which are known to the person by whom that name is pronounced, whether it be restricted to the little daisy with the crimson tipped petals, which has been called "daisy," or "day's eye," from its closing at night and opening in the morning, or to any of the other *compositæ*, which are popularly called by the same name.

We must bear in mind that, though the present momentary view is necessary to the obtaining of knowledge, it is not useful knowledge taken merely in itself. Observations bear nearly the same relation to knowledge that acorns have to oaks,—they are the seeds of knowledge, and we can no more have the tree of knowledge without first having the seed than we can any tree of the forest; but in the one case, as well as the other, the seed must grow before we can have the tree. A man who continued merely gathering acorns all his life would not be any more in possession of an oak than a man who never saw an acorn; and just so a man who kept all his life looking at mere appearances would have no more knowledge than a man destitute of all the organs, or all the means of observation.

But if a man observed an acorn *growing* it would be quite a different matter. If he noticed the place and the circumstances under which it began to grow and continued its growth, he would have no more to do than to place another similar acorn in circumstances exactly similar, in order to make sure of obtaining another tree.

Even then, the perfection and certainty of the success would bear wholly on the similarity, both of the object and the circumstances; and therefore it is in that that the value of observation consists. In all natural occurrences there is, to our perception, a little play—the circumstances may be a little different, and yet we may *observe* no difference in the result, let us scrutinize it as we may. But that is owing to the limit of our observation being always within the limit of nature, so that when the difference of the circumstances (all of them being known) eludes our observation, so does the difference of the result.

Upon difficult subjects it is astonishing to what an extent the multiplication of these little differences will in the end mislead us, if we do not keep the whole chain carefully in view; for in twenty successive occurrences we may attend carefully to each, and compare it with the one immediately before it, and find the very same apparent similarity in each of those comparisons; and yet the differences, unseen in the individual cases, may so mount up in the aggregate as that the last may be unlike the first—or even the very reverse of it. With careless observers, who are satisfied with a few of the external and more obvious circumstances, that is much more frequently the case; and as they who publish their opinions or conclusions to the world are not always the most close and accurate observers, that is the reason why so many errors have crept into the science and the systems of natural history; and as many of these errors are fortified by high authority, and all of them by some authority (for there always are people so forward in their belief that the very fact of being in print is an authority to them), they are very difficult to be reduced.

The only means of doing that is by going back to the beginning of the series, that is, to nature itself; and hence the superiority of knowledge which we get from our own actual observation to knowledge of any other kind. But it is only a little way that that will carry us without assistance. We must see the whole succession; and the cases in which we have that opportunity are few, while those for which a whole lifetime is too short are very many. It is in those cases of which we can personally observe only a part that the co-operation of society is of much value. We have the record of the past for that part of the succession which happened before we were born, and we have the intelligence of the present time for that which takes place when we are not present; and thus, though we cannot, in these cases, have so certain knowledge as we have of that which falls under our own immediate observation, we have it as well established as it can be by testimony.

Cases such as that of the entire destruction of a whole tribe, or species, of organic beings, do not come even within the scope of testimony; for history, being chiefly confined to the transactions of men, and, generally speaking, even to a very limited number of them, is silent with regard to the others, even in those instances which from the circumstantial evidence we would be led to conclude had fallen within the period over which it extends. In the instance above quoted, there is every circumstantial proof that the castle was built while the neighbouring ground was wood and copse, and not peat-bog: and the appearance of a castle with hewn revetments and grouted walls bespeaks a degree of civilization higher than that of any people altogether without a history. But still there is not a single trace remaining; and that is at once a proof that those people neglected the observation of nature, and of the loss which we now sustain from its being so neglected —and that, not at one remote point merely, but at all points. We have, for instance, the history of the inhabitants of London, the more remarkable buildings, and even the very streets, but where is the history of the Thames and its valley? and yet both may, indeed must, have undergone many changes since the Roman legions first appeared on the banks of the river. So also every river and river's valley must have changed; and those changes must have had an influence on the weather, the climate, the seasons, the plants, the animals, and the whole natural history of the country, in so far as that can be affected by the changes of time, or those of any thing that time changes. But for the want of observation and record, the whole of that is lost. We are consequently ignorant of the great natural monuments which are in progress in our own country; and as these must have an effect upon every operation of art which is in any way connected with plants or animals, or to which the state of the atmosphere has any relation, we must be, in so far, at the mercy of guesses in the conducting of these. That has passed, and we cannot help it; but it ought to be a warning to us, and induce us to examine the connexion and watch the succession of every thing we see.

The vegetable tribes are perhaps the best subjects of observation for those who make an amusement rather than a business of observing. The weather is a wayward thing, and we want many of the elements which would be necessary to form the little that we do know about it into a science. Animals, too, in their wild or natural state, the only state in which they are of much value to a genuine observer of nature, are, except in very few species, seen only by snatches; and very much of what is said and written about them is inference, and not fact. In many cases, too, it is very imperfect inference, for it is contradicted by the fact, whenever that is observed. The error consists in attempting to found a fact upon an inference, instead of drawing an inference from a fact, which is about as absurd as if we were to attempt to melt snow by cold, or freeze water by heat.

But in the case of vegetables, we can, in the majority of instances, observe the entire succession from embryo to embryo, not only in the course of a lifetime, but in the course of one year; and where we cannot do that with the individual, we can do what conduces even more to our information. In most species of plants the successions follow each other so closely that, unless in some of the animals which appear only for very short periods of the season, we can have all the stages of growth before us at once, from the first germinations of the seed to the final decay of the old plant. In a thousand plants of the same species we can thus observe a thousand points in the history of the same plant; and thus we have, before our eyes, as clear and satisfactory information as if we could work the seed up to the plant, or change the plant back to the seed by direct experiment, in the same way that we can dissolve or form a chymical compound. It is true that we cannot, in the case of the vegetable, keep the substances out of which it is immediately compounded in boxes and bottles, or pour the water directly out of a pitcher, or apply the fire directly by a furnace, in the same manner as we can do in the chymical experiment; but still we can "watch the progress" as closely in the one case as in the other; and we have no more knowledge of the ultimate principles of chymical union than we have of vegetable assimilation.

From what we do observe, however, we can accelerate, retard, and otherwise modify the action of vegetables over a very considerable range. It is upon our power of doing this that all cultivation, whether of the fields, the garden, or the forest, is founded; and that cultivation may be said to be the groundwork of all that we do and all that we can possess. Our food is either directly vegetable or obtained by means of vegetables. The corn, the pulse, the roots, the buds, the leaves, and the fruits, which, in their immediate substance, prepared or unprepared by art, human beings use for food, are very numerous; so much so that the list of those which are familiarly known in the British markets would fill a considerable volume; and when those that are used in other countries are added, the number is almost incredible.

When a number of species, having those appearances, which lead botanists to consider them as "allied," and form them into what they call a "natural order"—(there are no *orders* or *classes* in *nature*, for all the productions of nature are *individuals;* and, though there be *varieties* in the successions of individuals, sometimes produced by circumstances which we can imitate and sometimes not, the succession is in the *species*—that is, the plant bears more resemblance to the immediate parent plant than to a plant of any other kind)—there are often very contradictory or opposite properties in them. Thus, the *Jatropha manihot*, which has been mentioned as forming the bread of the natives of Central America, not only belongs to an exceedingly poisonous family (*Euphorbiaceæ*), but is, when raw, a deadly poison. The various spurges, and other members of the family which are found in England, are all acrid; and their milky juice, which blisters very delicate skin, is used to remove warts and other callosities. Some plants of that family yield valuable, or at all events powerful medicines, such as *castor* and *croton* oils; but some of them act too powerfully for being used even in the smallest quantity. The perennial mercury, or "dog's cabbage," said to be so called from dogs preferring it to any other plant, when they physic themselves with green vegetables, and which grows in the woods of some parts of Britain, the male plants usually in one patch and the females in another, is eatable, though still aperient when well-boiled, but poisonous raw, or even roasted or fried. That property is so general, that when experiments are made as to whether new vegetables may or may not be used as food, the safest plan is to boil them, and throw away the water in which they are boiled.

One of the most curious orders of plants in that respect is the *fig tribe*, or, as they are sometimes called, from comprehending the different species of bread-fruit, the *bread-fruit tribe*. Of fruits well known in England, the fig and the mulberry belong to that family; and though the fruit of these be eatable, the juice of both, that of the fig especially, is a poison. This family are very numerous in the warm countries, and some of them are highly interesting. The bread-fruit of the South Sea islands (*Artocarpus incisa*) is well known from the descriptions of the voyagers; and though its qualities have been extolled far beyond what they really deserve, it is a very interesting and, in those countries, a very useful tree. But as that tree furnishes bread in one part of the world, trees of the same family yield milk in others. There is a sort of animal principle, not a principle of animal life, but an affinity to animal matter, in most of the family. That is contained in the substance called *caoutchouc;* familiar to most people as "Indian rubber," remarkable alike for its elasticity, its insolubility in water, and the difficulty with which it can be cut. On these accounts it is now extensively used in the arts, not only for its original purpose of effacing black lead from paper, but as an ingredient in varnishing, in making water-proof cloth, shoes, and numerous other articles. Though the whole family contain more or less of that substance, there are many of them, such as the mulberry and the common fig, in which the quantity is so small that it is not worth extracting. But although the substance is procured in great quantities, the plants which yield the greatest abundance are not very clearly determined. Indeed, it should seem that the plants which produce the greater part of the caoutchouc of commerce belong to other families. That of Sumatra, and the other islands on the south-east of Asia, is obtained from some species of *Urceola*. One of them, the elastic, is very plentiful in Palo Penang, or Prince of Wales' Island. It grows to about the thickness of a man's arm, and is cylindrical, with pale bark, very much cracked. It runs along the ground, striking roots, but very seldom putting out branches; and it will run in that way to the distance of five hundred feet; but when it encounters trees, it climbs up the stems and spreads among the branches. The quantity of juice in an old plant amounts to nearly two-thirds of the entire weight of the plant. When recent, it very much resembles milk, and when consolidated it is Indian rubber.

It is not very clearly ascertained to which of the two families the *Palo de vacca*, or cow-tree of South America, belongs; but the people resort to that tree, fetch the juice in pitchers, and use it for the same purposes as animal milk. Nor is it a little curious that, in those parts of the world where, on account of the parching up of the grass, the milk of domestic animals is not so easily procured as in more temperate climates, there should be an abundant, and by no means a bad, substitute in the juices of trees.

But besides their eatable juices, these plants have a very deleterious principle, which in some of the species is a very virulent poison. That principle is *Strychnia*, so called from being first found in the kernels of the *Strychnos nux vomica* and *Strychnos ignatiana;* but it is also found in the *Upas*, and in other species: and it is not a little remarkable, that while some of the species of Strychnos are so deadly, others are valuable medicines. These coincidences in some respects, and differences in others, should teach us to be cautious in not generalizing to any of those artificial tribes of organized being any property which we have discovered only in some members of that tribe. The products of organization are quite different from both mechanical and chymical results. We cannot repeat one of them, and therefore we can never safely say that any one of them has a property, unless that property has actually been discovered in it.

Still the poison, or the other active matter that may be in the plant, is well worthy of our study; because, generally speaking, it is in the plant itself, and not in the food of the plant. In whatever part of the plant it may ultimately be found, whether in the root, as in the jatropha; in the juice, as in the spurges; in follicles, with prickles on the bark, as in the nettle tribe; in the oil of the seeds, as in the violen; or in their substances, as in nux vomica—it is always found in one part of the plant when in the embryo state. That part is the embryo itself, when the habit of the plant is such that that is considerably developed in the seed. When that is not the case, the most virulent property is in the tunics or coats; and that is the case also with roots, and it is the same whatever may be the nature of the poison. In the pulp of the peach there is not a trace of that prussic acid which scents the flower and flavours the kernel; the pulp of the yew-berry is harmless, and probably so are the cotyledons, if the embryo were removed, as that is the case with many of the seeds of the *Euphorbiaceæ*, and other tribes. In the potato, the poisonous quality, which, though not very strong, is still a poison, is chiefly in the tunic or skin, or immediately under it; and the same is, in all probability, the case in jatropha. Even the common turnip, which belongs to an order of which probably none are poisonous, though some are very acrid, has the rind of the bulb far more pungent than the bulb itself.

The uses of the plants classed under the fig tribe, and those resembling it, are exceedingly varied. Many of them, as has been stated, furnish food, and many more, from their active nature, are medicinal, and others form articles of clothing, either through the medium of something else, or directly. The white mulberry is the principal food of those silk-worms which every year spin so great a quantity of the most delicate and also the most beautiful substance which is employed in the loom. The paper mulberry, which, if it does not agree with the order in all particulars (and the agreement or disagreement of plants with an order or a genus in any system depends in a great measure upon that system), agrees with it in many, is used, as the name imports, in the manufacture of paper, and also of a species of paper cloth. The banian-tree, or Indian fig, gives habitation to numbers of the lac insect (*coccus lacca*), which furnishes the gum lac of commerce, and no doubt elaborates it out of the substance of the tree, in the same way that bees elaborate wax out of the juices of many plants. The wood of the yellow mulberry (*morus tinctoria*), which is a native of the West India islands and of Brazil, furnishes *fustic*, which is so well known as a yellow die: and there is little doubt that many others of the family, especially the cratons, the juice of some of which is of the colour, and nearly the consistency of blood, would form both die-stuffs and pigments.

These particulars have been mentioned with a view to show how much information, and how many useful substances may be obtained from a single family (and that one of which the properties are but slightly and imperfectly known), out of the many thousands of vegetable productions. But, apart from the applications to the purposes of art, there is a great deal of instruction and pleasure in the mere watching of the progress of the vegetable; and they who cultivate vegetables, and feel interested in so doing, have really more pleasure in the growth of the crop, whatever it may be, than in the profit which it brings when they carry it to the market. It is impossible to see a farmer surveying his fields, or a gardener his fruits, flowers, and vegetables, without being convinced of that; and it is not very easy to view such a character so occupied, without envying him his occupation. Yet why should we do the latter? In as far as knowing it is concerned, any one of the kingdoms of nature is every man's kingdom, and may be any man's kingdom if he will but come and conquer it. The conquest is a conquest without labour, too, for we have only to wait with patience, and notice with attention, and nature does all the rest.

We have no need for pausing times either—of waiting till nature is worthy of our notice in her vegetable productions. The winter is a time of repose to many of the plants; but it is the time during which others are in the greatest activity. The forests are leafless, and the fields are bare; most of the plants that people the waters in the warm season are down in the mud at the bottom, and altogether lost to the eye, and the few vegetables which remain are faint in their colours and feeble in their odours. But still, the winter mosses, and many of the lichens, to which cold is more congenial than heat, and which are brittle and crumbling during the hot season, are in the prime of their vigour in winter; and, perhaps, by their agency the very first steps in the progress of fertility are accomplished. If there is but a rock, or any thing except loose and dry sand, and moisture, and a temperature the least shade above freezing, there is certain to be a moss or a lichen of some description or other; and however untoward the circumstances are, that lichen or moss will keep growing until it forms something like a vegetable mould, in which other plants will in time take root.

Those mossy coverings which spread and thicken upon the surface in cold places and cold weather protect the naked parts of the earth from the severe action of the cold; and answer, in places where the snow does not lie, nearly the same purpose that the snow answers where it does. In some respects, indeed, they answer more important purposes. They are most abundant in humid places where the snow does not continue, though it occasionally falls; and there they protect the earth against the alternate action of the rains and the frosts. If the earth were bare, the frost which is of much service to the vegetation of the coming season, by breaking down the clods that have been indurated by the drought of summer, would, in the course of one variable winter, render the whole so soft that the rains would wash all the mould of the heights into the valleys, and the portion of land fit for bearing vegetables of any kind would decrease every year. Nor would there be merely a decrease of the productive surface, there would be a deterioration of the portion left. The soil which immediately produces the mosses, and lichens, and other plants of the high and cold grounds, is not adapted for the production of the soft grasses and flowers of the valleys: and these valleys are not suited in climate for the upland plants, though those plants and the soil in which they grow both tend to cool the climate and bring it nearer to their native one. Thus, if these plants were to "give way" in the autumn, as is the case with many of the plants lower down, the meadows would annually be strewed with unwholesome earth, which would in time destroy their fertility, and they would become bogs and quagmires. But the matting of mosses and lichens keeps the soil together, and equally prevents it from being washed away by the rains, and blown away by the winds; so that when the cold weather comes the soil is not much lessened in its quantity, while it is softened and divided by the frost, and thereby fitted for the action of the roots of those plants, the stems of which die down annually. In plants of that kind, more especially in those that have fleshy or bulbous roots, which most of the plants that die down in the winter in cold places have, the crown of the root is usually the vital part, so that if that sustains much injury the plant is killed. Now the winter crop of mosses is of great service to plants of that kind. It is not the absolute temperature that kills plants, it is the greatness and especially the rapidity of the changes; and if the operation could be performed gradually enough, it is possible that any plant (even those which are kept in the artificial heat of stoves in this country) could not only bear the frost, but actually to be frozen without much injury. The progress of ordinary freezings and thawings is, however, rather rapid for the safety even of native plants, unless the roots are deep in the soil—deeper than soil is usually found to be in cold upland places. Gardeners find great protection to fleshy roots in the ground, from covering them over with straw and litter before the frost; and the moss and lichen act, in those places where they come, as if they were a coat of natural litter.

Owing to those protections, the spring flowers, though not very abundant, come much sooner in those mossy places than one would expect, though they neither come so soon nor are so fine in their qualities as those in places which are covered with snow early in the winter, and remain in that state till the spring. If the snow lies long on a spot where the roots are, the snow-drops will absolutely push their little starry cups through it.

But these humble crops are as serviceable in the warm season as they are in the cold. Many of them absorb moisture at their whole surface, and all of them retain it in their thickly matted forms, so that they keep places in a moist and fertile state which, but for them, would be entirely parched. When the heath has been burnt on a mountain surface, or that surface in any other way laid bare, it is truly astonishing how speedily it becomes clothed with green mosses. These keep the surface cool, whereas the rays of the sun, beating upon it, would heat it like an oven, and it would be converted into blowing dust; and when summer rains did fall, they would be instantly removed by flowing off and being evaporated; and although the moss presents much more surface to the air than that of the soil on which it grows, it is so much cooler that the evaporation from it is considerably less. The absence of mosses is among the reasons why sandy and chalky places are so soon parched up.

But although, within certain limits, the growth of those plants is good, yet, when those limits are exceeded, it becomes an evil. For, though their tendency be to mitigate the severity of both heat and cold, they do in all cases produce cold by making the total evaporation greater than it otherwise would be. They take off the extremes of evaporation during the great heats, but they also occasion evaporation at times when otherwise there would be little or none, and thus they keep a moist atmosphere all the year round, and so where they abound the climate is less healthy. It also rains much more frequently, because that air, being always nearly saturated with moisture, is of course disposed to part with that moisture in the state of rain, much more readily, that is, with much less atmospheric action, than when the degree of saturation is less. Consequently they are injurious to cultivated grounds. To the annual crops they, indeed, do small harm, as they attain but little size, and are under the shade of these. But on grass lands they are much more destructive; and would in time change a good soil and climate into the opposite. The finest grasses, though they thrive well with occasional irrigations, decay when they are too moist, as they always are in old pastures that have got mossed; and if the surface had little drainage, the mosses would, in time, dislodge all the grasses, and produce a surface not well adapted for any kind of culture. When land has once come to that state, the only, or at least the effectual, means of arresting the mischief, are the spreading of alkaline substances, trenching, or paring off and burning the sod.

But it would be endless to enumerate even the trains of speculation and inquiry that present themselves to any one who studies vegetables, in their connexion and succession, however narrow the field of observation may be. A step taken anywhere that there are plants furnishes a study; and that walk which does not afford reflection for a week must be very short, as well as over a place comparatively barren. Even a public road may answer the purpose, for there are the hedges with their wild plants, creeping below or entwined among the bushes; and as the hedge is a sort of hill, and the ditch a sort of valley, the two together form a sort of epitome of a considerable tract of country. The changes that take place in the wild plants, from changes of soil and elevation, present a constant succession of new objects, so that, upon the most beaten path in the country, the man who uses his eyes need never weary, or feel tedious, even when alone. And if one be confined to the same spot, the changes in time have just as much variety and continual novelty in them, as the changes with the change of place. The spot must be a little one, in which something new shall not be met with every day; and whatever is found, if it be examined in its relations to other things, and to its own state previously, there will be knowledge obtained.

The great difficulty lies in beginning. Few people have their attention called to natural appearances and productions, in that early period of life, when the only object is the acquiring of knowledge purely for its own sake. The natural desire which parents and others, who have the care of young people, have that the preliminary instruction which is to prepare them for business should be uninterrupted and occupy their whole attention, naturally renders those parties rather averse to the observation of nature, as falling more within the category of play than of that of business. Also, when the young do take a turn for that species of occupation, they are apt to become inquisitive, and to put questions which are not very easily answered, even by those who know a little of the quality of natural history which is current in the printed books. Indeed, as the science of plants consists very much in the technicalities of a system, of which beginners cannot easily see the use, either in acquiring a knowledge of nature, or in applying that knowledge, the assistance which is given, although given with the very best intentions, is often as much a hinderance as a help. The greatest hinderance of all is the want of a popular language. The species of plants that have been discovered as native in Britain, and on the shores of the British seas, amount to nearly four thousand. The half of these have not English names; and of those that have, the names are mostly local, and do not find a place in the mother language of the country. The vast number of foreign plants which have been introduced have of course no English names, as it has not been the fashion with our botanists to Anglicise the learned names, in the way that they have been Gallicised by the French. Thus the people of different countries, and often of different parts of the same country, are unable to converse about the greater number of the plants, unless they shall first make themselves masters of the technical language of botany, and that can only be done by a very limited number. Even in that there is more difficulty than there should be; for the plants have so many names and synonymes, that if the whole were written in alphabetical order, the number of species would appear to be almost forty thousand; yet all these names occur in the books, so that they who read for a knowledge of plants must know what they all stand for; and thus the nomenclature of botany is nearly ten languages. The names, too, are such that a common English reader cannot attach a particular meaning to any one of them, and there are many to which no reader can attach any meaning, although he were master of all the languages that are spoken, or ever were spoken under the canopy of heaven, because they are "made-up names," and have no reference to any thing discoverable about the plant. As a specimen, we may mention a few of the names of the lichen which was mentioned before, as furnishing the bloom-die called cudbear. They are,

Lichenoides crustaceum et leprosum, &c.	Dillenius, in Raii.
Lichen tartareus . . . . . *Lichen saxorum*	Linnæus.
Verrucaria tartarea . . . *Parmelia tartarea* . . . . *tartarea* . . . . *Rhinodina tartarea*	Acharius.

There are seven names, two of them given by the one author, and four by another, and these too not the specific but the generic part of the names; and if the first one were not, if quoted, a description and not a name, it is the most expressive of the whole. Perhaps that abundance of nomenclature may have facilitated the progress of the knowledge of plants among professional botanists; but in a popular point of view it has been the reverse; because nobody who has not leisure to learn all those names, or who is not daily occupied on the subject, so as not to forget them, can possibly obtain a knowledge of the plants themselves—to say nothing of their habits; and though one had ever so much capacity, it is not possible, without contriving a set of new names, and making them English, and generally known and used (which is also an impossibility), to write any thing popular upon the subject to help beginners.

The case of animals is not quite so bad, because, to most people, there is more excitement about animals than about plants. There are many people in towns who do not know the name of a single vegetable—or, which comes to the same thing, cannot name the vegetable if they were to see it, or find it out among others by its name,—unless they are vegetables which they have seen in the markets;

and of many of these they have no notion, except in the state in which they appear at market or afterward. There are, in London, for instance, many intelligent, and by no means illiterate persons, well versed enough in all the science necessary for the conducting of business, and in the common literature and occurrences of the day; but who, if you were to walk through Covent Garden with them, and request them to make so simple a distinction as to point out all the vegetables there that were produced in the air, and all that were produced in the earth, would find themselves sadly puzzled. So also, if you asked them to point out which are the productions of annual plants, and which of larger kind; or which were natives of Britain and which not, they would be at a loss. In like manner, if the production were a seed, a fruit, or a root, they would not be able to tell you any thing about the leaf or the flower; and if you questioned them as to the mode of culture, you would find them still sooner at a loss. If they happened to have flower-pots or gardens, and were fond of these, they would, no doubt, be able to say something about what were grown in them, and mention the names and describe the appearances of the favourite and fashionable sorts. But take them to a common, or a natural copse, or a tangled hedge, or the sedgy bank of a river, and question them of the productions there, and the probability is that, in nine cases out of every ten, you would either get no answer at all or a wrong one.

If the question were respecting animals, the answers would, in the more familiar species, be more ready and more accurate. The motions of those animals that do possess the power of moving from place to place render the observation of them a much more palpable matter than the observation of plants; and as they move entire, and carry all their functions with them, while plants do not of themselves change their places, and, unless in any peculiar species, and those not of every-day observation by the public, their functions are suspended when they are taken out of the earth or the water, they are much less frequently seen in their active states. Even in these states, the progress of vegetable action is so slow that we must have an interval of time before we can notice it. Some of the gourds and turnips produce a great quantity of vegetable matter in little time; the growth of many of the fungi is still more rapid; and in the course of a day or two, the buds of a large mulberry-tree will expand into millions of leaves; but still we do not actually see the motion, even in the most rapid of them; and though we watched the mulberry-tree from the very first action of the buds to the full expansion of the leaves, we should not be able to find out that it had altered at all, if we did not remember a former state, and compare that with the present. That the plant acts at all is, therefore, a matter of inference, and not one of immediate sensation.

But the action of the animal is at once palpable to sense, and forms so immediate a part of our whole perception of it, that it is by inference we conclude that it has been or can be in a state different from that in which we see it. It is chiefly, if not entirely, from matter in motion that we get our notion of what we call power; and when we can trace that motion up to any substance, but not farther, we ascribe the power to that substance. Thus, when we see a horse start off upon the ground, a bird in the air, or a fish in the water, it having been previously in a state of rest, we say there is a power of running in the horse, of flying in the bird, and of swimming in the fish; and though the original word *animal* probably expresses "to breathe," or "that which breathes," our common understanding of it is so much associated with the fact of moving without being forced on by any other piece of matter previously in motion, that we consider life itself as having some relation to motion; for we call that which is quick "animated or lively."

And this liveliness of most of the animals, with which we are familiar (though there are some that have very little of it) gives a charm to the observation of animals far greater than we feel in that of any other of the productions of nature. The most magnificent tree, or the most beautiful flower, is but a denizen of one little spot of earth; but a quadruped can range the whole country, a bird cross the seas, and a fish circumnavigate the globe. There is a notion of freedom about them, and that is always an inviting notion.

Besides, there is an apparent communicativeness in animals which we cannot trace in any thing else. Every thing that we can know about the other productions of nature we must find out by labour, or wait for with patience, till the "creeping pace of Time" (which always appears slow when our wish is fast) brings it about. But the animal comes forward and tells its own story, thereby placing us in the easy situation of spectators at a dramatic representation; and then, the acting of different animals, or of the same animal under different circumstances, is so varied that we never tire of them.

Philosophically, we have no more reason to conclude that the action of any animal, however instantaneous and rapid it may be, is an *original* action, than we have to conclude that the germination of a seed, the growth of a plant, or the falling of a stone is an original action; because that which can begin its action, or in any way change its state without cause, must also have begun its existence without cause. But still, as the action of the animal is so much more rapid and varied than that of most other productions of nature, and as it is produced in the animal without any antecedent *that we can see*, it has so far the appearance of original action. When an animal runs, there is a natural cause for it, as certainly as there is when a river runs; when a bird flies, there is a natural cause for it, as well as there is when the wind flies; and when an animal swims, there is a natural cause for it as certainly as there is when a bubble swims on the current of a river; but as we cannot get at the knowledge of that cause, or at least of part of it, there is a mysterious sort of originality about the action itself, which engages our attention much more than if we could resolve the whole into material elements.

This more complicated nature of the animal than even the vegetable removes it at least one degree further from mere inorganic matter, and makes it more completely dependent upon organization. Consequently, we cannot so vary animals by culture as we can vary plants, although we can educate them for more active purposes than any that can be answered by plants.

As those who have paid even moderate attention to the subject can always distinguish the remains of plants, when dissolved but not chymically decomposed, from dissolved inorganic matter, so it is just as easy to distinguish animal matter when dissolved, but not decomposed, from vegetable matter in the same state. The plant, if we except the parts which are soon evaporated by the atmosphere or washed away by the waters, is found to consist of carbon, oxygen, and hydrogen, that is, of charcoal and the elements of water. That matter may be reduced to powder or to paste, but still we can easily distinguish, not merely by chymical examination, but by the touch and the smell; the last of these, though not very strong, is peculiarly refreshing, so that it is very healthful to walk over a field of good land after it has been turned up by ploughing.

Chymical decomposition, at least in the softer parts, very speedily follows animal dissolution; so that, when an animal substance has been long in the earth, it is not easily detected, except in the bones or shells, and both of these are found to contain lime, a substance of which most plants contain none, and some only a very little. But this lime, which, in itself, is not, strictly speaking, animal matter, is always in the living, or the recent state, cemented together by more or less of animal matter; and all animal matter contains nitrogen, which is usually regarded as the inactive ingredient of atmospheric air. When the animal substance is burnt, a portion of the nitrogen combines with the hydrogen of water, and forms *ammonia;* the peculiar pungent smell of which is well known in the solution usually called hartshorn, and which is always more or less perceptible when any animal matter is burnt. That smell is indeed the best test of the presence of animal matter in a state of decomposition. No inorganic substance is composed of the same ingredients as animal matter; and though some few vegetable products, such as Indian rubber, and the other juices alluded to, resemble animal matter, they are always accompanied in the same organization with other parts which are wholly and obviously vegetable.

Thus, the "living principle," which is the name usually given to the fact of organization in a state of action, not only suspends those laws of mechanics and chymistry which inorganic matter always obeys, but has a chymistry and mechanics of its own, by means of which it can dissolve those substances which contain the materials necessary for the growth or the repair of its own structure, works these into the necessary new compounds, and gives them the proper forms and consistencies.

In any one instance, that, when we think of it, is truly wonderful, and should, one would suppose, make everybody take an interest in the thousands of living creatures with which all around us is peopled. Take, for example the egg of a bird. That may be found when not bigger than a grain of mustard-seed; when the whole substance of it is yelk, and the white which contains the embryo, or at least some portion of the embryo of the future bird, is a pellicle of so very pure a texture that it is hardly discoverable. Well, it is brought to a certain stage of maturity by the action of the parent bird, just as a seed is ripened by the action of the parent plant. In that state it is an independent being, and is separated from its connexion with the parent.

External causes to stimulate it into action are all that are now required for bringing it to the same state as the parent, but it must have the stimulus of these, otherwise it not only remains inactive, but becomes putrid—yields to the laws of matter, and passes into the mass of materials. It may be kept perfect for a considerable time, if the air is completely excluded, but there is reason to suppose that it would in time undergo internal decomposition even then, in much less time than the seed of a plant, if so protected, would take before it lost the power of germination.

But still the egg is a very wonderful thing; and were it not that we are so familiar with it, we would go farther to see it than to see most of the subjects which engage our attention. It is handsome in its form, and every way beautiful to look at; so that a collection of eggs forms by no means an uninteresting cabinet—if the possessor can tell the tales of the birds. But the wonderful part of the matter is, that a body of the form of a pebble, and consisting of a thin shell of lime, lined with a soft membrane, and having within it first a transparent and then a yellow jelly, should have the power, by the action of heat and air alone, of evolving a vast number of animal organs and substances, all differing from each other in different kinds of eggs; but never deviating so far from the characters of the parent birds as that they cannot be instantly discerned to belong to the same species, and display to a very great extent the same phenomena, and the same habits. A careful observer may indeed find that there is in one part of the transparent jelly a little portion which has more consistency than the rest; but still a stretch of fancy is needed before it can be called organization of any kind. So that, if a person were to be told that out of those jellies there were to be evolved bones, and muscles or organs of motion, and nerves for sensation, and arteries and veins for circulating blood, and lungs for breathing, and air tubes in the bones to ensure the same purpose upon emergency; and that there were to be feet for running, or wading in the water, or swimming, or partially for all those purposes, according to the habits of some former organized beings, now dead or at a distance; and wings for flight, and eyes, and nostrils, and ears, and a mouth armed with horny mandibles; that further, the production was to have the very model of mechanical shape, for enabling it to make its way on the earth, across the waters, or through the air; and that it was to be clothed with plumage of the smoothest gloss, and the most brilliant colours; and that it would, in the most unerring manner, select those substances best adapted for its purpose; and by means of various sets of apparatus, each the very best fitted for accomplishing the end with the very least trouble, form them into the very substances of which its own organization were composed; and not only keep itself in perfect order and repair for its appointed time, but become the source of future beings of the same kind, without number and without end, excepting from the bar and hinderance of external circumstances: if a person who was ignorant of eggs, and the results of hatching, were to be told that, or even a small part of it, it would utterly shake his belief in the testimony of the narrator. Nor would his doubt be the less if he were told that the being to come out of one egg would have the fleetness of an arrow and the strength of a giant; that the gripe of death would be in its talons, and the rending of destruction in its beak; that its eyes would be piercing, and its aim certain, even when it rushed like a thunderbolt from the upper regions of the sky—the scourge and terror of all the beings to be produced by the other eggs of the collection. So, also, if he were told that the production of another egg would, without any external cause which man could discover (except a cause *presumed* from the fact), make the two hemispheres of the earth resound with its songs, alternately in the opposite seasons of the year: or, that it were to pass away to a far distant country, without chart of the way, and without guide; and thence return with the return of the spring, to build its house under the eaves, to produce a new succession of eggs, to toil on the wing the livelong summer-day in catching flies for the nourishment of its young; and then, at the appointed time, again take its departure, again to return the harbinger and the pledge of summer: if he were told of that for the first time, he would abandon any of the ordinary matters about which men busy themselves so much, and take a long pilgrimage to see the wonderful creature, so that he might have fame and credit among his neighbours, as the fortunate traveller who had seen with his eyes the very wonder of the world.

That, however, is only a little portion of what the animal world has to disclose, not to our laborious search, but of itself, of its own accord, if we would but be attentive and mark the disclosure. The general characters of the animal world are as numerous as the races, and the particular ones are as varied as the individuals, so that the transition from any one to any other one has the charm of novelty. Animals, from the greater number of functions that they perform, and the greater energy and celerity of their performance, have far more character than plants; and though the character does not perhaps admit of so great a change in the individual, it is far more rapid in the succession. In those animals with which we have been so long familiar as to know their appearances and habits intimately, we never find two that are exactly alike in any one particular. We know them by their form, their look, their gait, their voice, the sound of their feet, or any one particular which could be mentioned; and we do so with ease, even in cases where the greatest master of language would find it very difficult to say in words in what the difference consisted. And in making up a picture of an animal, if the artist takes with perfect fidelity those parts of several different animals which are deemed the most handsome in them, the compound is always a patchwork, wanting entireness and symmetry, and really less handsome than if he had been faithful to one of his models only. Each individual part, taken in itself, may be more handsome, but an eye accustomed to examine closely will soon find out that they do not belong to each other. It is usually said that the Grecian artist compiled for his Venus the charms of all the beauties in Greece; but, if so, the work must have been a motley and meaningless thing—something like those "best words of all authors," which the ignorant compile for the confirmation of the idle.

It is the same with the dispositions and habits of the animals, as with those instantly perceptible characters which, though we cannot explain them in cases where there is much resemblance, yet strike us at first sight. Similarity of disposition and habits always accompanies similarity of appearance, when we take the whole particulars of the appearance into the account. A skilful jockey or sportsman, who has noticed the appearances and characters of many horses or dogs, can tell their leading good or bad qualities at a glance; and so can one who has been very observant of human character come very near the character of an individual even before he opens his mouth, or any one action of his is known. All the blandishments which a treacherous person can put on will not hide the villain. That is his main purpose, and as such it takes possession of his whole frame; and probably nobody, at all in the habit of studying character, ever saw and examined his man and was subsequently deceived, without having a previous suspicion that such would be the event.

To reduce that to any thing like a science which one man can communicate to another in words is another and a far more difficult matter; and it is almost as hopeless to expect that a man can be able to tell how he sees those fine shades of distinctions, as that he shall be able to tell how he sees objects at all; it is not in the form of the head, or in that of the features, so that physiognomy and craniology are but scraps of the science, resembling indeterminate problems in calculation, because all the conditions for determining the answer are not known, and so the answer itself may be almost any thing. A man under the dominion of any resolved purpose, however he may strive to hide it, is imbued with the character of that purpose all over; and he who seeks to determine what that purpose is from the head or the face, or both together, is to the man who actually sees what the purpose is, what any common painter is to Raphael, in painting a blind man. The common painter's blind man is simply a man with his eyes shut, while all the rest of his body is in perfect repose and confidence that they will open again whenever he needs them. But Elymas, the sorcerer, in Raphael's cartoon, is blind to the very tips of the fingers and the points of the toes. Conceal all the figure except a hand or a foot, and yet you will immediately perceive that that hand or foot is purposeless and in the dark.

In the greatest variations, or varieties, as the instances of variation are called, even in those that amount to monstrosities, the changes are never out of the species. Several shoots of the pine often come united together, so that two will be united their whole length, and two pairs of these for half the length, and they will curl outwards at the tips, like the horns of a ram, or the sign (♈) of the constellation *Aries* upon the globe. Sometimes the inosculation will extend to the pith of the two portions; and sometimes it will be only external; but, in all cases, the substance is the genuine product of the pine. Cultivated plants are all more or less monsters; the additional petals in double flowers are the parts of fructification changed from their proper forms, and their functions are changed along with them. In some cases, the petals which are formed out of the parts of fructification, remain of smaller size than the others, as in anemones, and in some varieties of dahlia, where there is a row of large petals in the margin, and all those in the centre are small. The anthers of roses not only change to petals, but in some instances they change into leaves, or into the sepals of a calyx; and there have been instances in which an anther has changed into an imperfect calyx, and displayed a small badly-formed rose in the centre of the large one. A growth from the stem of a potato will sometimes change to a sort of tuber, even above ground; and if a plant of that species has proper room in good soil, it may be made to put out successive crops of tubers from the stem.

The parts of animals also sometimes undergo changes. Additional horns appear on sheep; and callosities, resembling horns, are sometimes found on the human body; colours change; and even the shape alters, we sometimes cannot even guess why. But in all these cases, the change, however monstrous it is, is never out of the species. The additional horns on sheep are still genuine sheep's horns, whatever may be their position or shape; and the horny excrescences on the human body, even though they grow on the face, as they have done in some instances, are just as truly human nails as if they were on the fingers or the toes. In the case of hybrids, too, whether of plants or of animals, and in the latter whether of quadrupeds or birds—we know little or nothing of hybrids among the other tribes, though there may be instances in them—there is a law of nature that maintains the species. The mules, of whatever they are hybrids, will not breed as a race, though they generally can with either of the parent stocks, and the result is a partial return to that stock; and if the system were continued, the ultimate progeny would be again assimilated or identified with the pure blood.

Thus we can, with very little reflection, get hold of the general principles that are to guide us in our observation of animated nature. There is a specific form handed down from race to race; and the general characters of that form cannot be altered so that one species shall resemble or merge into another. This character is in the embryo, even when that is too minute for being in any way the subject of observation. That keeps them all true to their kinds in the general way, so that we never find a cat taking to the water and fishing at the bottom, as an otter does, or a fish coming on land to hunt for worms. As little do we ever find a hawk robbing orchards, or a pigeon killing sparrows for food to its young.

But it is the general character only which descends by hereditary succession. When the young leaves the parent, and becomes an independent being, it is controlled by circumstances, and must accommodate itself to them. Thus, in proportion as the treatment varies, the individual character must vary; and that is the reason why cultivated plants and animals are so much more varied, in all their species, than wild ones. The wild ones have only the changes of the seasons to contend with, and as these are upon the average pretty nearly the same at the same place, there is, in the same place and at the same time, very little difference between any two wild animals of the same species, if they are both of the same age. Even if there is some difference of the places in quantity of food, or any other circumstance which is calculated to affect the race very deeply, thinning of the numbers rather than dwarfing of the individual is the immediate consequence; though when severe cold and scanty food are combined, the race diminishes in size.

If we are to observe *nature*, therefore, we must go to the wilds, because in all cultivated productions there are secondary characters produced by the artificial treatment, and we have no means of observing a distinction between these and those which the same individual would have displayed had it been left to a completely natural state. The longer that the race has been under domestication and culture, the changes are of course the greater. So much is that the case, that in very many, both of the plants and animals that have been in a state of domestication since the earliest times of which we have any record, we know nothing with certainty about the parent races in their wild state. As to the *species*, or, if you will, the *genus*, we can be certain. The domestic horse has not been cultivated out of an animal with cloven hoofs and horns; and the domestic sheep has never been bred out of any of the ox tribe. So also wheat and barley have not been cultivated out of any species of pulse, neither have Windsor beans at any time been grasses. But within some such limits as these our certain information lies; and for aught we know, the parent race may, in its wild state, be before our eyes every day, and yet we may not have the means of knowing that it is so. The breeding artificially has been going on for at least three thousand years, with some change at every succession; that, calling the average duration of the domestic animal ten years, and that of the bread-plant one year, is three hundred successions in the one case, and three thousand in the other; and what man is to live, nay, what kingdom is to last till the experiment is performed as many times, with any thing which is now in a state of nature! Even if we were to suppose that impossibility got the better of, there arises another every way as perplexing. How are we to know what was the first artificial mode of treating any one of those cultivated productions, or what were the effects of it, even at the end of one thousand or of two thousand years? Fashions of cultivation change as much as fashions of any thing else; and as the subject is one in which it is impossible to get accurate information upon, not a few only, but on many points, much of the change must have been theoretical; and, like all theoretical procedure, sometimes an improvement, and sometimes the reverse. But there is another difficulty. When great changes are made on the surface of a country, as when forests are changed into open land, and marshes into corn-fields, or any other change that is considerable, the changes of the climate must correspond; and as the wild productions are very much affected by that, they must also undergo changes; and these changes may in time amount to the entire extinction of some of the old tribes, both of plants and of animals, the modification of others to the full extent that the hereditary specific characters admit, and the introduction of not varieties only, but of species altogether new.

That not only may, but must have been the case. The productions of soils and climates are as varied as these are; and when a change takes place in either of these, if the living productions cannot alter their habits so as to accommodate themselves to the change, there is no alternative, but they must perish. Also, though we know nothing about the primary germes of plants or of animals, till we find them developed in visible and tangible embryos, we must not make our ignorance the measure of nature's working; for though we have seen them come only in one way, and, generally speaking, perish in another, we are not to suppose that that is all. When forests of one kind of timber are cut down, new plants make their appearance; and there are evidences that races, both of plants and of animals, have perished even in our own country, without any great convulsion of nature, for their remains have been left on the strand, and buried by the slow progress of the deposition of the matter washed down by the rains and stayed by the reaction of the waves.

Cultivation itself will deteriorate and in time destroy races, if the same race, and the same mode of culture be pursued amid general change. Our own times are times of very rapid change, and, upon the whole, of improvement; we dare not, without the certainty of their falling off, continue the same stock and the same seed-corn, season after season, and age after age, as was done by our forefathers. The general change of the country must have change, and not mere succession, in that which we cultivate; and thus we must cross the breeds of our animals, and remove the seeds and plants of our vegetables from district to district.

There is something of the same kind in human beings, and we have reason to expect that there should; because, in as far as man is material and mortal, he is just as dependent upon circumstances as any other material production. Hence we find that when a town or a district is busy and bustling, and strangers resort to it, both the population and the energy increase far faster than the numerical addition of strangers. But, on the other hand, when it becomes dull, and strangers cease to resort to it, it dies away, both in population and in mental energy, even though none of the people leave it. Thus, it is not leisure that mankind needs, it is stimulus and activity; and study, even the most profound and abstruse study, thrives better in the few snatches of time which the busy man can spare for it, than in all the listless and loitering days of him who has nothing to do.

That is as true of the study of the productions and phenomena of nature, as it is of those sciences which are more immediately the tools of art. [But these are the tools; nature furnishes the materials, which are of primary importance.] And there are many advantages. Nature is always at hand; our own senses are all the apparatus that we need; and we have only to look at the connexion in which any thing or appearance that we observe is placed, both in juxtaposition in space and in succession in time, in order to get a lesson from every thing that comes in our way. Could the whole people, according to their opportunities, bring themselves to do that upon all occasions, the extent, the correctness, the usefulness of the knowledge that must be obtained would be immense. As they would have no hypothesis of a school or dogma of a sect to support, each would communicate the result of his own experience to the general store, and receive that of his fellows in return; and error would be exploded, and so would silly and deceptive credulity, and skepticism equally silly and deceptive; for all men would see with their own eyes, and believe from their own understanding; and the heavens and the earth, in all their fairness and in all their fulness, would be every man's kingdom. That is a consummation to which it is perhaps hopeless to look; but every approach which can be made to it is an addition to the happiness of man, and to the rational and true adoration and glory of man's Almighty Maker.

THE END.

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