VINEYARD NEAR MOUNT S[T] BERNARD.

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From a Drawing by George Barnard

AUTUMN.

BY

ROBERT MUDIE

AUTHOR OF THE HEAVENS THE EARTH THE AIR THE SEA.

&c. &c. &c.

AUTUMNAL ARTIST.

LONDON.

THOMAS WARD & CO PATERNOSTER ROW

MDCCCXXXVII.

AUTUMN;

OR,

THE CAUSES, APPEARANCES, AND EFFECTS

OF THE

SEASONAL DECAY AND DECOMPOSITION OF NATURE.

BY R. MUDIE,

AUTHOR OF "THE HEAVENS," "THE EARTH," ETC.

SECOND THOUSAND.

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PREFACE.

It is, perhaps, more difficult to define the time, and explain, in popular language, the phenomena of Autumn and their causes, than it is in the case of any other season of the varied year. This is, in part, owing to the indefinite occurrence of Autumnal action, but more so to its compound and very complicated nature.

The two great parts of the compound are these: First, Autumn takes up the new or successional race, (we speak of the vegetable kingdom, as the one which must abide the seasons,)—and whether it consists in seed, in tuber, in bulb, or in any thing else, carries it onward to such maturity as that it shall be safe during the winter. Secondly, Autumn reduces to an elementary state, or prepares for reducing to that state, all that portion of the vegetable kingdom which has performed its function for the year, and is not to be stimulated into new action at any future time.

The first of these may be considered as a continuation of the summer-part of the regular course of the vegetative action of the year,—of that for which the spring is a preparation, and which by the act of summer is transferred from the present race to the succeeding one. Summer terminates with the simple elementary or primal act; and then this first, or conserving labour of the Autumn, is the nursing of the germ until it is so far matured as to be able to act for itself, as an independent being, when the proper stimuli are applied to it. This nursing is greatly promoted, and indeed chiefly performed by that portion of the summer heat which, so to speak, overlays the Autumn, and which, from there being less evaporation from plants than when they are in active growth, is not unfrequently more intense than during the summer, properly so called. It is more variable, however, upon the general principle, that whatever is easily heated, is cooled with equal ease. By these alternations of heat and cold in the Autumn, the seed or other germ is tempered for endurance as it is ripened; and when its action ceases, by its being fully ripe, it can bear more than in any other stage of its existence. It is in the surplus of this above what is necessary for the succession, that man finds the harvest of the year, and in that harvest many of the wild animals also partake. The parent plant, and the influences of the earth and the atmosphere, are the only agents necessary for the operation of ripening; and thus, though this is by far the more immediately important work of the season, in a practical point of view, the knowledge of no new agent is required in order to understand how it is performed. For this reason, and also from its being the view of the season which has been chiefly taken by writers—so as to leave little new to be said in the description of its phenomena—I have not treated it to much extent, or with any minuteness of detail.

With the other, or decomposing function, or action of Autumn, the case is very different. Those agencies which bring vegetation to the maturity of the year, have not in themselves any inherent power of operating its own decay. An animal does not die by the action of the living principle in it, neither does a plant or leaf wither by the action of growth. Death, in both cases, and in every case in which it can take place, is the opposite or antagonist of life; and that any power could be its own antagonist, would be a contradiction in terms. It is true, singular as the truth may appear to those who have not thought of it, that death ministers to life during the whole period of its continuance; and were it not for the resistance of this antagonist power, no kind of life could have its action brought up to such a degree as to be perceptible at all. What we call death is, therefore, as viewed in the general system of nature, a mere turning of the balance,—previously, life has preponderated, but now the scale of life kicks the beam, never again, in the case of the individual, to acquire the mastery.

In this view of it, and as applied to the display of life in material forms (which is the only true one), death is merely a phantom,—a general term: expressive of all agencies, and every agency, by which the functions of life in an individual plant or an individual animal are made permanently to cease. But those agencies, which constitute what we call death, are always distinct from and opposed to the principle of life, and neither plant nor animal can of its own living action terminate its own living existence, any more than it can of itself begin to exist. Opposite, indeed, as these two at first sight seem, they stand upon an equality; and, though the secondary agencies and the instruments by which they are brought about are very different, yet the primary agent in both cases is the same; and thus we can understand the force of the expression, "The issues of life and death are in the hand of the Almighty alone."

In the case of the annual death of nature with the season, and indeed in the death of all material beings, the withdrawal of the means of life is sufficient; and upon the summer vegetation, the diminishing of the action of moisture or of heat, or the disturbance of the balance of the two, is quite adequate to the purpose; and thus the Autumnal death of seasonal nature requires no new agent, and the explanation of it makes but little demand on the resources of philosophy.

But there is another function of Autumn to be performed; and that is the disposing of the part of seasonal nature which is dead; and this is a beginning, and as such, requires specific agents, varied according to the nature of that which is to be performed. The substance of all that dies, is organic; and as there is no more inherent power of self-destruction in organization than there is in life, agents for this purpose must be found. It is in these agents and their modes of action that the peculiar characteristics of Autumn lie, and they of course vary with the climates and characters of different places.

Agreeable with this view of the matter, the grand law of nature, attempted to be investigated and illustrated in this volume, is the law of Autumnal decay and decomposition ; and I believe I may venture to say, that this law has never hitherto been made the principal subject of a specific investigation, although it is one of the most important in the whole economy of nature,—one, but for which, the spring showers would weep, and the summer breezes mourn, over a ruined earth, desolate once and for ever.

In order to bring home the general principles to the reader, with as much of practical usefulness and of the function of artificial memory as possible, I have selected from the mighty multitude of the Autumnal host, those cohorts, which always stand ready to invade the fields of the husbandman, when any thing is untoward in the state of his crops. I have laboured to explain the rusts, the smuts, the ergots, the mildews, the moulds, and all the other small but irresistible destroyers which may invade the staff of life in every stage of its progress, from the first rudiment of the ear, to the loaf set on the table. I have also endeavoured to point out some of the baneful effects of those little plants upon human life, not without hopes that my remarks, few and simple as they are will not be wholly useless to families.

Besides these, there are many classes of Autumnal agents, and modes and phenomena of Autumnal action, which would claim attention in a work fully explanatory of the season. Such a work, done justice to in all its parts, would, however, extend to many volumes. Some of them connect the Autumn with the winter, are wintry in their causes, and will be noticed in the volume on that season; while others must be omitted, as too abstruse in their nature, or too vague in the information we have of them, for being fit subjects for popular disquisition.

More I need hardly write by way of preface, the size of the book required the utmost condensation; and, for further particulars, the reader is most respectfully referred to its pages.

ROBERT MUDIE.

Grove Cottage, Chelsea,
August, 1837.

ANALYSIS OF THE CONTENTS.

CHAPTER I.

GENERAL DEFINITION AND OPERATIONS OF THE SEASON.

CHAPTER II.

AUTUMN IN DIFFERENT LATITUDES.

CHAPTER III.

AUTUMNAL DECOMPOSITIONS, AND THE AGENTS AND MEANS BY WHICH THEY ARE PERFORMED.

CHAPTER VII.

PRINCIPAL FUNGI BY WHICH GRAIN PLANTS ARE INFESTED.

CHAPTER VIII.

MISCELLANEOUS APPEARANCES IN AUTUMN.

ILLUSTRATIONS.

No subject whatever can, by possibility, be chosen, so as to represent the general character of Autumn in all places and at all the times when Autumnal action occurs; and, therefore, we have selected one of the blithest of its scenes, as the subject of our frontispiece,—namely, the vintage under the sunny skies of Lombardy, in the vale of Aosta. The vignette is the large Garden Spider, *Epeira diadema*, which comes not till the Autumn; but, at that season, its labours are equally curious and characteristic. In both subjects, we feel confident that our readers will agree with us that the execution improves as the seasons advance.

AUTUMN.

CHAPTER I.

GENERAL DEFINITION AND OPERATIONS OF THE SEASON.

Even in the most simple and popular view of this season—the view of it which is taken by the most illiterate and least observant or reflective part of the community—it is one of the most interesting in the whole circle of the year. It is, by way of eminence, the harvest—the season of plenty, both to man as a cultivator, and to all the children of wild nature. It is the time during which the produce of the fields and of the orchards is collected as a store, not only during the inactivity of the winter, but until the return of another Autumn brings a fresh supply. Not only this; but in the more productive parts of the country, where cultivation is carried on in an advantageous manner, it both leaves a surplus for the inhabitants of places less favoured by nature, or restricted by the arrangements of art from being the producers of their own food, and has a store in supplement, against years of scanty production, so that, with proper regulation, and one district and one season reciprocating with another, there is a uniform supply of the essential necessaries of life, and mankind are left free to pursue their various arts and occupations and studies, for the comfort and the improvement of the individual and the race, without being alarmed by any fear of want, and far less of suffering those periodical visitations of famine, which, in a less advanced state of the arts of cultivation, fell so severely upon the people, even of our own country, when their numbers were but a small fraction of what they are at present.

We shall not now enter into the particulars, or endeavour to describe how the inhabitants of different countries, and different districts of the same country, are engaged, according as their soils and climates are adapted for, or their habits have been inured to, the culture of different kinds of vegetables; because these are matters of detail, and the common character of the season belongs to them all. They are joyous labours, as compared with the field labour of any other time of the year; because, in them, the reward of the labour of all the others is, upon the average, collected together, and the feeling which the whole inspires is thankfulness. Yes, there is a cause of thankfulness in the return which Autumn brings to the labour of the cultivator, which is not prompted by similar success in any other occupation of the human race. In every such occupation there is, no doubt, a power, or rather a combination of powers, in nature, which works along with man, and which even guides him in his working; but, in very many human occupations, and especially in such as are carried on within doors, this is not very striking, either in apparent amount or in time; and in most of these operations, if the materials of our work are the same, and used in the same manner and to the same extent, we can predict, with the utmost certainty of which human judgment is capable, that the results, in any number of cases, will be perfectly uniform. This is especially the case in all mechanical trades; and thus the workman feels that the whole burden of the work is on his own shoulders, and the whole merit in the case of success, or of blame or disappointment in the case of failure, falls exclusively and undividedly upon him. In such occupations there is, therefore, something which tends to induce man to take more merit to himself than he is in justice entitled to, and to overlook that goodness of the Creator, which has so framed the materials as to fit them for the work, and so endowed man with wisdom and discernment, as that, by successive steps of improvement, he has been enabled to turn the properties of material substances so largely to his individual advantage.

In the case of the cultivator of the ground, whatever may be the subject or the object of his culture, the case is widely different. The auxiliary principles which cooperate in bringing about the results which he desires, or rather which he merely seconds, by applying the results of his observation, are most palpable, and they continue throughout the whole period of his cultivation, from the time that the seed is committed to the ground to that at which the harvest is gathered in. These are so habitually conspicuous, that no man can be in the fields and overlook them; neither is it possible to avoid perceiving that they are of two kinds, and equally beneficial,—the actual performance of good, and the prevention of evil. That alternation of weather, which brings the crop to maturity, and but for which the seed corn might as well be cast upon the barren sands or to the idle winds, cannot be overlooked; and, although not quite so open to ordinary observation, the number of perils through which the crop comes, against scarcely one of which man can find a certain remedy, is certainly not less wonderful. Take, for example, a grain of wheat—of that corn which to us is the most precious of all the earth's productions—and there is not one instant, from the time that it is committed to the soil, to that at which its produce is brought home, at which it is not exposed to some enemy, sufficiently powerful for effecting its destruction, and yet sufficiently concealed for entirely escaping human observation, until its existence is first shown by the irreparable mischief which it has committed. These destroyers all exist for benevolent purposes in the system of simple nature; and that they should be held suspended while man changes by cultivation the course of that nature, is a never-failing subject of admiration; and that the produce of the harvest should come safe through so many perils, against which the utmost vigilance of the husbandman cannot be the slightest protection to it, cannot fail to inspire him with a gratitude to Heaven, which those artists who are comparatively little subjected to the uncontrollable contingencies of nature, can feel very faintly, if at all.

If Autumn had nothing more than this to recommend it, it would be well worthy of our most profound study, and our warmest regard; but the bounty of the great harvest of nature is not confined to man as a cultivator but is distributed throughout the whole of nature, in proportion to the necessities of the numerous and varied members of the great family. It is the time especially, at which, while they each secure themselves, they afford a surplus for the rest, over and above this security. There is not a weed in the fields, or a tree in the forests, which does not produce enough of the germs of life to cover the whole surface of the land with its own species, in the course of a very few years, if all those germs were to come to maturity. This, however, is not the law of nature; for just as the individual race, whether plant or animal, is self-maintaining for its appointed time, even so is the whole system of organized nature, whether animal or vegetable, self-maintaining, by the redundance of one supplying the necessity of another. Hence, while this is the season during which, in seasonal countries like Britain, vegetable life is in a great measure suspended, or in the progress of suspending,—when the future twig and flower are beginning to be mantled up in the hybernating bud—when the perennial herb is retreating for safety to the root—and when the annual, and also the succession in all the rest, is stored up in the seed,—it is the season at which the plants can spare their surplus as food for the animated races, not only without injury to themselves but with great advantage, by thinning them down to that number which is consistent with the due and proper balance of the system. At the same time that Autumn brings a greater supply of food for every creature whose habit it is to remain active during the season, it diminishes the labour of the greater number; and the consequence is, that they are all in better condition than at any other time of the year; and thus they are prepared both for enduring whatever of hardship they may be exposed to in the winter, and for resuming their labours with increased energy in the spring.

If the Autumn had no further recommendations than those which could be amplified out of the few hints which have now been thrown out, and the details of which are so very pleasant in the books which treat of the phenomena and the labours of this season, it would be well worthy of a high place among the subjects which enter into the general education of all classes of the people, or at least which ought so to enter, in order to enable them to perform their various duties in society with pleasure and profit. These, however, are but a mere beginning of the various elements, which go to the formation of what may be considered as the Autumn, in the proper sense of the term. The word Autumn, indeed, involves, perhaps, more than is involved in any other of the seasons; because it has a peculiar mixed character, to which there is nothing corresponding in any of the rest, and more especially in the spring or the summer. Taking the vegetable kingdom as our guide,—and it is always the best one, because it is the most seasonal,—the more conspicuous actions of the spring and summer are confined to one grand division of the kingdom only, and to one great purpose in that grand division; the annual addition to the growth, and the annual preparation for the continuance of the common plants and trees, which clothe and adorn the surface of the earth. To these purposes, it may with truth be said, that the whole action of the spring and summer tends; and tends as one continued chain of operation, displayed, upon the average, in the same individual, from beginning to end. But, when we turn our attention to the Autumn, as its action is displayed in the vegetable kingdom, we find that the state of things is very different; and that we have a compound operation, both parts of which have strong claims upon our notice.

As in the crisis of the other seasons, so in that of the Autumn, we must not content ourselves with the mere three months of the year as measured off in the calendar; neither must we take such latitudes as that of Britain, where the seasons are pretty regular in their times, as the standard whereby we are to judge. We must look at the globe, in all its varied latitudes and climates, and we must look at all its varied productions; and if we do this we shall find that at some place or other, or in the case of some one production, even when we confine ourselves to the phenogamous vegetation, it is always Autumn, just as in other places and in the case of other productions, it is always spring, or summer, or winter. Thus Autumn in the one hemisphere answers to spring in the other; and the time of either taken in any one hemisphere is summer or winter in the middle or equatorial latitudes, according to circumstances. If the country abounds in humidity, then it is summer under a vertical sun, and consequently the most luxuriant of all summers; whereas, if there is no humidity, it is the extreme burning sterility of a tropical winter. So also, even in our own country, there are various races of vegetables to which Autumn is really the spring or the summer; and there are some of the smaller animals to which it stands in the same relation.

Hence, if we are to have a correct notion of Autumn, one which will meet the whole case, we must take it as quite untrammelled by time, by geographical situation, or by any one class of the earth's productions; and look upon it as a certain stage in that progress of the works of nature which performs its round in the year or in a longer period, according to circumstances. But, in doing this, we must take some one department of nature as a standard wherewith to compare the rest, so that our conclusions may be fixed and definite; and there is no standard more general and conspicuous, and therefore better suited to our purpose, than the *phenogamous* or flowering plants of seasonal countries, where the majority of them have one state of activity up to the producing and perfecting of the flowers, and one state of subsiding toward a winter of repose, in the course of the year.

In treating of the activity of these plants, in our volumes on Spring and Summer, we endeavoured to show that, whether annuals or perennials, there is a double action, the one part of which tends to the developmcnt or the increase of the individual, and the other to the continuation of the race; and that at whatever times these may happen, the first is, properly speaking, a spring action, and the second a summer one. The spring action goes no farther than the development of the individual plant and the increase of its size; but this proper spring action may take place in spring, according to the calendar, in any other of the seasons, or all the year round. Thus the midsummer shoots on fruit-trees, and the aftermathe on hay grounds, are both spring actions; and in a lawn which is kept short by mowing, by pasturing sheep, or by any other means that prevent the plants from coming into flower, is really a spring action, over whatever portion of the year it may be extended.

In like manner the producing of flowers, of tubers, or of any other parts, out of which new plants are to be elaborated, is a summer action, whether it precede, or accompany, or follow, that spring action by which the individual plant is developed or its bulk augmented. But this summer action continues no longer than till the germ of the new plant is fecundated—has become an independent being, capable of obeying, as such, the stimuli which may be applied to it, whether through the medium of the parent plant, or directly to itself, after the connexion with the parent plant has been dissolved.

Such are the limits of the spring and summer action on flowering plants, whether their stems be annual, as in herbaceous plants, or of several years' duration, and receiving annual additions to the wood and the bark to their stems, as in trees; and whether the incipient germs of the succession plants exist as rudimental seeds, as rudimental bulbs or tubers, as simple multiplications of the roots, or as any or several of these according to their various modifications, which depend partly on the nature of the plant, and partly on that modification which every plant receives more or less from the soil and circumstance in which it vegetates.

This being the proper limit of the action of those two seasons of vegetation which precede the Autumn, at whatever time of the year, according to the calendar, their work may be accomplished, we are brought at once to the proper function of the Autumn, or at least to that stage in the progress of vegetation, at which the action up to the time when the plant passes into its winter's repose, or starts to a new vegetation in cases where there is no hybernal pause, is Autumnal. It therefore only remains to consider what has to be done during this period or stage of natural action, what are the powers prepared for the doing of it, and what the modes of their operation.

The general principle is thus both an obvious and an easy one; and though the details are many and complicated, yet, when the principle is once understood, every reader can, with little difficulty, work them out for himself, in as far as may be necessary for his particular purposes, whether of general knowledge or of practical application. From what has been stated, it will readily be perceived that the grand autumnal action of nature resolves itself into two distinct parts, namely, something to be done, and something to be undone; and it is necessary to have an accurate general notion of each of these before proceeding to the details of either.

That which has to be done by the autumnal action, is the bringing forward of the seed or other germ, whatever it may be, and wherever situated upon the plant, from the instant of its fertilization until it has acquired that peculiar degree of maturity, by which it is enabled to preserve the life that it contains, independently of the plant which produced it, or of any other plant, until it shall be placed in circumstances that are favourable for its germination and growth as a plant. When it has once been placed in those circumstances, and has begun to act in obedience to them, it must then run its course, without any other pause than those which belong to its race, and to the seasons of the place where it grows; but until it has begun so to act, the time during which it can retain its vitality uninjured is, in the case of a seed especially, indefinite, and, in many instances at least, very long,—longer, indeed, than any which we can positively number in years. There have been instances in which earth that had remained undisturbed in a mound many feet below the surface for nearly two thousand years, and from which every kind of seed was carefully excluded, after its exposure to the air and light, and the supply of humidity, produced an abundant crop of plants, evidently from seeds which had remained uninjured in the ground during that very long period; and there have been many instances in which weeds had been buried while in seed by deep ploughing, and which did not make their appearance during culture by a number of shallow ploughings, yet returned in all their abundance when a second deep ploughing had again brought the seeds so near to the surface as that they could be stimulated into activity by that action of the elements which puts the powers of vegetable life in motion.

We shall afterwards have occasion to notice very briefly the mode in which this part of the grand action of Autumn is performed; but the reader cannot fail to perceive that it is one of the utmost importance in the economy of the vegetable world, and one without which the flowers would display their beauties in vain. The plants themselves are fixed to the earth; or every flowering plant which is not so fixed, is confined to the tree or other support upon which it is borne; so that if there were no means of distributing vegetables over the globe, except by plants in a state of actual growth, each would be chained to its locality; and whenever, by means of any of those contingencies of which examples are so frequent, any space should be denuded of its vegetation, there would be no alternative but for it to remain in that state for ever. There is no provision in nature for the transfer of a plant in the state of growth from one place to another, except in those few plants which grow floating in the water, and which cannot of course go farther than the water carries them; but in the state of seed they are prepared to undertake journeys of any length, and the greater number of them are so formed that they can readily be transported by the winds and the waters; while not a few are winged for flight, and in all probability, countless myriads far too minute for any eye or any instrument are constantly floating in the most limpid water, and even in the most transparent atmospheric air, and are thus taken into the bodies of all animals and all larger plants, and exist in these ready to perform their functions whenever circumstances call them into activity. These last, however, do not belong to that class of the vegetable kingdom which has summer or flowering action so open to our observation, as that we can point out the different seasonal forms of its action. They do not belong to the ordinary vegetation wherewith the earth is clothed and ornamented at all times, and in which the succession of the seasons is so strongly marked. They rather form part of a vegetation which, though not necessarily Autumnal in time according to the calendar, is yet essentially so in its use in the economy of nature: we mean the very curious race of the fungi, to which we shall have occasion to refer in a subsequent chapter of this volume. But independently of these, there is a wonderful power of distribution in the seeds of flowering plants; so much so, that if a new island is upheaved from the bottom of the sea, or formed by conflicting currents of water, no sooner does it become a fit receptacle for any species of plant, than that plant finds its way to it,—no doubt in the state of a seed, but by means and in a mode beyond our powers of explanation.

The Autumnal rains occasion a pretty general distribution of the seeds of wild plants, although this is in great part from the higher to the lower grounds in the same country. Very many of these are conveyed by the water-courses into the rivers, and stranded upon the banks. These banks are not always fit receptacles for the seeds and germs which are thus brought by the waters; but when the dry season comes, many of these stranded germs are wafted to distances from the banks of the rivers, where they find soils more congenial to their nature, and grow much more luxuriantly than in the more upland places upon which they are produced. There is a reciprocal advantage in this: the rich low-lands are more favourable for individual growth, and less so for flowering and the production of seeds, than the upland places; and the seed from the upland grows better in those low grounds. In severe climates, where the weather breaks in snow, and not in rain, there is a still greater preservation of the seeds of wild plants than in the rainy countries. In such places the dry weather continues up to the very day on the evening of which the snow begins to fall—for it usually begins in the evening, or rather during the night;—and the seeds, of whatever plant they may be, are perfectly secure under the snow, for the temperature there is never such as to hurt any ripened seed; and even bulbs and fleshy roots are much more safe under its protecting mantle than if they were exposed to the air at a much higher temperature than that which prevails over the surface. Then, when the snows melt, and the spring rains set in and swell the water-courses, the preserved seeds are borne down in great numbers; and it often happens in the high latitudes, that fields are formed and sown with the seeds of wild plants by these spring freshes, sometimes with a mass of ice below, which, protected by the deposited mud and sand and vegetation, may remain, not only for one season but for a number of years, unthawed under these curious lands. These buried masses of ice, with soil and vegetation over them, have often led to strange mistakes about the temperature of the interior of the earth in the high latitudes. Thus it has been said by many of the old describers, that if the soil in the vicinity of Hudson's Bay is dug into to the depth of a few feet, the interior of the earth is so cold that the ground is frozen. Now the great heat of the summer, as compared with the latitude, and the rapidity with which the snow comes on in the Autumn, are such as to preserve a much greater winter heat in the ground there than there is in many places further to the south, having the winter more open, and the temperature of the air over the surface much higher. The sudden fall of the snow, and the pertinacity with which it lies, prevent that radiation of the action of heat from the surface which would otherwise take place; and thus there is a very safe Autumnal preservatiou both for the seeds and the roots of plants. Of the Autumnal action, as maturing and also as preserving the germs of flowering plants, we shall afterwards have occasion to speak more in detail; and therefore what we have stated must suffice for a general notice of what the Autumn has to do in the case of these vegetables.

The next part of the Autumnal action, as it refers to the same class of plants, is what it has to undo; and this is, perhaps, a more curious part of the subject than the former. Of course it lies wholly in the opposite direction, and is as much connected with the general destruction of vegetables as that which has been stated is with their general preparation. The seasonal growth of plants, whether as producing additions to the permanent volume of the individual plant, or as preparing for those seeds and germs which are to be matured by the preserving action of the Autumn, requires the use of many organs of a temporary character; and which, even in the most lasting of ordinary trees, are perfectly seasonal in their use, and, like the parts which produce the flowers and the seeds, are altogether incapable of performing their functions more than once. All the parts of vegetables which are thus destined to perform a single function, and have performed it, cease from that moment to be part of the living vegetable world. But the law in nature is general, that every thing which is without a use, and not in a state of preparation for a use, is really an incumbrance in the way; and the system of nature would be quite imperfect if there were not some means of removing those incumbrances, and transferring to a new use that portion of matter which had ceased to be valuable for its previous one.

We have illustrations of this law everywhere, in every growing and living thing to which we can turn our attention. Whatever is applied to the plant or the animal, in the way of food for the increase or the maintenance of the substance of its body, in the way of air for carrying on the functions of its system, or in the way of heat, light, or any other of those displays in nature which are known as action only and not as substance,—whatever is applied, naturally, to plant or animal in either of these ways, invariably consists of two portions, one of which may for distinction's sake be called essential, and the other vehicular. The first of these may be taken as a convenient general name for the matter which goes wholly to the substance of the plant or the animal, either as new matter for an increase of growth, or as renovating matter to replace that which, having already performed its function, is no longer fit for the support of life or growth; and which, were it to remain, would be the same kind of incumbrance to the proper working of the individual, as that surplus of annual growth of which we are speaking is to the working of the general system of nature. In like manner the essential part of the heat, the light, or the other action, is that which is wholly transferred to or absorbed by the system of the plant or the animal, without being given out to, or becoming apparent in, anything else.

The vehicular part is that which conveys the other, simply as a means of conveyance, and which subdivides or dilutes it to the exact degree which the condition of the plant or the animal requires. This vehicular portion is sometimes a separate ingredient determinable by our means of analysis, and sometimes it is not; though we have reason to believe that, in every case, there is a natural distinction between those two portions, if our analysis could be conducted with sufficient nicety for ascertaining it; and that when by any means more than enough of the essential portion is applied to any plant or animal, the system is thereby overworked and injured.

This fact of there being an essential and a vehicular portion in every kind of substance, and every degree of stimulus which is applied or which can be applied in any one of the operations of nature, or to any one being possessed of growth or life, is one of the most extensive and most important facts in the whole economy of nature,—so much so, indeed, that it may be considered as the grand law, of which all the others are merely modifications. It is a law, indeed, which is not specifically recognised by the schoolmen, or set forth in the books which we are taught to look upon as authorities; but it is not on this account the less true or the less important. It is, indeed, the only law which enables us to apply one philosophy to the whole system, and make nature its own interpreter in all its parts.

The parts of nature are also so beautifully adapted to each other, and to the keeping of the materials and the powers of nature constantly in use, that that which is merely vehicular in the case of one being, is essential in that of another; and thus the very fact of growing and living in the one case, actually prepares the means of growth and life in the other; and if we follow out this principle of mutual assistance and dependence, we find that it is perfectly general, and so beautifully regulated as to keep up the whole system without any assistance.

This principle is one with which it behoves us to make ourselves thoroughly acquainted, not only because without it we can never understand the system of nature's working as it ought to be understood, but because the knowledge of it is essential to the preserving of a healthy state in our own bodies, in respect of food, of clothing, of exposure to the atmosphere, exposure to heat, exposure to damp, and every other case in which different degrees of that which is applied to the body can affect us in a different manner. It is the want of this knowledge which has, in every age, caused the medical profession,—or, to express it more correctly, the drugging trade—to be peopled with more abundant, more absurd, and more impudent, but still more successful and profitable quackery, than all other trades upon earth—the trade of public legislation for the benefit of quacks and impostors of another kind, perhaps, only excepted;—and the latter is but of modern growth, and may be only of mushroom duration, while the drugging quack has existed from the beginning, and will continue until men acquire so much knowledge of their own bodies as part of the system of nature, as to enable them to do the best in every change of circumstances under which they may be placed. This is the grand practical purpose to which all our inquiries into natural causes and natural substances ought to be directed; and it deserves to be generally known and carefully inculcated, more especially upon the young, who are not yet bound to the chariot-wheels of custom, that there is no royal road to this species of knowledge; but that if they will not observe and think for themselves, they must be contented to remain for life in that helpless and pitiable condition in which they are defenceless to every species of imposture which can assail them on the subject.

We shall afterwards have occasion to mention one remarkable case of the provision of nature for supporting one class of beings upon that surplus which becomes an incumbrance to another class, when we go a little into the detail of means by which Autumn removes those materials which are left over when the purposes of summer and spring are accomplished; but still, as the principle is one which should always be ready, it may not be amiss to give one or two simple and familiar examples in further illustration of it.

The most general and familiar instance that can be given is that of the air which we breathe. There are always a few foreign substances mixed with this fluid; but, whatever these may be, their quantity, unless in the close vicinity of those substances that give them out in vapour, is so small that they have very little effect one way or another; and thus, when we speak in general terms of the air as applied to the lungs in breathing, we may leave those foreign substances out of the estimate. Now the air, in the average circumstances in which, in Britain, it enters the lungs in breathing, contains two parts out of nine in weight (which is the proper measure of absolute substance) of oxygen, and the remaining seven parts of nitrogen; the first of which is the essential portion of the atmospheric fluid in breathing, and the second the vehicular portion. When the air is in the lungs, the nitrogen is wholly passive, except in so far as it may be expanded by the heat of the lungs, which in ordinary circumstances is greater than that of the air which is inhaled in breathing; and may thus assist in the expiration of the breath, after the oxygen—the essential part—has done its work. But the oxygen takes up in the lungs as much carbon or charcoal as converts it into carbonic acid gas, without any change of bulk except what it may receive from difference of temperature. In this process of breathing, 338 parts, by weight, of the oxygen of the lungs, take up from the blood 127 parts of carbon or charcoal; which makes the compound or acid heavier than oxygen in the proportion above stated, and more than one and a half times the weight of the same bulk of common air at the same degree of temperature. Thus, the carbonic acid which is the result of this operation, contains much more matter in the same bulk than it did when it entered the lungs in the state of oxygen. From this we would naturally infer that, as it takes a higher degree of the action of heat to keep any quantity of matter expanded into a greater bulk, than it does to keep it in a smaller one, there should be a portion of the action of heat set free by the conversion of this oxygen of the breath into carbonic acid in the lungs. Such is found to be the fact; for while the action of heat which keeps the nitrogen in a state of gas remains the same, that of the carbonic acid is considerably less than that of the equal volume of oxygen from which it is formed; and thus it is probable, that while the breath removes the surplus charcoal out of the system, a certain action of heat is at the same time evolved by the process, which may stimulate the lungs, and at the same time protect their exceedingly delicate structure from the temperature of the inhaled air, which is generally lower than that of the interior of the body. According to some of the earlier theorists,—who wrote before the doctrine of the different agents, agencies, or actions by which the operations of nature are carried on, were so well understood as they are now,—it was supposed that this was the only source of heat in the living body. This, however, is far from being the case; for heat is an invariable concomitant of material action, in what manner soever that action may be carried on.

In the instance which has been mentioned, we have more than one illustration of the general principle. In the air we have the essential oxygen, diluted to the proper extent by the vehicular nitrogen; we have the carbon, which had become incumbrance and waste in the system, removed by means of the oxygen; and we have a new compound in the carbonic acid, which, being retainable in the atmosphere in a very small portion only, is precipitated to the earth, into the pores and openings of which it runs like water, and in all probability forms an extensive as well as an essential part of the food of plants.

The perspiration, which is at all times given off from the surface of the body in an insensible manner, is another instance of the discharge of a substance when it seems to be necessary to the healthy action of the system; and the stoppage of this by what we call "catching a cold," or by any other means, is so injurious, that we cannot fail in being convinced that the removal of that which has ceased to be useful, is as necessary to the proper working of every part of the system of nature, as the application of that of which the system stands in need. Thus the moment that this surplus or incumbrance is discharged from that to which it would be injurious if it were to remain, there is always a new use ready for it; and thus no part of the material of the creation is ever idle, though its combinations and forms are constantly changing as it passes from race to race.

Length of time, as we judge of it, is not a necessary element in this part of the system of nature. The period during which any identical portion of matter may be required to remain in the same production of nature is quite indefinite. It may be more brief than the smallest fraction of a moment of which our senses can take note, or our imagination can form a notion; or it may be days, months, years, ages, or periods so long that we cannot name them by any number. In all cases, however, of which we have any knowledge, whether the period be long or short, there is a growth of the individual, which is really a spring action,—and a fructification, which is really a summer action. After these, there is a maturing of the seeds or other germs, until they are independent of that by which they are produced; and then a transfer of the matter which has done its work, to some other race; and both of these are Autumnal actions—the two characteristic actions of that season, whether we consider it as a portion of the year, or of any shorter or longer period of time.

In the case of annual plants, we have of course only one annual Autumn, in which the maturing of the germs and the destruction of the old plant are both completed within the year. In shorter lived plants, there are, of course, as many Autumns in the year as there are successions of the plant; and in some species, in those places which are favourable to their rapid growth, this may amount to five or six, or even more. None of these Autumns of the plant, whether there is one or there are more than one in the course of the year, is absolutely confined to the Autumn according to the calendar. They vary in their times even in wild nature, and man can vary them still farther by artificial means. Thus, if we were to take our Autumn according to the months, we should have a very garbled and uninstructive notion of the real function of the Autumn.

In plants of perennial duration, the case is still more complicated. Such plants in seasonal countries,—the common deciduous trees of our forests, for instance,—have a double period, a period for the season, and another period for the tree, longer or shorter according to its duration. In those cases the destruction of the seasonal Autumn is, generally speaking, accompanied by an autumnal perfecting of germs; but the destruction of the long Autumn of the tree is a final destruction, not necessarily accompanied by any means of providing a successor; and it is by the action of this kind of Autumnal destruction, that the characteristic vegetation of large tracts of country is often changed—of which there are many instances in the British islands; and the greater part of them consist of the removal of trees, and the substitution of surface vegetation, or of peat bogs in their stead; and then, when another and more mysterious wheel, in the curious and in many instances inexplicable revolutions of our globe, comes round, the lofty plants, with the entombment of more humble ones by which they were at the first hidden from the air and the sun, are converted into beds of coal. Thus, if we follow out the study of the Autumn in a proper manner, it leads us to all the revolutions that have taken place in the surface of our planet; and in this way a plant of which we can, in a few months, see the beginning, the perfection, and the decay, becomes to us an epitome of the system of growing nature in its widest extent and through its most prolonged duration.

This is the grand advantage which studying the productions of nature in their connexion, and the events and occurrences of nature in their succession, has over the mere observation of the individual substance and the passing moment; and it is this which gives to the law of the seasons so high a value above all the beauties of the seasons taken in their individual character. It is this also which makes the principles of seasonal action thicken upon us as the year advances; and the Autumn to become the harvest of knowledge, as well as of the fruits of the earth. Nor can we help admiring that bountiful and beautiful wisdom, which has laid the elements of instruction most abundantly, in the grand season of plenty and of gratitude.

There is something fresh and delightful, and peculiarly fitted for giving buoyancy to the spirits, in the opening of the spring, and something lovely in the bloom of the summer; but in them we behold only the progress of one generation as it were, in which each plant (we speak of plants only, and of flowering plants especially,) works chiefly for itself,—first for the increase of its substance by leaf and stem, and then for its adorning, by the symmetrical form, the radiant beauty and the delightful fragrance of the flower. It is true that the great act of nature, the most important one in the whole revolution of the seasonal period, whether that extends to a year, or more, or less, is accomplished in the summer, and is the grand work and purpose of that season; but, like all beginnings in nature, it is a matter of inference, not of observation; and therefore, by all mankind for many ages, and by the majority of mankind in every age, it has been, and is, unheeded.

But the want of knowledge of this act of the summer, has a most unhappy effect upon the feelings which we have in respect of the Autumn. It is impossible, indeed, that we can pass unheeded the plenty which the Autumn brings us. But the reflections to which this is calculated to give rise are few, and they are also narrow and selfish. For as the annual harvest which we obtain from the earth is viewed by us as resulting from that in which we have a right of property, a merit in labour, or both united, we are apt to forget the part which nature has in the productiveness of the year, and look upon the whole produce as the return of our own capital and our own skill, just as we do in any mechanical work or mercantile speculation. That this is the true state of the case, is proved by the habitually proverbial fact, that the cultivators of the ground, for what purpose soever they may cultivate, are always complaining of the weather, as the grand enemy by which all their labours are frustrated, and all their products diminished. They are nowise at fault themselves, but "the weary weather" never will be obedient to their dictates. What with rain, what with drought, what with heat, what with cold, each thrusting itself forward at the time when its opposite would have been by far the more beneficial, the crop which they get is always "below a fair average;" and what they do get is gotten in spite of the weather, and not by means of its cooperation. It is in vain that the fable of the farmer,—into whose hands Jupiter gave the management of the weather, and who, by having rain and drought, and sunshine and snow, when and where he wished, brought his land into a state of such utter sterility that he was fain to plead more earnestly than ever that so dangerous a power might be taken out of his hands,—has stood on the record against them from remote antiquity; for the majority contend stubbornly that all the merit is their own, and that all the blame falls upon the weather, which, notwithstanding all the examples which have been set before it, and all the experience it must have had, "will not understand and obey the rules of good husbandry."

But if the season is thus blamed—and any one who chooses to collect the evidence may find that it is very generally so blamed—in so far as it is concerned in that portion of the produce of the year in the producing of which the labour of man also bears a part, how much more fell and fatal must it seem in those cases where, without the interposing hand of human skill, it works for dissolution only, and without any saved remnant or any useful result which the eyes of common observation can discover!

In its very beginning, it takes the growing world,—

we say the growing world as that which must abide the season, and is therefore most expressive of it,—it takes the growing world in the very fulness of its beauty, shrivelling the petals of the flowers, and casting them to the dust, alike unseemly to the eye and ungratifying to the smell. And this is only the mere beginning, or rather the signal to begin; for it takes place when all the rest of nature is in the full vigour of its activity. But yet a little, and the trees are stripped of every leaf; the herbage is consumed from the pastures; the winds awaken, the clouds congregate, and the rains come down, scourging the earth to the bare rock;—while the swollen streams roll the fat of the land onward to the sea; and then, as if to make the work of desolation doubly sure, the cold mantle of the snow is cast upon the land, and the waters are bound in fetters of ice.

This is the visible progress of the Autumn, which the people of seasonal climates witness every year, and which displays itself with more force and fleetness, in proportion as the climate is more seasonal; and thus the Autumn is emphatically termed "the fall" of the year, and spoken of in gloomy terms as a season prominently fatal to human life. There is no doubt that this is the general impression among the majority of those inhabitants of the country whose thoughts extend beyond the mere event of the hour; and there is as little doubt that, from the close analogy that there is between this decline of the year and the decline of human life, gloom and despondency are produced, and the mind shrinks from thought upon the most important of all subjects, because of the horror which it fails not to inspire in the unrenewed heart.

It is in vain that recourse is had to the delineations of those occupations and scenes which are usually supposed to take off the gloom of this season,—the reapings, the vintages, the harvest-homes, the huntings, and all the other characteristics of the rural Autumn. These are, like "merry music when the heart is sad," an opiate for the time; but, like other opiates, they leave the mind enfeebled and the anguish deepened when their very momentary influence is over; and this is the reason why it is of so much importance to have clear and comprehensive views of the Autumn,—views much more comprehensive than can be obtained from observing and studying the phenomena of the season in any one country or climate.

We must also make ourselves acquainted with both the means and the mode of action of each of the parts of the double function of the season,—the perfecting and preserving of all that is essentially necessary for the spring and summer of the coming year; and reducing to the condition in which it shall be most useful for future growth, all the vehicular portion where function ceases with the year, and which requires to be decomposed before it can again run the same course.

Hitherto, this has been viewed chiefly in the case of flowering plants; and we shall still continue to view it through them, because there it is most conspicuous and most perfect. Flowering plants have not, as animals have, the power of subsisting directly upon organized substances as food; they do not take into their system solid food of any kind; or at least if they do, it is in a state of atomic division, or nearly so; and as it is taken in along with water, we are not able to draw the line with any precision between the essential and the vehicular parts of the food of these plants, or to trace any function in them at all analogous to that of assimilation in animals. But when we contrast the average appearance of flowering plants in a country whose seasons are strongly marked, at the two periods of their greatest development and their greatest nudity, we cannot fail to observe, that as much must be done in order to reduce them to the last of these states as is done to bring them up to the first. It is true that trees and shrubs accumulate an addition to the substance of the individual, which is not lost in the reversal brought about by the autumnal action. But this has a limit; and a greater Autumn is at work in reducing the matter of the most long-lived tree, and often goes on in the central parts for years, or even for centuries, before the external or living part of the tree yields to final decay. It is probable that, taken upon the average, this gradual decay of the solid parts not only keeps pace with, but in most instances exceeds the annual increase of solid matter in trees; for, except in a few spots, and they are but few as compared with the whole surface of the land, almost every country gives evidence, in the remains which are buried in the earth, of having been more thickly wooded at some former period than it is at the present day. But this belongs to the progressive history of the earth, rather than to the seasonal history of the year; and therefore we are not required to go into the details of it, though it is necessary to keep the general principle in mind, because it explains various matters which otherwise would appear anomalous in the annual Autumn. Indeed, in all our examinations of nature, and more especially in those which have reference to succession in time, we must bear in mind that the system of nature, in all its days, and years, and ages, is one; and we can never have a proper understanding of even the most brief period of this succession, though narrowed to the most limited, to the smallest extent in space, if we view it apart from that natural succession, in which all its appearances are effects of what went before, and become in their turn causes of what follows after. It is this which forms the great difficulty as well as the great charm of the study of nature in any one of its departments, in any one of its individual productions, or in any one momentary state of that production. The charm consists in the microscopic animalculi and the majestic array of a planetary system bringing us alike near to that part of the study where it rises above all human philosophy, and leads us captive in bonds of delighted veneration to the adoration of nature's God.

Hitherto, we have considered only or chiefly the flowering plants as an index to the proper function of the Autumn; and we have done so because they are at once the most easily observed and the most striking. But we need hardly remind the reader, that the season tells upon the whole of nature, though differently on the different parts; and that the immediate agencies by which these Autumnal changes are brought about, vary with the different classes. In all of them, however, there is an Autumnal action, *upon* rather than *of* the individuals themselves. If in the course of the season they cease to be possessed of vegetable or animal life, then we may consider them as entirely passive, or given up to the common laws of matter; but if the life is not extinguished, we can consider them only as being modified, and of this modification the varieties are almost innumerable. In the animal kingdom, the slightest seasonal influence upon the actual condition of the creature, may be considered as taking place in those birds which summer in the cold latitudes, and perform Autumnal migrations into warmer ones; and the extreme limit in the other direction may be taken in those invertebrated animals which are consigned to the egg, and those reptiles which become so completely dormant in the cold weather that they may be broken in pieces without the slightest signs of motion or sensation. In the vegetable kingdom, the pines, and the other evergreens, which carry their foliage through the utmost severity of the winter, in the most polar situations in which a plant will grow, are to be regarded as those which are the least affected by the Autumnal agency; while those plants which remain during the winter in the state of seeds only, are obviously those upon which the influence of the season of decay is the most complete.

But in all these instances, it is only what may be considered a seasonal modification of continued or transmitted life; and this depends in a very great measure upon the astronomical and meteorological influences of the season, and does not demand a reference to those special terrestrial agents which must be regarded as the appropriate armies of Autumn, in preparing the productions of the earth for the action of a new spring and summer; and it is in those of them which are more especially its own, that we are to seek the proper character of the season.

This is not done in the ordinary books which treat of the Autumn, and therefore they present us with little else than a number of phenomena, which have no apparent connexion except that they follow each other in a certain order of time; and a list of this kind, how long soever it may be, and how finely and forcibly soever the several parts of it may be delineated, cannot be so generalized as to form any part of that vital description of knowledge which contains in itself the principle of its own extension. We must, therefore, take our range somewhat wider than this; and if we shall fail in producing the effect which we wish, our failure will be where few or none have hitherto attempted.

CHAPTER II.

AUTUMN IN DIFFERENT LATITUDES.

In the phenomena of nature in different latitudes, and the extent of its action there, Autumn is as much diversified as any of the other seasons; and as its action may everywhere be regarded as consisting, in great part, of a reversal of the action of spring and summer, it follows as matter of course that it should also be the reverse of that action in its power. In our volume on Summer, we endeavoured to explain the nature of the surplus of summer action, which is the power left at the disposal of man, as available for the purposes of artificial cultivation. In as far as the Autumn prepares and preserves the seeds, the fruits, and the tubers, and other root or stem accumulations of matter for the succession of plants, man reaps in the Autumn a harvest proportionate to the advantage which he takes of the surplus of summer power. In cultivated countries the domestic animals, which bear their share in the labour along with man, and contribute largely to the amelioration of the soil, have also their share in the abundance of Autumn. Many of the wild animals partake along with them, and the numbers of these increase as cultivation advances. In wild nature also—where there is no labour of man except in the destruction of that which nature produces spontaneously and unassisted by him—the wild animals have their share in this abundance of the season; and those which are the most numerous and have the largest share, gradually fade away in their numbers as the dominion of man becomes more fully established. But in every case, whether of wild nature or of the highest degree of human cultivation, there is a strengthening of those wild animals which are to winter in activity, which is not equalled at any other season of the year; and this is wisely done, inasmuch as it prepares them, not merely for enduring the hardships of the winter, but for performing those labours to which their economy calls them when spring again renews the year. There is a great deal of beautiful manifestation of design in the several adaptations of the creatures in this way; for the waste of the system not only diminishes in the extreme severity of the winter, when food is difficult to be obtained, but in the fulness of the abundance of Autumn, when the most nutritious food is obtained with the least labour, both by the vegetable feeders, and by the carnivori which feed upon them. The mammalia and the birds, which are the classes of animals most open to common observation, and therefore most useful for illustration upon all general points, have, generally speaking, two labours to perform previous to the Autumn, although both the one and the other are in some cases carried into the Autumnal months as these stand noted in the calendar. The first operation, and the most important one in the progressive economy of nature, is the producing and the rearing of their young for the year; and the second, which is more exclusively for the individual, is the renewal of their clothing—the production of new hair or fur in mammalia, and new feathers in birds, secreted by those organs of the skin which nature has provided for the purpose, and which work with the utmost nicety and perfection in proportion to the necessity that there is for them; so that every animal is clothed for the winter in proportion to the degree of winter severity which it has to endure. The performance of those parts of their annual economy, calls forth powers in the animals which are not required in their ordinary every-day labour of finding their food and attending to their safety; and as it is a law of the whole system of nature, that every power, whether animal or anything else, continues for some time after it has accomplished its purpose, those very powers of the animals whose working had to a considerable extent exhausted their systems, remains to work during the Autumn for the recovery of their tone. What we thus see in the individual animal is a sort of epitome of what takes place in the year itself, as applicable to the whole of nature; for in so far as Autumn is the season which matures and conserves all that is to work in the succeeding spring and summer, a surplus of what may be called summer action is carried forward into the Autumnal months for the performance of this part of the Autumnal action of the year. This portion may naturally be supposed to be the reverse, in regard to latitude, of the proper action of the Autumn, that is to be smallest where the real Autumnal action is greatest, and the reverse; but still it is necessary to bear it constantly in mind, otherwise we shall be in danger of falling into error in our estimate of the more characteristic action and use of the Autumn. This being understood, we may proceed to take a rapid glance at the characters of Autumn in the different latitudes, or, to speak more correctly, in the different climates, considering these as dependent upon local circumstances, such as elevation, soil, and exposure to the sun and the atmosphere, and to the effect of surrounding surfaces, as well as to mere distance from the equator.

This view of the Autumn involves what may be considered as the astronomical cause of the season, though it is not wholly confined to that cause; and in the former volumes of this series on the Seasons, as well as in those on the Heavens, Earth, Air, and Sea, we have had occasion so frequently to allude to this as dependent on the motions of the earth, that repetition in this place is quite unnecessary. We may, therefore, hold it as understood, that the astronomical Autumn in each hemisphere, is that portion of the earth's revolution during which the sun apparently declines from the tropic in that hemisphere, toward the tropic in the opposite one; but that it does not begin until the time of the tropic is past, longer or shorter according to circumstances, and also more marked in its character, according to the latitude, the elevation above the mean surface, and those other particulars which tend to vary the seasonal appearances and productions of different regions of the globe.

In the more favoured spots under the equator, nearly on the level of the sea, where there is at all times a sufficient supply of moisture to accord with that maximum stimulus of heat which constantly occurs in such places, there is no perceptible difference of seasons, and consequently no marked Autumn or Autumnal action; for if there is any pause in the flowering and fruiting of the vegetables, it is occasioned not by the ordinary astronomical causes of diversity of seasons, but by the reciprocal action of the hemispheres upon each other, or those of land and sea, occasioning atmospheric currents, in consequence of which drought and rain alternate with each other. But in the tropical districts of extreme fertility, to which we allude, the alternation is not that of growth and scorching, as it is in the more arid places of the same latitudes: it is an alternation of flood and marsh—of water stagnating to the depth of a good many feet at one season of the year, with rich muddy soil at another, but so shaded from the sun by lofty trees, and twining parasitical plants of most luxu iant growth and extreme beauty, as never in the least to suffer from the torrefying influence of the solar beams. The comparative equality of day and night throughout the year, contributes to this uniformity of the seasons; and though such places are the most favourable on the surface of the earth for their own rich and peculiar vegetation, they are particularly unhealthy for man, and for those animals which are especially valuable to man in a state of civilisation. Rice, and some of the plants which produce the farinaceous substances known by the names of arrow-root, tapioca, aud others, grow luxuriantly; but the culture of them is fatal to Europeans, and unhealthy even to the native population of these countries. Ground animals which graze the herbage, there are none, and there is no herbage for their support; consequently the larger carnivora which prey chiefly upon such animals are found on the margins of those districts rather than in them. The mammalia, which are at home there, belong chiefly to the pachydermatous, or thick-skinned animals,—as for instance, the hippopotamus, in the river or the stagnant water, though breathing air like a land animal, and gnawing twigs and aquatic plants for its food; then the rhinoceros, not actually in the water, but among the reeds aud giant grasses, in its immediate vicinity; and afterwards the elephant, in the rich forests, which we would call between the wet and the dry; and next to the elephant there succeeds the wild hog, still partial to the water, and closing the list of the living pachydermata of the rich and humid places of the warm latitudes; to which the buffalo succeeds, and the series continues in the ruminant animals, until these again mingle with the wild asses on the margin of the desert, which are again pachydermata, though very different in many of their characters from those which occur in the tropical waters or their immediate vicinity.

In this respect, however, there are great diversities in the different continents or quarters of the world which are intersected by the equator. The hippopotamus occurs only in Africa; and the rhinoceros and elcphant in that quarter of the world and in Southern

Asia, and there are specific differences between both as occurring in the two quarters. In the corresponding latitudes of South America, there are no mammalia of large size, though such as do occur belong also to the pachydermata: these are the tapir, bearing some slight resemblance to the rhinoceros, but without any horny appendage to the nose, and the peccary, which has some character in common with the hog. The tapirs of America are about the size of asses, and there is a species in the Asiatic isles a little larger: the peccaries are small animals, about half the dimensions of the wild hogs of Europe, and they are peculiar to the warm forests of the American continent.

Such are the ground mammalia of the more fertile portions of the tropical zone of the world, where there is hardly any difference of seasons, and Autumnal action and Autumnal agents are unknown. They are associated with the largest and most powerful of the reptiles,—the crocodiles and alligators among the sauria or those of the lizard tribe, and the pythons in the East, and boas in the West, among the serpents which are possessed of great mechanical strength, but have no poison fangs.

At a higher elevation above the surface of the ground, we find the quadrumana or four-handed animals, in vast numbers, and in great variety of size and form, though all in so far resembling each other in that type which is so often, but so improperly, regarded as a sort of caricature of the human body. There is no caricature in the case; these animals are adapted for living habitually and for finding their food in trees;

and their hands, of which they always have four, and sometimes the tail answers as a fifth one, are merely grasping instruments, and not instruments of all work, like the human hand. Higher still in the giant-growth of those tropical forests, there is another, and a very peculiar race of mammalia, the sloth, confined as living animals entirely to South America. They live more exclusively in the elevated parts of the trees than even the apes, monkeys, and other four-handed animals; and in their mode of life they resemble the common ground mammalia, reversed in their positions. They move about among the twigs, hanging by the feet with the back undermost, and browse the leaves over them; they also repose in this posture, which is with them the posture of rest; and when they are compelled to descend to the ground, they are out of their place in nature, and comparatively helpless.

The mammalia and reptiles which we have noticed, remain in their perennial forests, with little or no change of seasons, and without ever migrating into any other parts. In addition to these, there are many tree birds, of the zygodactylic, or yoke-footed order, that is, the climbers, which have two toes to the front, and other two to the rear; which have the feet well adapted for action among the twigs, but which are very awkward upon the ground. The short-tailed and thick-bodied parrots, the toucans, and many other genera, have these characters; and they remain as constantly in the forests, and are as little seasonal in their habits, as the mammalia and the reptiles which have been described as inhabiting the same places at all seasons. In their colours, these birds' form a remarkable contrast to the mammalia of the tropical forests, for they are as gay as these are dingy. Their bright colours and the adroitness of their motions among the branches are, however, their chief attractions; for their voices are harsh and screamy, and they are in general mischievous in their habits. It should seem, indeed, that both the mammalia and the birds of these rich forests assist in breaking down the trees which they inhabit; for when they are kept in confinement, they are very much given to gnaw and pull in pieces every thing that comes in their way.

In those places which may be considered as having the minimum of seasonal action, and sometimes no perceptible seasonal action at all, the particular agents of the Autumn are not required, and they accordingly have no place. Thus we may take these places as the first beginning from which seasonal differences become apparent as we ascend in latitude and also in height above the mean level of the sea. Before, however, we attend to the gradation and the use there is for Autumn either way, it may not be improper to notice what may be termed the fall of the year, in places in the same latitudes, but differing in their physical characters from those humid ones which we have described. In them there is a season of annual vegetation, and a season in which that vegetation disappears, the spring of the vegetation coming on with the seasonal rains, at what time soever of the year those rains may occur, and the Autumn commencing when the heat and drought have become so powerful as to begin to wither the annual stems and the annual leaves. In those places, both the conservation of the preserved plants, and the extinction of those plants or parts of plants which have performed their offices in nature and are no longer required, are brought about by the influence of the sun and the atmosphere without any special Autumnal agents to perform the decomposition. This, by the way, is one of the reasons why the exposed surface in such places is so apt to turn into desert. The intense heat of the sun evaporates all the evaporisable parts of the decaying plants ; and what remains is dust before the wind, or scum upon the waters when the rains come; and thus both these agencies tend to transfer it into the rich and marshy places where such exist, or into the courses of the rivers where there are no woods and marshes to entangle it as in a net-work, and in the latter case it goes to form banks in the sea, or deep and extensive alluvial deposits in the lowest estuaries of the rivers. It is owing to this that the dry and the humid lands within the tropics, or in places having tropical climates, form so striking a contrast with each other, as compared with similar places in the temperate latitudes. The quantity of soil which is formed in the lower valleys of some of the great rivers in the warm latitudes, is perfectly astonishing as compared with any deposit of the same kind which occurs in the temperate ones. The lower valley of the Ganges is a remarkable instance of this, where the entire extent appears to have been gradually gained from the sea to a depth of several hundred feet. In the valleys of some of the American rivers, the alluvial deposit is one of immense depth. The most perfect skeleton of the megatherium, (a huge animal of the sloth family, of which we have not the smallest traditionary notice in the living state, which is now in the cabinet at Madrid,) was found in the alluvial soil on the banks of one of the affluents of La Plata, near Buenos Ayres, at the depth of a hundred feet below the present surface, where it had evidently not been buried by any violent convulsion of nature, but by the slow progress of the annual deposit during the rains. The lower valley of the Mississippi, toward the Gulf of Mexico, has not been much explored, and it is a turbulent river, and constantly changing its channel; but the quantity of matter which it has accumulated through a long extent of the valley is very great. The Mississippi is not within the tropics, and the regions from which some of its waters come are very seasonal; but the seasons toward its confluence with the Gulf of Mexico partake not a little of the tropical character.

In some of those tropical countries there are double seasons in the course of the year, as the apparent shifting of the calm action, both northward and southward, brings rain, and the setting in of rain in the warm latitudes is always a spring time for the vegetation, at what time soever of the year it may happen. But still, at whatever times the rains occur, and whether the intervening periods of drought be longer or shorter, there is never any thing that we can call a specific action of Autumn. The decomposition of that seasonal part of the vegetation which has performed its work, is always effected by the means which have been stated.

Even in the case of the decomposition of the solid wood of the tropical trees, in what we have called the "long Autumn," to distinguish it from the Autumn of the year, the destroyers which are employed in supplement to the decomposing powers of the sun and the atmosphere, have never a summer character. They are insects which enter the trees in countless myriads, and reduce the whole of the interior to dust; but which, of course, do not change them into any other vegetable substance more easily decomposed, so as to be available as a pabulum for new vegetables of the same kind. Thus, in whatever light we view the tropical countries, we are unable to find in them any thing that we can call an Autumnal action; and it follows that, in these countries, there is really no Autumn.

Setting out from the low-lying countries within the tropics, where the seasons are blended, and where there is no definite Autumn, there are two directions in which we may proceed, if we wish to trace the differences of seasons. The first of these is met with as we ascend in elevation; and the second as the latitude increases. Immediately under the equator, the differences of seasons are not very great at any elevation, though they do become a little more conspicuous as we ascend the mountains; but when we pass to some distance from the equator, the seasons upon elevated places become different from what they are in low situations. In the latter, the prevailing action of the whole year is summer action, and the modifications of wet and dry, without much reference to change of temperature, farther than the secondary influence of evaporation in producing cold, which, however, is often greater than one would suppose. Within the tropics, snow never falls on the low grounds, or at moderate elevations; but there are frosts on the hills, and hail-storms which sometimes descend into the plains and do great damage to the more tender crops. From this cause the cultivation of indigo in the valley of the Ganges, which is now one of the staple articles of Indian farming, and of which between nine and ten millions of pounds are annually sent to Britain from the lower valley of the Ganges alone, is rendered a hazardous crop, though when no casualty occurs it is a very profitable one.

In all those tropical countries of which we have been speaking, the decomposition of the year is effected without any particular Autumnal agency, and the conserving part being against heat and drought, and not against cold, is provided for by the peculiar structure of the plants themselves. Plants there are so numerous, and so varied in their structure and habits, that the whole space to which we are restricted for the Autumnal characters of all latitudes and climates, would not suffice for half of them. But we may state that, in general, the epidermis of such plants is so formed that it is very decidedly a non-conductor of heat; so that, though the ardour of a vertical sun beats, day after day, upon the plant, standing upon parched earth or heated sand, the internal part of the plant remains as cold as if it were growing in Lapland. This is partly occasioned by the smooth surface of the epidermis, which reflects away the heat, and partly from the little evaporation that goes on at the surface. There is a curious property in those plants which remain in leaf abiding the utmost fervour of the tropical sun. The means by which it acts, and the mode of its action, have not been explained, and perhaps they are not explainable on the principles of science as at present known. But the fact of its operation is well known; and it is certain that plants which are clad in this tropical armour, can endure vicissitudes of the atmosphere which would speedily be fatal to those which are natives of climates the most inhospitable in respect of cold. The chief peculiarity in the action of such plants is their great power of absorbing moisture, and the small tendency which they have to give it out. The absorbent power does not reside in the roots, or in any specific organs; for the plants continue not merely to live but to grow, though the earth, as far as their roots extend, is as dry as dust. The moisture which thus sustains their life and growth is not derived from the soil; for water-melons, which are not named from any reference to their growing in or near water, but from the cooling nature of the juice of their fruit, which is as refreshing as a fountain in the desert, grow to the weight of fifty or sixty pounds each fruit, upon sand, in which there is no water till a depth of two hundred feet or upwards is attained, and where not a drop of rain falls to aid them in their growth.

Such plants are circumstanced in a manner in which no plant of our temperate climate could subsist for even a week, and yet they grow most luxuriantly there, and come to even greater maturity than they would in humid grounds, or exposed to those regular showers, which are so essential to the growth of our vegetation. That they must absorb a great deal of water, or of the elements of water, is certain, from the succulent nature of their leaves, for the plants of the hot and dry deserts are internally the most succulent of all plants; and we have an approximation in the house-leeks and several other plants of our own climates, which grow upon house-tops, old walls, and other places, where they have little soil, and very limited means of deriving a supply of humidity by spongelets or absorbing organs upon the epidermis. It is obvious, therefore, that those plants of the desert must receive that moisture which not only preserves their existence, but in many of the species supports a vigorous growth, and under circumstances which we would consider the most unfavourable, by absorption through the epidermis, close and poreless as that epidermis seems to our inspection. The process of absorption by a living subject, whether a plant or an animal, is, however, one the mode of which is very obscure. It is doubtful whether, even in the case of ordinary nourishment or growth, the new matter ever passes in substance into the body of the plant or the animal. On the other hand, the probability (for there is no positive certainty) is, that the absorbed matter, when it passes into the system of the plant or the animal, *so as to become part of that system*—to be changed from dead matter to living, is always in an atomic state, that is, divided into parts so small that neither they nor the passages through which they enter, can possibly be discovered by any microscope. The matters which are given out by the living animal or plant, are dead matters when they are given out; and thus they are given out by pores or openings of some dimensions, how small soever those dimensions may be.

This is a very important matter, and one the knowledge of which is indispensable to a proper understanding of the working both of plants and of animals, and their adaptation to different climates and different seasons; and it is a matter which can, perhaps, be more advantageously studied in the plants of the desert, which are to all appearance *deserted* there by the ordinary assistants of vegetation, or at least by what we consider as such, and thrown entirely upon their own resources; for in them we can contemplate the single subject and its adaptations much better, than when it is confounded with a number of others which we regard as auxiliary, and contributing—we cannot tell how much—to the result which we observe; and yet we never can understand as we ought how a plant or an animal is affected by the action of Autumn, or of any other season, unless we have some notion of the function of an absorbing or assimilating surface.

We are apt to be misled by an error which is very prevalent upon such subjects as this, and which the generality of the printed books tend more to confirm than to correct. We are apt to look upon the action of a living vegetable or animal as being mechanical, or chemical, or a compound of the two; whereas, the very slightest consideration of the case might satisfy any one that the real principle, the operating power, both in vegetable and in animal action, is not only different from every kind of mechanical or chemical principle, but in direct opposition to them,—that the plant or the animal maintains its place in nature as a distinct being, only so long as it can act effectively in opposition to the laws of dead matter, whether we regard those laws as chemical or as mechanical, according to the ordinary distinction made by the schoolmen, though it must be confessed that that distinction is by no means clear to the comprehension of ordinary readers, and the boundary is by no means well defined even by the said schoolmen themselves; inasmuch as that all chemical action passes into mechanical action when carried to a certain extent,—of which we have an everyday example in the steam-engine, which furnishes, by chemical agency, the most energetic and at the same time the most manageable power which we possess, and of which we have still more energetic though less manageable instances, in the explosion of gunpowder, and also frequently attended with the most direful consequences, in the blowing up of the boilers of steam-engines by an excess of heat and a deficient supply of water, resolving the steam into its constituent gases, oxygen and hydrogen, the expansive force of which at the instant of their separation is greater than any mechanical resistance that we can name. There are also instances of an opposite kind, in which substances are melted, or burned, or otherwise have their chemical constitution changed by rapid motion, and other mechanical means, such, for instance, as the hammering of a rod of iron until it becomes red hot.

These mechanical and chemical actions, and also the passing of the one into the other, we can understand; and the knowledge which we obtain of them from our own experiments is exceedingly useful, as applied to explain the phenomena and the action of all those parts of nature which are not connected with life, either animal or vegetable. But when we come to consider the relation between action in dead matter, and any of those actions of life, we find ourselves beset by difficulties which we cannot overcome; because the transition of any portion of matter from the dead to the living, or from the living to the dead, whether the living state be that of animal or of vegetable, is a mystery beyond the limits of our ordinary philosophy. Some have indeed stumbled upon what they supposed to be the steps of the transition here, or at least a vague sort of approximation to them, and we have had, and have at the present day, men seated in professorial chairs, authorized and appointed for the instruction of the young and the ignorant, and guarded against public inquiry by "Doctorial and other dubbings," who, in violence of logic and common sense, and outraging even the shadow of philosophy, speak of "organic matter waiting to be organized," and so docile withal in its nature, that it is more plastic than Hamlet's cloud, which, in the opinion of the old courtier, was in the consecutive moments of his speaking, "backed like an ouzel—and very like a whale;" for this plastic matter is, it seems, quite ready for sea or for land, for plant or for animal, and, just as the waves set or the winds blow, it may become a sea-weed or a lichen, a lettuce or a lion.

As long as doctrines of this extraordinary nature are maintained by those who are actually prepared and appointed for the teaching of others, so long must we expect that much both of ignorance and error will abound in society; and, therefore, despite the doctors, it behoves every man who loves the truth, and who has any opportunity, how apparently slight soever, of maintaining the truth, to expose such absurdities, by whomsoever they may be abetted, because the more high and honourable the party is in station or repute, the more he is a real pest in the way of knowledge.

This is not a mere error in the philosophy of matter, such as that of mistaking one substance or species of material action for another; for it strikes directly and immediately at that fundamental doctrine of all religion and all morality, the creation of the world by a being of infinite wisdom and power, and of every living creature after its kind, as is expressly declared in the sacred volume. It is worthy of remark that, in the account of creation given in the first chapter of the book of Genesis, though those portions which could not easily be explained to human beings, and are not essential to any important point of human belief, are very lightly passed over, the specific creation of the individual kinds of plants and of animals is clearly and expressly set forth as an emanation of the Deity himself: "God said, Let the earth bring forth grass, the herb yielding seed, the fruit-tree yielding fruit, *after his kind*;" and again, "Let the earth bring forth the living creature after his kind, cattle, and creeping thing, and beast of the earth *after his kind;*" and in order to guard against this very mistake, this supposition that there is or can be, in the mere matter of the earth, of itself, and without the germ or emanation of life, originally from the Creator, and subsequently transmitted from generation to generation, a power of originating any one animal or plant, even the most simple and the most microscopic, it is added: "GOD MADE the beast of the earth after his kind, and cattle after their kind, and every thing that creepeth upon the earth after his kind."

It would be irrelevant to our purpose to enter into the philology of these most important passages. We may, however, mention that the word translated "grass" obviously does not mean the *gramina*, or grasses in our modern sense of the word; for these are included among the "herbs yielding seed," and are, in fact, the most important of all seeding plants, as they form the bread-corn of every nation on the earth. The word seems rather to denote those humbler vegetables, the lichens and others, which have no visible seeds; for they are they which immediately clothe the surface—the earliest vegetation upon new lands, and they merit the distinctive epithet of contrast with "herbs bearing seed."

The introduction of this principle of life, as an element of action in all the displays of nature, whether seasonal or not, occasions a difficulty which does not occur in any part of matter that comes wholly within the laws of chemical and mechanical causes; and in the study of this principle, or of its results, which are, in fact, all of it that we can study, we do not derive the least assistance from any or all of their principles. When a plant or an animal overcomes a mechanical resistance, we are in the habit of saying that it does so by mechanical means; and when it overcomes a chemical resistance, we say in like manner, that it does so by chemical means; but our observation and expression do not, in any case, reach the origin of the action, or the manner in which the first and esssential part of it takes place. In what we call the mechanical structure, both of plants and of animals, we find, in the organs by which these actions are performed, instances of contrivance and adaptation so perfect and beautiful, that our choicest art not only falls far short of them, but differs from them in kind as well as in degree; and when we endeavour to understand and to describe that which puts the animal machine in motion, we are left entirely without any one relation or analogy that will connect it with our mechanics; and when we have simply stated that it is "the action of life," we have reached the utmost bound of our philosophy, and any thing further that we attempt to say, is not explaining, but, as is emphatically expressed, "darkening counsel by words without knowledge."

If we have recourse to chemistry, and resolve the animal or the vegetable with the utmost nicety of our analysis, into the different substances of which its body is composed, we are still not a jot nearer the principle of life than when we look upon it in the living state, and the performance of its functions. Indeed, we are not so near; for in the living plant or animal, we see all of life that can be seen; and before we can bring our chemistry to bear on it, it has ceased to be a living thing, and so our analysis of it tells us nothing more of the nature or the functions of life, than the analysis of a mineral dug from the deepest mine.

In all the phenomena of the animal and vegetable world, and more especially in the autumnal phenomena of the latter, the principle of life is a most important element; and the reason why it is more important to a right understanding of the action of Autumn than of that of any other season, arises from the fact, that in the Autumn, both parts of the action of life, or the action *upon* life, are concerned,—the conservation of that which is necessary for the following spring, and the decomposition of that which is to be in future useful only as matter.

We have already mentioned that the external agency against which the tropical vegetation has to be protected, upon the low grounds, in the Autumn, is an excess of dry heat. At great elevations in those latitudes, and in the high latitudes, the external action against which the vegetables have to be preserved, is the very opposite of this—extreme humidity, or extreme cold, according to the local circumstances. Now, as these are obviously the reverse of each other, the means by which plants are protected must also be quite different; and we must take this into our consideration, if we wish to understand the differences of preparation which the plants of different climates undergo in the Autumn. The decomposition of the parts which had done their office, is a distinct matter. We have already said that, in tropical countries, the influence of the elements—the powerful influence of the sun, the atmospheric air, and the heavy rains, are sufficient to effect all that part of it which more peculiarly belongs to the year, without the calling in of any, or at least of many of those agents which we shall afterwards have more particularly to notice as the autumnal army—the specific and appropriate decomposers of organic matter in temperate and polar latitudes.

Viewing, as we must, the action of life as a matter, with the intimate nature of which we can never become acquainted, we must at once admit that there is in a living membrane, a power of which no analysis of dead matter, even although the subject is the very membrane whose living action we wish to ascertain, can give us even the slightest knowledge, so far as we can judge of it; the action of life is an action of surfaces only, and in this it agrees with electricity, and with various other kinds or modifications of action, which also refer only to surfaces, and are not varied in their intensity by increase or diminution of the thickness of that which presents the surface. In this view, which, though shadowy, is the clearest that we can obtain upon so nice and difficult a subject, it should seem, that while the membrane is alive, the two surfaces of it perform different functions with regard to the very same substance. The one, for instance, absorbs matter probably divided to the primary atom, as we have frequently had occasion to state; and the other secretes, or gives out matter, derived from the absorbed elements, but totally changed in its compositions and properties. This, however, contines only so long as the membrane is alive; for the moment that life ceases, it becomes passive to all external agencies which are strong enough to act upon it, and transmits whatever is capable of passing through it with equal ease both ways, unless, in so far as can be easily explained by the text, the colour, or some other property of its two surfaces, be considered simply as matter. A fruit remaining on the tree affords a familiar, and, at the same time, an appropriate illustration of this. As long as the said fruit continues in vigorous life, the epidermis or membrane, with which it is invested, continues smooth and expanded; and there is no doubt, that besides what may come from the tree through the pedicle or stalk, it absorbs matter from the atmosphere, which matter it assimilates and appropriates to the purposes of its contents; but the moment that the fruit dies, this action of the epidermis ceases, it shrivels, and the substance of the fruit diminishes without being taken back again into the tree by means of the peduncle. When the fruit attains its full maturity, this action of the epidermis ceases, and as it has then passed into a state of autumnal preservation, the separation of the mature fruit from the tree is not attended with that shrivelling which is almost invariably displayed in an immature one. In leaves, and more especially deciduous leaves, which are adapted for action in the spring and summer only, this difference between the living membrane and the dead is even more conspicuous. Leaves, when in the full vigour of their growth, become flaccid and wither much sooner, and also shrivel up to a much smaller and more brittle volume than leaves which have passed the vigour of their growth, and are subsided into ripeness. Not only this, but they are much more affected by differences of external action upon them, when in the living state, for the most vigorously-growing leaves and plants are the first to droop in a hot and drying day; and, indeed, the leaves even of the very same species of plant are so different in this respect, when grown in humid and in dry atmospheres, that we can readily understand why these should be great in different climates.

But the power of the living vegetable in resisting heat, is as obvious as in resisting evaporation; for as long as the leaf, the fruit or any other portion, which is annual, or otherwise seasonal, remains in vigorous action, it preserves a wonderful uniformity of temperature, even under the most varying state of the air, and of the heat and light of the sun. But as soon as its proper action ceases, it approximates dead matter in the readiness with which it is heated and cooled. A very striking and satisfactory instance of this may be observed in the old and the new leaves of laurels, hollies, acubas, and the other evergreen shrubs which are common in almost every garden. The young leaves of these are, in the healthy state of the plants, very considerably advanced, before the old leaves begin to show much change of colour or other evidence of decay; but if, when the sun beats warm upon them, the finger is applied, the young leaves will feel cold, and the old ones warm; and as the season advances, and the old ones come nearer to that stage in which they are to heal off from the plant, this difference will be found to have increased. But though the old leaf is thus evidently much more obedient to the alternations of heat and cold than the young leaf, it is by no means so liable to be injured by the extremes of their action. The heat warms it sensibly to the touch, but does not make it droop, and the cold is also felt in it, but the returning heat does not wither it as it withers the young leaf. In these plants, we have the action of spring in the young leaf, and that of Autumn in the old, brought together, and thus we can compare them more easily than we can compare the effect of the two seasons upon plants at their respective times in the calendar. The leaves of those evergreens also give us at least a close approximation to the vegetation of tropical countries; for the Autumn of their leaves is really a tropical Autumn, as it is produced by the heat of summer. It is of no consequence of what latitude or region of the globe those evergreens may be natives; for they follow the same law in all climates, from the equator to Lapland, and some of them are the last plants we meet with in that inhospitable region. They also resemble the tropical plants in their flowering and fruiting, the flowers and the fruit being produced upon the shoots of the year, along with the young leaves, though the fruit does not, generally speaking, ripen until the next season, and sooner or later in that season, according as the leaves are shed. We have examples of this in the holly, the pine, and the juniper, and there are gradations in various other plants. These plants grow at higher elevations above the level of the sea, as we approach the equator; and thus we have a vegetation, which is uniform in its seasons, along the whole quadrant, as far as vegetation extends,—so that there is an Autumn produced by the hot season in some plants of every latitude, only in the cold latitudes, and the lofty situations of the warm ones, two seasons are required to produce this action; while in the seasonal plants of warmer latitudes and places, a single year, or even a shorter period in the case of some of them, suffices for the running of the whole course.

These facts, and they are facts which any one may verify by observation, show very clearly that it is quite impossible to understand the results of autumnal action in any one latitude without some knowledge of the same in every latitude ; and this is the reason why we have endeavoured to explain, in as far as it is explainable, the action of the sun and atmosphere upon vegetables, in connexion chiefly with the vegetation of the tropics. Having done so, we shall take a rapid glance at the general action of the season, or rather the effects of that action in latitudes and at elevations above the surface, where the characters of the warmer places within the tropics, and the seasonal displays of their vegetation, in so far as it has such displays, are departed from.

Taking then the low-lying and rich portion of the equatorial lands as that where there is the minimum of seasonal action, and where that action depends in a great measure upon the presence or the absence of humidity, as the minimum or beginning of seasonal diversity, there are two directions in which we can follow the series of increasing differences,—we may follow it in elevation up to the mountain-top, where vegetation ceases, because the temperature, except under the immediate influence of the sun's presence, is below the freezing point all the year round; and we may also follow it in latitude, until, from similar causes, vegetation again ceases, only the causes of its cessation are distributed in very different portions of time.

Upon the summit of the intertropical mountain, the rays of the sun beat with great vehemence during every day of the year; and during every night the temperature of the air sinks considerably below the freezing point. It must be understood, however, that independently of the greater rarity of the atmosphere, and of the small radiation of heat from a surface covered with snow, as compared with that from a surface not so covered, and especially from the surface of the naked earth in a warm latitude, or at a warm season, the daily influence of the sun is inferior to the opposite influence. That this must be the case will be at once understood when we consider the successive elevations of the sun during the time it is above the horizon. The average time that it is so during the twenty-four hours, is twelve hours. Immediately under the equator it never varies from this, and for several degrees on each side of the equator the seasonal deviations from this are so small that they are not worth taking into the account. The small addition to the sun's appearance above the horizon arising from the refraction of the atmosphere, may also be omitted in the general estimate; and thus we may say, that in these latitudes the sun rises at six and sets at six all the year round, or, in other words, that there are twelve hours of the presence of the sun alternately with twelve hours of its absence. Now, during the quadrant of the sun's apparent daily path, which extends from sunrise till the luminary is on the meridian at noon, the sun has the same gradations of elevation above the horizon as it has on the quadrant of the earth's meridian, from the pole to the equator, at the equinox; and during the quadrant from noon till sunset, it has the same succession of elevations in a reversed order. Thus, at sunrise and sunset, the influence of the sun is a minimum, and its momentary effect is no greater than on the poles at the time of the equinoxes; and it gradually increases to its maximum at mid-day, and diminishes in a similar manner to the time of sunset. Some portion of the morning elapses, therefore, before the sun's influence upon the surface of the earth is equal to that of the winter sun in those high latitudes, where snow lies unthawed for several months of the year. Thus, a considerable portion of the day must be spent before there is any thawing of the night's frost, upon a lofty mountain within the tropics; while, in consequence of the time required for producing an effect, the hottest period of the day will be about two or three o'clock, and the freezing temperature will be again arrived at a few hours after sunset. Thus, though the rays of the perpendicular sun have just as much heating power upon those mountain tops as they have upon the low grounds in the same latitudes, the effect which they produce upon the surface is very small; and as dependent upon the sun only, there is but little melting of the snow during the day, or accumulation of ice during the night; and this being the case, there is very little seasonal change of vegetation, in the highest situations under the equator where vegetation grows. The snow upon the lofty mountains there may be said to be permanent at the same level, except in so far as it is affected by the seasonal shiftings of the atmosphere from hemisphere to hemisphere, which bring alternate rain and drought, the first of which tends to produce cold, and the second heat. Therefore, let us take what altitude we will, there is really very little seasonal action immediately under the equator, except in so far as the latter part of the rainy season brings frost there, which is not the case on the lower grounds. In consequence of this tendency of the rains to bring frost, the vegetation in very lofty places must have an autumnal defence something similar to that in the high latitudes; but as this depends not upon the general action of the sun, but upon the rains, which set in at different times of the year at different places, it does not admit of reference to one specific time, or even of general explanation. There is another mountain phenomenon resulting from seasonal action, which does not occur in these equatorial situations, namely, the formation of glaciers, or fields of ice, lower down than the mountain snows. Those glaciers, though permanent in their larger masses, or probably diminishing in some places and increasing in others, owing to local circumstances which cannot be explained upon general principles, are spring formations. The heating of the earth does not keep pace with the solar influence; and thus while the sun acquires so much power during the day as to melt a certain portion of the snow, and send the water down the slope, the water so sent is frozen during the night; and if the situation is favourable for its accumulating, its mass soon becomes such as to resist the power of the summer sun. The warmer parts of the temperate zones are the situations in which those glaciers are chiefly to be met with, and the most remarkable ones are found in the Alps. There are none upon any of the British mountains, because none of these mountains are of sufficient height for having their summits clad with snow the whole summer round, though several of those in Scotland retain snowy patches. In such high latitudes as the Grampians, the year is considerably advanced, and the day much longer than the night before the snows on lofty summits give way, unless to the influence of atmospheric currents; and thus there is not a sufficient return of cold during the night to convert into ice the snow which has been melted during the day. On the north-east sides of some of the mountains, which have lofty precipices there of a horse-shoe form, there are slight approximations to glaciers, or rather, perhaps, we should say indications of the mode in which those vast fields of ice are formed; for in a few of those peculiar mountains, there are small lakes at the bottoms of the precipices, the water of which remains in a state of ice all the year round, though a stream is discharged from it during the summer. The reason is obvious: those precipices facing the north-east are turned away from the most powerful action of the sun; and, therefore, in the early part of the year the cold of the night in them predominates over the heat of the day; and while the snow melts away from the upper part of the precipice, the cold thereby produced, and the shading of the bottom from the direct rays of the sun, occasion a freezing temperature there.

As we proceed farther to the north there is still less tendency to the formation of glaciers than there is in the Scottish mountains; because, before the mountain snows there yield to the influence of the season, the season is much further advanced, and the day is much longer in proportion to the night.

This action of the spring, or the summer, as it happens, in the elevated regions of the several latitudes, is necessary to a right understanding of the autumnal action. In every thing which is completely seasonal the Autumn is just the converse of spring; and as spring has to contend with an accumulation of winter cold, greater in proportion as the winter is more severe, so autumn has to contend with an accumulation of summer heat, greater in proportion as the summer is warmer as compared with the winter. Both these circumstances tend to increase the violence, and to shorten the duration of the particular seasons to which they refer. This is a very general law of nature, and one of which you ought never to lose sight. Mechanics in estimating the effect of compound machines, are well aware of the invariable truth of the maxim, that "What is gained in power is lost in time, and what is gained in time is lost in power," the product of these two being the expression for the work done; and, therefore, as the one increases the other must diminish. But in this case the numerical values of the two, in order to produce the same result, are not always the same. The result is a maximum, or the most advantageous possible when the two are equal; and in proportion as they become unequal the effect diminishes. Any one may understand the general principle of this by taking two numbers whose sums shall in all cases be the same, and which shall be equal to each other in one case and unequal in every other. Say the numbers 4 and 4, whose sum is 8, and the unequal divisions of that sum in whole numbers are 3 and 5, 2 and 6, and 1 and 7. The products are respectively, 16, 15, 12, and 7, the first being the product of the equal numbers, and the others diminishing until the product in the case of the greatest inequality, that is when one of the numbers is 1, the product is one less than the sum of the numbers.

We cannot, however, apply this rule arithmetically to all cases, or, indeed, with perfect accuracy to any case of natural action; because there is one of the elements—and the most important one—the natural principle or active power, which cannot be reduced to an arithmetical expression. The time can always be so reduced, and we can judge in a general way of the increase or the diminution of the power, but we cannot apply our arithmetic so as positively to say that it is twice or one-half, or any other definite proportion in one case of what it is in another. We are unable to do this even in those cases to which we apply measuring instruments, and read the degrees of their variation arithmetically,—as for instance, when we estimate heat by a thermometer, humidity by a hygrometer, light by a photometer, and so on in other cases, the names of the instruments merely expressing that they are measures of the agencies which we compare by means of them. But in these cases it is not the active power that we measure, it is the effect of that power upon the measuring instrument, and upon that instrument only. Thus, in the case of heat, the degrees shown on the scale of the thermometer are nothing more than the degrees of the expansion of the mercury, the spirit of wine, or whatever other fluid the instrument happens to contain; and all that we can infer from it is, that when the degree of expansion in two cases is the same, the action of heat to which the instrument is exposed is also the same in both. This is a relative standard which serves very well for comparing degrees of heat, though it gives us no information of the absolute heat in any one degree. The common thermometers, which consist of fluid enclosed in a glass ball, with a stem to it closed at the opposite end and containing no air, show heat by the expansion of their contents. But there are others intended for measuring, or estimating much higher temperatures than those instruments can bear; and they are called pyrometers, or fire-measurers. Some of them are composed of earthy matters which can bear a very strong heat without being melted, but which contract, owing in great part to the giving out of water, with which they are intimately incorporated. They are, generally speaking, formed of clay; and as they do not expand again when cooled, an equal contraction of two pieces exactly agreeing with each other in form and size, is presumed to indicate an equal degree of heat in the two cases. We say "presumed;" for even in this simple case there is a little uncertainty, upon the very principle of gaining in time and losing in power, which we are endeavouring to illustrate, and in consequence of this it is at least highly probable that long exposure to an inferior action of heat will produce the same effect as a more brief exposure to a higher one. In order to be perfectly accurate in our comparison we must, therefore, take equal times into our consideration, otherwise we shall be in danger of underrating the power which acts during the short time, and overrating that which acts during the long. Equal expansions, or equal contractions of the same instrument, or of instruments exactly similar taking place in exactly equal periods of time, are, therefore, the grounds upon which we infer equal actions of heat, and the same rule applies to every other kind of action which we can estimate by its effect upon an instrument.

The principle which we have now attempted to explain is one of essential importance in forming an accurate judgment of the seasonal action, autumnal or otherwise, in the different latitudes. In temperate climates, say about the middle of the quadrant, or forty-five degrees of latitude, in the northern hemisphere, which is the most seasonal one, or a few degrees more or less, according to the local circumstances, the seasons are gradual in their action; and spring and Autumn are so extended in their duration, that each of them occupies in favourable situations not much elevated above the mean surface more than a fourth part of the year. Here, therefore, whether we regard the grand causes of seasonal action as working for the spring, or working for the Autumn, there is a considerable gain in time, and consequently a loss of power could be borne, and the same effect produced as if the time were more brief, and the energy of the power greater. But the solar influence upon every latitude is in proportion to that latitude—local causes being the same, whether the spring and the Autumn are of longer duration or of shorter. Hence, the power which, in consequence of the longer time, could be dispensed with to produce the same result, is not withheld, but is a surplus power, an additional advantage, which those latitudes possess over both the tropical and the polar ones. It is quite true that the momentary action there is never brought up to the same intensity which it has upon the low grounds near the equator, or even to that of the short summer of the high latitudes, where the night is either very short, or sunless or sunlight throughout; and thus there are degrees of obedience to this action in the vegetation and also in the seasonal animals, at both extremes of the quadrant, which do not, and which cannot take place in the middle latitudes. But notwithstanding these, the middle latitudes have advantages over both the extremes, not only in the longer duration of their spring and their Autumn, but in the absolute quantity of the working power of nature during both these seasons. There is no better illustration of the truth of what has been said of the superiority of those climates, not only in the mildness of their seasons, but in their excess of beneficial yearly action above what theory would assign them, and even the observed average temperature, than that they have in all ages been the regions in which the human mind has had its greatest and its most beneficial development, and where the human hand has been most advantageously turned to every description of useful labour. If we look at the history either of ancient or of modern times, we find that this has been permanently the case. Neither the people of the tropical countries nor those of the polar ones, have ever become civilized of themselves, and far less have they distributed civilisation over any other parts of the earth, though there are instances in which hordes emigrating from the north in a state of great barbarity, have improved after a long residence in the middle latitudes. We have no instance of any considerable movement of the human race from tropical climates into temperate ones; and it does not appear that the contrary movement has had any beneficial effects either upon the physical constitution, or the intellectual, or moral character.

It is worthy of remark, too, that the whole of what may be called the great events of the history of mankind, have taken place, or at least had their origin, in these middle latitudes. Egypt was, no doubt, gorgeous and savage in grandeur, and possessed considerable, though comparatively useless, learning, in very early times, and that Upper Egypt reaches the tropic, and is partly within it; but Egypt, though nearly a tropical country in situation, is a remarkably seasonal one; and in the extreme south of it, the winter nights on the rocky hills are intensely cold, while, at particular times of the year, there are heavy showers of hail, or rather of pieces of ice. But we cannot judge, with any degree of accuracy, of the former climates of different latitudes, or of the nature of their seasons, from what we observe at the present time. Even now, the winter is often intensely cold, upon the elevated grounds in the southern parts of Greece, in Calabria, in Sicily, and in the Isles of the Levant,—evcry where, indeed, under the exposure to the uninterrupted winds which sweep from the Pole across Russia, the Black Sea, and so on to the Mediterranean; and this influence is felt to a very considerable distance up the valley of the Nile, and was, no doubt, more extended and more powerful before so much of the adjacent country was converted into deserts—for those deserts, as they become heated during the day, deflect the cold air from the valley, and disperse it upward through the atmosphere. It would be foreign to our purpose, as well as incompatible with our limits, to trace the progress of human improvement, or to show how much it has been dependent upon that average species of climate, and protracted duration of the spring and Autumn, which is the most advantageous. But any one who chooses to advert to the history, will find the voice of all ages in favour of it.

There is, however, a single circumstance, which we may mention, as tending to show how the progressive changes of climate, and those of the centre of civilisation (so to express it), have proceeded together.

Of India, we cannot speak with any thing like certainty; but we have no reason to believe that there ever was any very high degree of civilisation there. At all events, whatever it may have been in itself, it never, by the effort of its own population, produced any decided effect upon the rest of the world; and so we may leave it out of the estimate. Doing this, and taking the range from Persia to the Atlantic, we find the centre of the most early civilisation about the parallel of thirty degrees north latitude; that is, passing through Egypt and Babylon. After a time it was farther to the north, and Tyre and Carthage were the chief seats of art and enterprise. At a period still later, the parallel of forty was the average line; and at the present time it has passed the middle of the quadrant, and may be reckoned somewhere about the parallel of fifty. We do not know the state of the parts remote from this general parallel, in the earlier periods of their history, or even during the greater part of it, as the average line of our information is that of civilisation and enterprise. But there is every reason to believe that the northern countries were then much more covered with woods and marshes, and that the seasons were more severe, and the country altogether much less fitted for agriculture, or for the support of the more useful domestic animals, than in modern times; while the woods and marshes prevented that intercourse, without which there can be little or no human improvement.

It is an agreeable proof of the unity and perfection of the system of nature thus to discover that man, who, in his bodily structure, is the most universal of all terrestrial beings, and who, by his mental contrivance and resource, can subsist under far greater changes than any of the rest, so far obeys the law, that he succeeds best in those latitudes, where the general action is most mild, and at the same time most favourable.

The latitudes to which we allude are those in which the polar and the equatorial actions are most nearly equal to each other. Whatever the season is, whether spring or Autumn, the one of these two actions may always be considered as the producing power, and the other as the resistance by means of which that power is enabled to bring up the effort to the useful degree; and from their being thus in the even balance, a very little increase in either of them causes the other to give way. It is this which makes both the spring and the Autumn so prolonged and so gradual; and enables the skilful cultivator to extend seed-time and harvest, in one or another of the plants which he cultivates, over a very great portion of the year. But, although this balance of the polar and the equatorial actions enables man to select his crops and his seasons, and adapt them to each other from experience: yet, in wild nature, the seasons of those climates follow in nearly the same succession year after year.

In the more extreme latitudes of the quadrant, the state of things is of course different. At the confines of those parts which have a decidedly tropical character, the seasons are consequently mixed, or rather there are double seasons in the course of the year,—a tropical winter in the warm months, and a polar winter in the cold ones; but both of these are much less decided in their character, than where either species of winter arrives singly. Each of these winters is preceded by its own Autumn; and both winter and Autumn tell upon one part of vegetation from the drought, and upon another from the rain or snow. Generally speaking, the Autumn of the herbage precedes the drought, and so also does that of many of the bulbous-rooted plants; and the Autumn of the timber trees precedes the cold and humid winter. With us, the Autumn of the hay-fields falls in the summer, the Autumn of the orchard and the forest agrees with the Autumn of the Calendar, and the Autumn of the corn-fields is intermediate between the two. In regions further to the south, the harvest of the grasses is over, and they are overtaken and parched by the hot and dry winter—as we have termed it from its effects—before the time that our field grasses come into flower. In such places the harvest of the grain plants falls about the time of our hay harvest; and still farther to the south, it occurs, in some of the kinds of grain, as early as our spring.

As we proceed northward into higher latitudes, the dry winter, or pause of nature in the hot months, which occasions the double seasons, becomes less and less apparent, until it at last vanishes altogether, and the seasons are single in the year, as respects that part of the vegetable kingdom from which we have drawn our principal illustrations. Still farther to the north, the winter encroaches on both the spring and the Autumn, and continues to do so till both these seasons are nearly obliterated; and after this it continues to encroach both ways upon the summer, till that is at last wholly or nearly obliterated, and the polar winter holds dominion over the year.

As this tendency toward winter increases, the character of the native vegetation changes, and the cultivated plants are fewer in number, and their periods of harvest are changed. In northerly places, wheat does not ripen, unless it is sown in the Autumn of the preceding year; and then it suffers in winter, unless in places which are well sheltered, or where the snow covers it until the spring fairly sets in. The cultivated plants have, however, been collected from very different climates; and as no culture can wholly change the climatal nature of a plant, we cannot take them as perfect indices to the seasons in any one latitude. If, however, the reader has attended carefully to the scope of this chapter, he will be able to form a general notion of the office which Autumn has to perform to the seasonal vegetation of the different latitudes and climates of the quadrant; and thus he will be in so far prepared for entering upon the consideration of the mode in which the work of the Autumn is performed, and the agents and means which are employed in the performance of it.

It is necessary, however, to bear in mind that, when we speak of the seasons as having certain characters, and the Autumn as having certain operations to perform, in any particular latitude, we are not to be understood as saying, that the state of these things is the same all round the parallel, even where the height above the mean level is the same; or that all places which have their autumnal action the same, have necessarily the same latitude. There are so many local causes that affect the characters both of places and of seasons, that before we can speak with precision of any one, we must be in possession of its particular case from actual observation continued through a series of years, among which we must include the changes that have taken place, whether in the course of nature or by the operations of art. To do this, even for one place, is incompatible with the nature of a short sketch; and thus we must content ourselves with the broad outlines of the principles.

We cannot lay down a rule even for the temperatures; for the *isothermal* lines, or lines of equal mean annual temperature, never lie nearly on parallels of latitude, but trend northward in some places, and southward in others; and they are not the same in any two consecutive years. Even if we could depend on the mean temperatures, which we cannot, they are no guides to the seasonal variations; for, of two places with the same average temperature for the year, one very often has the seasons mild, and passing gradually into each other, while another has them in extreme contrast, and with violent weather at the changes. Upper Canada and middle Europe form a case in point; for in Europe the seasons are mild, and in Canada, with the same temperature on the average of the year, it is hotter than India in summer, and colder than Lapland in winter: and, as the Autumns of such places have different labours to perform, they must be furnished with different powers for the performance, in terms of that general and beautiful law of nature, according to which every agent is fitted for the performance of its work, in that inestimable manner which is in itself an ample demonstration of the being and a ttributes of God.

CHAPTER III.

AUTUMNAL DECOMPOSITIONS, AND THE AGENTS AND MEANS BY WHICH THEY ARE PERFORMED.

We take the decomposing action of the Autumn, which is exerted in bringing the old vegetation of the year to the dust, in precedence of its ripening or preserving influence; because it is more decidedly an Autumnal action, and not, like the other, performed by the plants themselves, and as such, really the perfection of the Summer action; and we shall consider it not only as it refers to the decomposition of that which has been produced within the year, but as referring to that of organized vegetable matter generally. We might also, without much impropriety, have included the decomposition of animal matter, for that is an action of the same kind; but it is not so strictly seasonal as that of vegetable matter.

It has been mentioned, that in tropical climates, the action of the elements is sufficient to effect all the seasonal decomposition of vegetables, with much assistance from special agents; and that the decomposition of the more solid and durable parts, when it does not yield to the great changes of temperature and humidity, which are the elemental means of decomposition, are reduced to dust by the direct labours of vast myriads of insects, —insects, whose numbers are so great, that the broods of the season might suffice to reduce to powder the most ample forest on the face of the globe. Their labours are, however, restrained to the need there is for them by their very nature; for though no vegetable substance is proof against the action of their little jaws, they do not assail the living timber of trees, or injure any of the parts in which the vital action is carried on. Dead wood is that upon which they feed; and when a tree is dead in the interior, which is a condition to which the greater part of exogenous trees have a tendency to come, and a greater tendency in warm climates than in cold, these insects will sometimes excavate into a system of tubes, without any external appearance of the depredations they have committed. In Australia, where the forest trees appear to have a particular proneness to internal dying, these insects often attack painted posts near the houses of the settlers,—or the posts and other timbers of the houses themselves,—and eat them away to the thin portion which is impregnated by the paint, before the owners have any conception that they are in the least injured. They generally enter the trees at the lower part, and they come in secret, and often under the mask of a covered way, which they construct as they advance; and which they carry on, not only from tree to tree, but partly up the trunk, if the portion next the ground is not quite suited to their purpose. Some of these creatures are not only blind, but so impatient of the action of light on their bodies, that they are never seen in the open air during the day. Still they make their covered way as directly toward the tree which is to furnish them with food, as if they were not only provided with eyes, but had actually made a previous survey of the place, with all the science and sagacity of experienced engineers.

The numbers and the action of these little creatures are alike astonishing; and they show very forcibly, that we must not estimate power in the works of nature, upon the same principles as in those of man. They also present another subject for our consideration, which must be very perplexing to those who advocate the possession by animals of reason and purpose, similar in kind, and differing in degree only from those possessed by man. We have said "suited to their *purpose*," when speaking of their making their attacks only on those trees which are internally dead; and we have done so in order that we might thence take occasion to point out why, of themselves, they can possibly have no purpose, but merely answer that purpose in the economy of nature, for which they were designed by the Author of nature. We can imagine no purpose of theirs, by which they are guided to the tree, either by previous experience, or by present sensation; and we might say, with quite as much philosophic truth, that an egg is hatched, or a seed germinates, of its own forethought purpose. That they are organized, and otherwise fitted for the performance of a certain part in nature, and perform it, is true; and when we have said this of them, as of any other race of animals, we have exhausted all that we can rationally say about the matter. They do this by the law that God has given to their nature; and nothing that man can plan or execute, can at all come up to the perfection and certainty with which that law works, without the slightest knowledge of any kind on their part.

The labour which these wood-destroying insects perform, belongs to the class of Autumnal labours, because they consume the waste of vegetation; but they are called into being by the stimulus of Summer action, and are found only in countries which have the hot and dry, or tropical winter. They do not, therefore, belong to the class of Autumnal agents, as we understand that class in temperate climates; for they may be considered as one of the means by which the ardour of the elements performs its work.

As long as the tropical energy continues so powerful as to occasion a double season by the ardour of the summer, both the preserving and the decomposing which are effected by the Autumnal working, as the heat and drought become intense, are of the same character as those under the tropics, where the only winters are parching ones. But when we advance to such a distance from the equator, as that there is a winter's pause arising from cold, the preceding decomposition is an Autumnal one, in our ordinary sense of the word, and the proper Autumnal agents are employed for carrying it into effect; though, up to the highest latitude at which there is a flowering vegetation, with leaves that are shed, or stems and leaves that die down in the season, there is still a remnant of the tropical action, so that the decomposition is not wholly effected by the Autumnal agents.

Here, a question may not unnaturally present itself to the mind of the reader,—and it is a question worthy of some consideration:—"Why should agents be required in performing the labours of an Autumn, which is to be followed by a cold winter, or winter arising from a deficiency of temperature; and not in the case of a warm and dry winter, or one which arises from deficiency of humidity?"

The answer to this question is easily seen: There is a deficiency of action as the cold sets in, for cold is not action, but its opposite; and there is an excess of action when the sun parches the earth, and withers the vegetation. The excess of solar action in this latter case, is applied to the decomposition of the surplus vegetation, in as far as that is decomposable by heat, which of course reaches all the parts of it which can be turned into vapour by the temperature; while, with the declining heat of a temperate or a high latitude, there is no surplus of this kind, after the weather begins to be a little cool, and humidity increases on the surface of the earth, which is generally the case under these circumstances. Thus, we can easily see that something in the way of decomposition is produced by the action of the sun in the tropical Autumn, which cannot be so produced in the temperate one, and especially in that of the colder latitudes.

But we have not yet stated the whole of the difference. Those parts of plants which are products of the season, and require to be turned into materials for new plants when the proper labour of the season is accomplished, are mostly cellular, or consist of an accumulation of little vesicles or compartments, separated from each other by thin partitions, and containing fluids of some kind or other. Now, in a tropical country, after the walls and partitions of these cells have lost the tenacity and flexibility of life, and also the resistance to heating, which the living membrane possesses, the whole structure becomes heated, the fluids expand, and the cellular membranes of tissues are rent in pieces by the force of the expansion. In the cold Autumn, again, there is not sufficient solar action for performing this disintegration of the cellular tissue, and therefore, other agencies are required for the purpose of reducing it. Maceration in water effects some decomposition of the unnecessary parts of vegetables in the Autumn of temperate climates; but still the effect of this, in destroying the cellular structure, is comparatively slow. It is true, that the deciduous leaves in temperate climates are destructible by less powerful means than the leaves of tropical plants. The latter have to endure a much greater action of heat, and greater and more frequent changes of temperature, during the period of their activity on the trees, than the former. They are, of course, proportionally strengthened in their structure and texture, so as to enable them to endure this increased severity of vicissitudes. Accordingly, great part of them are strong enough to endure all the seasons of the year, in the same manner as the matured leaves of our evergreens are equally proof against the summer's heat and the winter's cold, until the period of their usefulness is run; while there are few deciduous leaves capable of enduring much alternation of frost and warm sunshine. There is, however, a difference between those evergreen leaves of the tropics, and the leaves of our evergreens; for, as we have already remarked, the young leaves of the latter are equally liable to injury from frosty nights and sunny days, as those leaves which fall in the Autumn.

In the tropical countries, the leaves and stems of that herbaceous vegetation which dies down in the parching season, are reduced to powder by the disruption of their cells, and very speedily disappear; whereas, in the cold latitudes, they in great part remain proof not only against the Autumn, but against the winter. There is some advantage in this, for these withered stems form a sort of protecting mantle to the crowns of the roots, during those trying times, when winter is struggling with Autumn, before the snows, and again, during the struggle of spring and winter, before the night-frosts altogether cease, and the good weather sets in. Thus, when we speak of Autumnal decomposition as taking place, either in one country or in another, we must always be understood to speak with limitation, and not as if the whole of the vegetable structures, which have no future living function to perform, were decomposed to an equal extent, and with equal rapidity. Some resist both the Autumn and the winter, to fall in the ensuing spring or summer; and some remain upon one kind of surface, while they are dissolved upon another; so that here, as in all cases of nature, we must observe the characters and habits of the several species, before we can venture to say how far they come within the operation of the general principles, or, to speak more correctly, the prevailing ones.

With these allowances we can, however, have a tolerably clear notion of the mode of acting and the agencies in the different climates. As compared with the whole mass of vegetation, there is much more to be done on the low grounds of the middle latitudes, than on any other places of the globe. The trees there are almost exclusively deciduous; very many of the small plants are annuals; and most of the herbaceous perennials die down and wait in their roots, till they are stimulated by the returning energy of the new season. In consequence of this, there is much of the matter of vegetation thrown off unfit for vegetable purposes, and the greater part of it in a state of nature is but ill adapted for the support of vegetable-feeding animals of whatever kind; and therefore nothing is left, but either that it should remain as unseemly and injurious waste, or that it should be decomposed. For it to remain in the first of these states, would be contrary to the whole system of nature's economy, the fundamental principle of which is that nothing shall lie waste; and therefore the means of decomposition are prepared.

It is in accordance with the perfection of design which runs through the whole, that this matter, which is annually decomposed, so as to prepare it as a natural manure for the fields, should be greatest in those latitudes where we have endeavoured to show that the whole system of nature works to the greatest advantage, and most beneficially for man. As we recede from this middle latitude, whether toward the equator or toward the pole, we find this quantity of matter prepared by annual decomposition to become less and less. Both ways, more of the trees are evergreens. In the direction of the equator, a greater and greater portion yields to the decomposition of the dry season as we advance farther and farther into regions of a decidedly tropical character. In the direction toward the pole, the numbers and also the size of the herbaceous flowering plants continue to diminish; but, as the decomposing power of the elements also diminishes, in at least an equal proportion, the proper agents of the Autumn are not the less required.

Before we proceed to the more particular consideration of these agents, there is yet another general view of the decomposing operations of the Autumn, as contrasted with those of the spring and the summer, which it is essential to take correctly, and to bear carefully in mind. At every season of the year, from the first moment of the bud or the germ, or even of the rootlet, which is anterior to both of these in its seasonal action, at least in many plants, there is always a destroyer ready; and if, for the general well-being of the whole, of which we are very incompetent judges, the action of this destroyer should be required, it is never slow in the performance of its work, and the cases are few indeed in which human agency can prevent its operation. Of these destroyers, which attend on the vegetable tribes during the whole season of their growth, a few are vegetable; but by far the greater number are animal,—namely, various species of insects, chiefly in the larva state, but some of them also when full grown, as in the case of the aphides, and various others.

As is the case everywhere in nature, the destroying agents of the spring and summer, or those of the season of growth, are, upon their confines, blended with those of the Autumn, in the reduction of the yearly growth which has performed its office, back to the state of an inorganic material for future use. So that we cannot, in the case of every individual of them, say that this belongs to the spring or the summer, and that belongs to the Autumn. But this does not arise from any want of natural distinction between the two; it arises from the imperfection of our powers of observing, which cannot follow nature into any of the more nice and delicate parts of its working. It is the same in the nicer distinctions of vegetables and animals, and even of inorganic matter, or matter which takes its peculiar form without any organization. There are many substances on the confines, which show so few of the common characters, either of animals or of vegetables, that they have been equally claimed by writers on the two kingdoms, as falling within their proper dominion. It has been, in some of the more obscure instances, the same with both of these and the mineral kingdom. But, in every case where finer instruments and more accurate methods of observation have enabled the investigation to be carried a little farther, the proper place of the substance in the system has been clearly ascertained.

Now, if there have been these difficulties in the case of substances which can be examined in their separate state as existences, how much more must it be the case with agencies, which are and can be known in their effects only? But still, in every case, it is only when we carry the matter to the extreme limit that there is any difficulty. In those every-day matters, which are in reality the only important ones, and in which alone the great body of the people can take any interest, there are none of these sources of mistake. Plain people may not be able to define in set phraseology what they mean by an animal, a vegetable, or a mineral; but they never commit the slightest mistake with regard to any one of these with which they may happen to be practically concerned. It is exactly the same with the distinction between the action of spring and summer, and that of Autumn. They may not be able to state, in logical terms, how these are to be distinguished from each other; but they can at once refer the one to the season of growth, and the other to that of decay.

As to that which may call the destroyer into action, the case is by no means so clear; because it is very probable that, at whatever season it may take place, there is a particular state of that which is destroyed, which brings the destroyer, and, in many instances, rouses it into life. The appearance of insects in such numbers as to be decidedly hostile to vegetation in the season of its growth, is so much more conspicuous in seasons and situations when and where there are obviously checks to its growth, than under the opposite circumstances, as to leave no doubt that a diseased state of the plant always precedes, and we may almost say occasions, the depredation. Any one who chooses to observe the state of vegetation in an inconstant spring or early summer, where it meets with repeated checks, and in another season of uniform progress, will find the difference in the insect ravages in very exact proportion to that of the states of the weather. It is not the extreme changes, however, that bring on the attacks of the insect destroyers. When a temperature below that of freezing alternates with warm sunshine, the destruction of the early leaves is accomplished without the aid of insects; and it appears that these extremes are unfavourable for their development. Hence, in valleys among lofty mountains, where the spring alternations come with severity when they do come, vegetation suffers much less from insects than it does upon low plains, where the alternations in the early season are more mild. The retentive clays are the soils upon which there is the greatest devastation in this way; and accordingly it often happens that, to the northward of London, the hedges and gardens are clean stripped to the last leaf, and nothing but the old silken tents of the caterpillars left in their stead, while there is hardly one leaf injured where the subsoil is gravel. Where aphis or coccus makes its appearance at a more advanced period of the season, it always appears first upon the least vigorous trees or parts of trees; and the same may be said of every other insect, to whatever plant or part of a plant its ravages may be more immediately directed.

But although those spring and summer destroyers may thus be regarded as always making their appearance consequent upon some diseased state or action of that which they attack, yet they always act upon vegetation in its growing state, or its progress toward maturity, and not after it has performed its seasonal function, and requires to be removed in the ordinary course of the healthful action of the system; while those dissolving agents which are really Autumnal in their character, never begin their operations until the function of that upon which they exert their energy has been performed, or, at all events, until it has been rendered unfit for the performance of that function. There are, however, as we might expect from the fact that the seasons overlay each other in point of time, some which stand so intermediate between the summer and the Autumn, that it is not easy to pronounce with certainty to which of the two they in strictness belong. This is especially the case with some of the parasitical plants, which commit the most serious ravages upon the crops of cultivated grain; but, as those crops are wholly in an artificial state, and we know not exactly what their habits are in wild nature, or to what enemies they are subject there, we cannot assign these parasites their proper places in the natural order of the seasons.

There is one distinction which deserves especially to be kept in mind, notwithstanding the apparent anomaly in the case just mentioned, and in some others. The spring and summer destroyers, or, as they may be more correctly designated, regulators of vegetation in its progress toward maturity, are, with very few exceptions, and those chiefly referable to plants in an artificial state, animal; and the greater number of them are insects in the progressive stages of their growth, and before they come to their state of full and final development. The Autumnal ones, on the other hand, are chiefly vegetable, and in great part peculiar to that season, not making their appearance till it arrives, and ceasing to appear when it is over. Even in these matters, however, it is impossible to speak in perfectly general terms; because places which are so sheltered as not to feel the great natural variations of the sun's influence and the atmosphere in the different seasons, cannot be affected to the same extent, or even in the same manner, as places which are fully exposed to those influences. Whenever the causes of these exceptions exist, we must make allowance for the exceptions themselves; and thus our general reasonings regarding the phenomena of the seasons in any latitude or place, must always have reference to free exposure to seasonal action there.

There is one particular in which the spring and summer regulators, and the Autumnal reducers or decomposers of vegetation, agree with each other; and it is one in which both of them differ greatly from the more permanent tribes, both of animals and of vegetables. Certain years produce or develop them,—or, as we say, bring them in great numbers,—while in other years they are comparatively few. Now we have every reason to believe that the individuals are just as prolific in those years when they are many, as in other years when they are of rare occurrence. Hence we must conclude that the numbers of eggs on other germs, must be in proportion to those of the parent animals or plants by which they are produced. In consequence of this we would naturally conclude, that after one year of great abundance of those enemies of vegetation, whether animal or vegetable, we should have a greater abundance the following year, and so on progressively. So far, however, is this from being the case, that their occurrence in great numbers for two consecutive years is exceedingly rare; and if there is more than an average production any one year, there is generally less in the year following. The actual development of those animals and plants has, therefore, no relation to the number of germs that are produced and fit for development; but appears to depend wholly on the circumstances by which they are called into activity. It thus appears that their office in the system of nature is a secondary one. They come not for themselves, so to speak, but for the benefit which they render to a more important part of nature; and when they have done their duty they disappear, and do not again return until their presence is required. They also come in exactly the requisite numbers; and although, in seasons when they are more than usually abundant, they appear, for the time, to lay waste the whole of the vegetation, yet it is in general found that the improvement in future years more than compensates for their temporary depredations.

In this subservience of what we may regard as the inferior parts of the creation to those which are superior, we see the beginning of a chain of relations, which, when we follow it out, is fraught with instruction of the most delightful kind, and which is a sharp reproof to us when we limit our notice to the mere individuals in their insulated states, or merely in their individual functions as having reference to themselves, how curious or how wonderful soever these may be. To examine the individuals, and to collect and keep them as objects of study, is so far from being wrong, that the omission of it is a criminal neglect of those opportunities, which, as rational beings, it is our duty to improve. But this is but a small, and, comparatively, an unimportant part of the subject; and the working is far more instructive than the mere works.

Of that working, the grand lesson to us is not so much in that which the parts perform, each for itself, as in that which they perform for each other. In this we can trace a very beautiful gradation. The humbler tribes minister to those that are next above them; and these again to others, in a long-continued series; and, whether it is plant or animal, we invariably find that the higher it is in the scale of organization, its servants are the more numerous. Take, for instance, the humbler kinds of vegetation,—the lichens and mosses on our cold and elevated mountains,—and contrast them with the more valuable plants which we cultivate. The watchers which nature has set over the former are very few; and even the influence of the seasons upon them is comparatively limited. They creep on in a sort of perennial dulness; and many of them keep constantly dying at one part and growing at another. But if we turn our attention to the plants on a farm, in an orchard or garden, or even to the trees of a forest, planted by the hand of nature, we find them peopled, and watched, and regulated, and served by innumerable hosts; which hosts are always more numerous and varied in proportion as that to which they minister is more valuable in its nature and more energetic in its growth.

In every department of living nature, whether vegetable or animal, we can trace this ministering of race to race; and in both departments we find, without exception, that the more completely developed any one race is, the more numerous are those that attend upon it. It is true that there is, in all cases, a reciprocity, and the race which ministers subsists either directly or indirectly upon the other; but still, that which is the more highly developed, is the more continual in its duration, either in the individual or in the succession; while the others are more seasonal, and come only at such times and in such numbers as they are wanted. Thus, in the mammalia, which stand at the head of the irrational series, there is no pause in the succession, no preservation of the germ, even for the shortest period of time, apart from the parent animal. In the period required for their development, there is great variety in the different orders and genera; but there are no means by which a host of mammalia could be called into being to meet any momentary contingency. The birds, and the oviparous reptiles and fishes, have some pause in the germ, and may be transported from place to place in that state; but the eggs of all of them are masses of considerable size, and of compound structure; and they are liable to suffer, both from mechanical contingencies and from changes of temperature, even within a moderate range. They are subject to destruction by these casualtics, much in the order that we have mentioned them—first, the birds, then the reptiles, and lastly, the fishes,—although there are considerable differences among the members of each class. Their prolific powers, taken upon the average, also increase, as their organization becomes lower; and under favourable circumstances, many more of their germs come to maturity, than when the circumstances are unfavourable. But still they all require some considerable time for their full development; and therefore, no part of any one of them could be produced to meet any momentary contingency in the state of the inferior classes,—as for instance, if any check given to vegetation in the growing season shall multiply the caterpillars greatly beyond their average numbers, there are no means by which the caterpillar-eating birds can be increased in the same proportion, so as to save the vegetables from the ravages of these temporary swarms. This would, in fact, be defeating the purpose of nature; for it is not the birds, but the vegetables, which require the additional insect supply, and it comes for ultimate good to them, however it may seem to work for evil at the time.

If we follow the chain of being still further downwards, we find at every step a fresh confirmation of the general principle, that the less perfect the development, the more is the race obedient to contingencies; and that it is not only more obedient to them, but better fitted for yielding this obedience. The germs of its life are more abundant, more portable, more generally distributed, and more indestructible; and when we approach the limit of observation, we are unable to say where the germs may not be, or against what agency or length of time they may not be proof. Those very minute, but most numerous of all the children of nature, often make their appearance, we know not whence, how, or by what agency; but they do come, and we can have no doubt that in them the law of succession is as perfect to the race, as it is in the most fully developed and important of the mammalia; for, though many of them appear to be immediately stimulated into activity by particular states of substances, which have neither animal nor vegetable life in themselves, yet they act in opposition to these substances, and not in concert with them. Their quantity of matter is so exceedingly small, that they interfere much less with the laws of inorganic matter, than the larger plants and animals do; but in so far as our eyes or our instruments can examine them, their organization is as perfect, and as wonderful, as that of the very largest species.

It does not appear, indeed, that quantity of matter has any thing to do, as an element, in animal or vegetable life; but that, on the contrary, it is an incumbrance; and that, in proportion as it is increased, a larger portion of the action of the life must be expended in carrying it about, or in protecting it from the common laws of matter. The proof of this may be taken upon any one of the more conspicuous actions which can be compared in animals. Compare the leap of a common flea with the spring of the lion or the tiger, or the bound of any one of the mammalia. The march of an ant over rough gravel, or the clods of a border, is as great in comparison to its volume, as if a dray-horse were to cross indiscriminately over London in a straight line; and the distance over which it can travel among such obstacles, is as much in proportion to its bulk, as it would be to the horse to do forty or fifty miles of this sort of steeple-chase in the course of, not one day only, but of many days in succession. Observe a small beetle, or even a caterpillar, moving with ease substances equal to several hundred times its own weight; and see if any vertebrated animal, even the very strongest, could perform a similar feat. There is no doubt, that the invertebrated animals which have been mentioned, have an advantage over vertebrated ones in mere force of motion, in consequence of their muscles being internal of the supporting crust, while those of the vertebrata are external of the bones of the skeleton.

But although the internal muscles of the invertebrated animal have thus a considerable advantage over the external ones of the vertebrated, both in power of action and capacity of endurance, the whole difference between them does not depend upon that, for much is also owing to the much smaller weight of matter which the action of those muscles has to put in motion; and the advantage of this comparatively small quantity of matter is especially conspicuous, in what the little animal can bear without being in the least injured. If size were an element of endurance, then the fall of an insect from a branch of a tree to the gravel-walk below, would be, to it, fully more than a fall from the top of St. Paul's, upon a heap of angular masses of granite in the street below, would be to a man; and yet the insect is not in the least hurt,—not nearly so much as a man would be, by merely slipping and falling on the smooth pavement. Considering its small quantity of matter, a little insect could not, in falling from any height whatever through the atmosphere, acquire such a momentum as seriously to injure itself, even though it were possessed of an internal skeleton, against which the external soft parts might be bruised, or which might be fractured by the fall. Thus, whatever view we take of it, the small quantity of matter with which the principle of life in the insect is loaded gives it a wonderful advantage in respect of the accidents which it can bear uninjured, and also of the labour which it can undergo without being in the least fatigued.

This, however, is only a part of the advantage which it possesses over a vertebrated animal. The firm covering, whether approaching more nearly to the nature of leather, or to that of horn, with which it is enveloped, protects all the internal or working parts both from the influence of the atmosphere, and from blows; and the muscles, being shielded in cases, and proceeding in straight lines from their origin to their insertion, and through the centre of motion in the bending of a joint, or in the moving of any of the parts of the body, at all times work to the greatest advantage; whereas, the external muscles of an animal which has internal bones always work to a disadvantage, and sometimes the portion of labour which is lost in bringing the muscle into play is much greater than that which is available for the purposes of motion. Thus, while the invertebrated animal is secure against casualties, it is enabled, at all times, to devote the entire force of the muscles to the producing of the particular motion or effort to which it may happen to be impelled by the instinct of its nature. We are apt to refer to the wings of eagles as organs of mighty power in the way of flight, and to admire the beautifully smooth motion of a kite, as it glides down the wind, or the graceful floating of a kestrel, as it leans on the viewless air. And among vertebrated flyers, we are ready to admit that these are splendid and beautiful motions, and the mechanism by which they are performed is one of the finest studies in the whole circle of the mechanical arts, and, we will add, one of the most useful to those whose profession it is to ascertain how, under particular circumstances, the greatest effect may be obtained with the least possible expenditure of power, which is, or ought to be the grand point with every practical machinist. But splendid, graceful, and easily performed as those motions are, they sink into absolute insignificance when compared with those of the winged insects. Even "the shard-borne beetle, with his drowsy hum, that rings night's yawning peal," as the Arch-poet of nature most truly and graphically expresses it, has more power of wing than all the eagles which ever breasted the tempest athwart the mountain-top. Ascending from the earth, in which he has a power of burrowing downwards, as great in comparison as if a man were to work his way down to a field of coal by mere bodily exertion, without tool, or the removal of any part of the rubbish, and shouldering aside clods and pebbles many times his own weight, he elevates his shards—his wing-covers, or elytra,—unfolds the filmy expanses of his wings, and winnows the air with them, until the energy produces the humming sound; and any one against whom such a beetle has impinged, when "wheeling his droning flight," can tell with what impetus he cleaves the air. This, too, is one of the most sluggish-winged of all the insect race; but any one can observe instances, as, for example, the common fly and the gnat, or the bee, for swift motion of the wing; the diurnal lepidoptera, or butterflies, for smooth and easy gliding; and the iridescent gleaming of the dragon-fly, as it starts from place to place by the margin of the brook, as if it were an embodied rainbow dancing in joy before the majesty of its parent sun.

These, and thousands of others, woo our attention at almost every spot where the foot can fall; and they are all so interesting, so curious, so redolent of the most sublime—the most God-like philosophy, that the willing student has no choice but that of giving the preference to the new one during the time of its novelty. When we say, "God-like" philosophy in this case, we use the word neither irreverently nor unadvisedly; for the school of nature is God's own university for the instruction of all his creatures in the philosophy of nature, and though the lessons can be appreciated by us only in the humble and limited condition of earthly students, the lessons themselves are lessons from Heaven. Our present allusion to the subject is necessarily incidental, and we cannot enlarge upon it; but every reader who studies his own best enjoyment will take especial care that the philosophy of insect life is to him no neglected portion of the mighty volume of terrestrial nature.

We have gone into the illustration of the higher orders of organized being, as requiring service, and of the lower ones, as being fitted to serve, upon the case of the animals, rather than upon that of the vegetables, because the more numerous functions of the animals render them better adapted for popular description; and we have taken the broad distinction between the two great divisions of animals which have internal skeletons, and animals which have not, because that is at once the most comprehensive and the most obvious to which reference can be made; and also, because it leads to certain other conclusions, without which the contrast would not be so complete as to warrant the deduction which we mean to draw from it, and which has been anticipated in the assumption, that the one race are qualified more for being served, and the other more for serving.

But although we have thus taken the animal kingdom as the chief subject for our illustration, it must not be supposed that the vegetable kingdom is unavailing for this purpose. As the actions of plants are more limited and less diversified than those of animals, we may naturally suppose that the lines of demarcation between them are not so clearly drawn. But still, if we take the two great provinces of the vegetable kingdom, the plants which are vascular in their structure, and those which are cellular—that is, those which consist of elongated tubes or canals more or less mixed with cells, and those which consist of cells only, we have a division bearing no inconsiderable resemblance to that of the animal kingdom,—the vascular plant answering to the vertebrated animal, and the cellular plant to the invertebrated one; and the first being more especially the served, and the second the servant. We shall have occasion to enter somewhat at length into this subject, or at least part of it, in another chapter, inasmuch as a portion of it is more immediately belonging to and characteristic of the Autumn; and consequently we may now pass it with a single remark, in which the principle of the distinction may be seen. Take any majestic tree, an oak, for instance, among exogenous trees, or those which grow at the surface, and a palm, as among the most stately of those which are endogenous, or grow at the centre, and how long soever either of these giants and glories of the forest may endure the common action of the seasons in climates and under circumstances which are favourable to them; yet, let either the one or the other be once completely dried in the whole of its substance, and let it remain in that state for only a very short time, and giant as it is, and long as may be the period of its natural endurance under circumstances favourable to it, there is no more return for it to the living and growing world; and it is a useless thing until the agents of the long Autumn bring it to the dust and make it fit for being the mere matter of some new race of plants. But if, in contrast with this, we take some of the more minute of the cellular plants which to our common observation seem nothing else but stains on the surfaces of stones and other solid substances, we find that they can be dried, and remain so for a long, and, probably, an indefinite period of time, and are again revived whenever moisture is supplied to them. Of the strength of the action of those very minute and simple, we shall in the mean time say nothing farther than that they are as remarkable in this respect as they are in their tenacity of life under changes which are fatal to all plants of more complicated structure, more varied functions, more imposing appearance, and more ornamental to the surface of the earth in wild nature, as well as more valuable to man in the arts of life.

But, notwithstanding the greater capacity of endurance, and of overcoming as well as abiding mechanical resistances, which the invertebrated animals and the cellular plants possess, we must not suppose that they have, upon the whole, a higher function in nature. Viewed with reference to the part which they perform in the system, none of them is higher than another, for they are all equally perfect—all the very best adapted to their several purposes; and, therefore, the estimate which we take of their relative values is founded upon their usefulness to man. In the particulars of this estimate we are necessarily often in the wrong, because our knowledge of uses is very limited and imperfect; but we shall see that the foundation of this estimate is the true one, and the only one which shows purpose and design in the whole system.

Let us again revert to the animals as the most appropriate subject for illustrating the principle; and we shall at once perceive that the two grand divisions are organized upon parts of the system which have very different functions. All the systems of the invertebrated animals are contained within the general crust or firm integument in which they are cased; and the vital functions, or those that work for the nourishment of the individual, or the continuation of the race, are those to which all the others are subordinate. They are creatures which have little or no resource in themselves; and while no animal proceeds by reasoning from experience, as man does, it is very doubtful whether, in very many instances, they proceed upon what we may call the momentary stimulus of sensation. Their actions are often exceedingly curious, so much so that we are apt to be carried away by the very seductive vanity of taking ourselves as the standard, and so place them at the very top of the series in point of what we call "animal sagacity." Sagacity—*sagacitas*, from *sagire*, "to have quick perception" *(Sagire, sentire acutà est)*,—always involves the idea of something to be perceived; and even if we concede to an animal the most acute and perfect senses with which material organs can be endowed, they can perceive nothing but that which affects them at the time. No eye can, to-day, see the sun of yesterday or of to-morrow; and to revert to the past, or anticipate the future, is the province of mind, not of matter. Finite mind could not, indeed, accomplish that which, when we are led into temptation by this very seductive and very general error, we impute to the sagacity of these animals. We never hear enough of the marvellous science of the bee, which, in the formation of her cells, gets the maximum of accommodation in the minimum of space, and the maximum of strength from the minimum of materials; or of the wonderful sagacity of other insects, not only in placing their eggs in situations where the the young shall have food, but in placing them in the bodies of other insects; and, as the small one feeds upon the internal parts of the large, making it avoid the vital portions, until it makes its last meal, after which the skin of the one upon which it has fed becomes a place of refuge to it during the time that it is in the crysalid, or dormant state.

These, and countless other cases have been adduced as proofs of the sagacity of the invertebrated races of animals, and they are no doubt all exceedingly wonderful. But, we would ask the special wonderer at those small and insulated parts of the great system of nature, to name any one production, or any one action or phenomenon in the whole range, which is not wonderful. The especial wonder of the whole is that the system of nature should exist, and that we should be endowed with the faculties of perceiving and enjoying it; and surely we will not give our sagacity credit, either for creating the system, or acquiring our powers of discernment, whether in the observation of present subjects by means of the senses, or in that mental power which supplies us with the vinculum uniting the past with the present, and making the two an experimental guide for the future. This last part of the perception (and it is the only one in which we can be said to have design or purpose, in the limited sense in which that can be predicated of us) is not obtainable by the exercise of our mere bodily senses, how acute soever we may suppose them to be; and if we were to suppose that, as mere corporeal organs, or rather as functions of such organs, they were sharpened, in some other animals, to tenfold, or ten thousand fold the acuteness they have in man, that would not give them the slightest tendency to connect the sensation of one moment with the sensation of another. In human beings we find that the acuteness of the senses is not only not in proportion to the intellectual acquirement and power, but that it seems to have a tendency to follow the very opposite ratio. Savage nations, low in the intellectual scale, and having none of the enlightenment of science, or the advantage of art as founded upon science, are proverbial for the extreme sharpness of all their bodily senses. When the natives of America were first visited by Europeans, they could see the foot-print of an enemy, hear a sound, or scent an object, under circumstances where the most enlightened European found no impression upon any one sense; but even those among them who had made the greatest progress towards civilisation (we cannot say progress *in* it), had no name for a number greater than three, and consequently no distinct idea of such a number itself.

Among mankind, therefore, the development of the senses as bodily, and that of the mind as intellectual, follow opposite laws; and it is a kindly provision of Heaven, to man in a state of privation and destitution, that the senses should be sharpened to him under circumstances which prevent much intellectual development. But even in these cases man is not destitute of mind, how little soever it may be improved by cultivation; and, therefore, in the very lowest condition in which we can suppose him to be,—unless, indeed, under that singular modification of disease, temporary or permanent, which destroys the connexion between sensation and thought, is still upon a much higher level than the most fully developed of the other animals; and, therefore, even in those states in which man may with propriety be said to have no sagacity, he is still higher than they are.

This brings us to the grand distinction, not only between man and all mere animals, but between the two grand divisions of these the invertebrated animal stands lowest, inasmuch as the organs of sense are much less developed in them than in the vertebrated races, and in not a few of them the existence of any sense, except mere sensibility to atmospheric changes, is extremely doubtful. We must therefore discard entirely all notions of the superior sagacity of such animals, and view them in their proper place in the system, namely, that in which they are more under the influences of the circumstances in which they are placed than any other animals whatever. This agrees with the observed facts, and also with what we have stated as being the principal office of such animals in the economy of nature, which is indeed only an inference from the facts. They come in their requisite numbers when circumstances require their presence, and when they are no longer necessary they disappear, but wait in the rudimental state ready to obey a new call, though never coming till that call is made. Their coming and their going thus depend upon causes entirely external of themselves; and in whatever way they perform their functions, that is a portion of the very constitution of their nature from which they cannot depart, and which, instead of being the result of sagacity, cannot, in many instances, be looked upon as in any way resulting from sensation. That we are not able to say what it is owing to, is no argument, as ignorance can never be made the foundation of reasoning; and the same plea for sagacity to a bee in the structure of its cell, upon principles of the most refined mathematical nicety, might, with equal propriety, be applied to the form which any organ of an animal, or even a vegetable, assumes; for if we understood the use of the organ rightly, the organ itself is always the very best adapted for that use, that can be imagined. We have gone somewhat at length into this question, because it is one upon which erroneous opinions are very generally advanced, and have a very mischievous tendency; and, therefore, no opportunity of laying a sure foundation for the truth ought to be omitted. There is one little matter which we may still repeat in illustration of what we have said of the natural place of the invertebrated animals. They are better adapted for external contingencies—that is, states of things, in the bringing about of which themselves have no part—than the other animals; and it is the general law of nature, that every production or class of productions is, upon the whole, though not perhaps always in the individual instance, placed in that situation for which it is best adapted.

When we turn our attention to the vertebrated races, we find, that though in their four grand classes they may be said to inhabit four distinct localities in nature, —namely, the birds in the air, the mammalia on the surface of the earth, the reptiles in the mud and sludge, and the fishes in the water,—yet, as there is one general plan of organization among them, there is one general purpose, (though both plan and purpose are greatly diversified,) not only in the four classes which have been enumerated, but in the different members of each class.

In all of them there are two distinct systems; the one external of the bones, though more or less included within partial protections of bony substance,—and the other, in its more important parts, internal of the bones. It is this latter system which stamps the grand distinguishing character upon all the vertebrata. The vertebral column consists of a skull, in which the brain is lodged, without any other organ along with it; and a back-bone, consisting of vertebræ, or jointed pieces, varying in number and form in the different races, and containing, safely protected on its inner side, toward the great cavity of the body, the dorsal cord or continuation of the substance of the brain. In all the invertebrated ones, the bony parts which support the brain and dorsal cord are wanting; and, generally speaking, the parts answering to the contents of these bones, are but imperfectly developed, and follow the direction of the alimentary canal.

Upon comparing the powers of sensation and the development of the brain, and its vertebral or spinal continuation in different animals, we find that there is a constant correspondence between them; so that though we cannot say the relation is exactly the same in every particular case, yet more acute and perfect sensation so constantly accompanies a more perfectly developed brain, that we consider that organ as the grand part of the structure, upon which the sensation depends. In using the word "sensation" we must, however, exercise a little caution, for mere sensibility to atmospheric changes, or other external circumstances, is not synonymous with that sensation which has a developed brain as its centre, but in many respects the very opposite. If the words may be used, the sensibility to the ordinary physical state of things may be called passive sensation, while that which has its centre in a brain is active. The objects which affect the two are also quite different, and refer not to the physical nature of objects, but to particular states of them. Sensation of this active kind is still only momentary, or active during the presence of its object; but it has much more to do in the conduct of the animal, than any of those which can be called active sensations, or referred to a particular organ in those animals which have not a developed brain, a skull, and a backbone; and, therefore, as the animals are, so to speak, more under the control of their own sensal perceptions and less under that of external circumstances than the invertebrated animals, they require a differently modified organization, and requiring it they possess it.

The first object which is obviously attended to in the structure of the vertebrated animals (and it is most conspicuous in those that have the brain most fully developed), is the securing of that organ and its spinal continuation against injury from jolting and concussion when the animal moves. Such animals never have the bones of the anterior extremities articulated or jointed on the spinal column, but merely embedded in the soft or fleshy parts which are united to the processes, or projecting pieces of the vertebræ. Thus, whatever jar the fore legs, the hands, or the wings, as it may be, meet with in the performance of their motions, is never communicated to the important part of the animal farther than through the medium of the soft parts, which break the shock,—as the jolt of a carriage upon the wheels is broken by the springs; the other vital parts being suspended from the spinal column, by the ribs, which are not, in the more typical animals, articulated upon it, but merely attached by flexible cartilage, are equally secure against injury from concussion. Concussion from the action of the posterior extremities is not so liable to be injurious; but even this is guarded against by there being some cartilaginous unions, more or less flexible, between the spine and the first articulation of these extremities. Thus the organs of motion are left free to the performance of their offices, without any risk of injury under ordinary circumstances, either to the system of sensation, or to that of motion; but as the first of these is the most important one in the economy of the animals, it has the most complete protection.

In all the moving parts of the vertebrated animals, the muscles, or organs of motion, are external of the bones which they move; and thus they never can pass through the centre of motion, and much of their mere power is lost by the situations in which they have to be placed with reference to the parts which they move. The muscles which raise and depress the wing of a bird in flying, offer a familiar instance of this.

Both sets have their origin, or fulcrum of motion, on the sternum, or breast-bone of the bird; and thus, if they were both inserted in the same manner on the humerus, or shoulder bone of the wing, they would both pull in the same direction. But the muscle which depresses the wing is inserted on the under side of the humerus, farther from the body than the centre of motion in the bone, and that which raises the wing is inserted on a process nearer the body than that centre. Hence, although both muscles in their contraction pull in the same direction, the depressor pulls the humerus down, and the elevator pulls it up. Of these muscles, the depressor acts the most directly, and has the advantage in the lever; and, consequently, besides being the larger and more powerful muscle of the two, it acts with less waste of its energy. But as the elevator acts on a shorter lever, its action is more rapid, though less powerful. This is a great advantage to the bird in its flight, as a rapid elevation of the wing and a powerful downward stroke, are exactly what are wanted.

There is not one joint in any of the vertebrated animals which does not furnish a most pleasant and useful lesson in mechanics; but we cannot enter farther into the details.

There are, however, various advantages in the action of joints with external muscles, which render them far more commodious than those which have the muscles internal. With the internal muscles, passing through the centre of motion of the two parts which are jointed together, there never can be motion by the flexure of a single line passing through the joint; and this is the only kind of motion which admits of being turned into any direction. We have examples of it in all those joints of vertebrated animals: a round head of bone works in a socket, and which are thence called ball-and-socket joints. From this, which is the universal joint, there may be all varieties, down to a simple hinge-joint, which has motion in one plane only. With internal muscles there cannot possibly be any joint, consisting of one hard surface working directly upon another, except a motion on two points, one of which is situated at each side of the openings in the two pieces, through which the internal muscles pass from the one to the other. If the articulated substance is very hard, a joint of this kind is exceedingly firm and accurate; but it has motion in one plane only, from which it cannot deviate, and thus all the variety of which it admits is merely a greater or a less degree of flexure. The joints of a crab's claw are very perfect examples of this, and they work without the slightest shake. If, however, the least twisting motion, or deviation from motion in the one plane, be required, a joint with internal muscles can have no stability; because the only way that even this limited change of motion can be obtained, is by uniting the ends of the two pieces by means of a ring of flexible matter, which shall "give" in the requisite direction, and to the extent which is necessary. The joints of the walking legs of a crab, and also the proximal ones of the pincer claws, are of this kind; and so are the proximal joints of the legs of insects which have motion in more planes than one; and therefore all such animals appear very feeble and lumbering on their legs, as compared with vertebrated animals. If steady motion in any number of planes is required, there must be as many separate joints as there are planes; and thus, in order to have even a very inferior command of its limbs, an invertebrated animal must have many more jointed pieces in them than a vertebrated one. The human arm and hand are capable of more varied motions, both in the positions of the arm and the actions of the hand, than any other piece of animal mechanism; for, to say nothing of the different movements of the parts of the hand itself, the point of the finger can, without any motion of the shoulder, divide space, not only down to the two thousand five hundredth part of an inch in every direction, but absolutely to an indefinite extent beyond this—an extent which cannot be stated in numbers, as the finger can glide with equal smoothness throughout the whole, without any perceptible starting from one point to another. It is true that the hand is the extreme instance, because it has to obey the eye, the wish, the thought, and the feeling, in every manual operation in the arts, some of which, as in the touch of an instrument by a first-rate musician, are so exquisitely delicate, that, instead of being described, they cannot be appreciated, or even felt by one who is not possessed of equal dexterity, and equal feeling of the art.

But the human hand stands alone among the mechanical structures of animals, inasmuch as it is the servant of a much higher power than any which is found in them. It has to minister to mind—to an intellectual principle which is in its nature perfectly untrammeled by any thing material; and consequently it cannot enter into any estimate of the relative perfections of the others.

It is, however, the ultimate point to which all the remarks which we have made on the gradations of nature tend; and we must come to it, and even to the intellectual principle of which it is the servant, before we can rightly understand or duly appreciate the truly wonderful system of creation, or reverence aright that wisdom, power, and goodness, by which it has been made, and is sustained.

But when we confine ourselves to the vertebrated animals, we find in them an adaptation of the parts for varied actions, and an accommodation of organs to senses, of which there are no traces, or at least very faint ones, among the invertebrated tribes. Thus the proper organs of the allocated senses,—the eye, the ear, the nostril, and the tongue,—have their own distinct organs of motion as well as their susceptibility to sensal impressions. We ourselves can fix the eye, bend the ear, or extend the nostril, so as to catch through any of them an impression, or a succession of impressions, which would pass unknown if it were not for the power which we have, of calling the organ to the performance of its duty.

In as far as we can judge from similarity of the general structure, the mere animal power of sense in the vertebrated animals, the mammalia especially, must have some resemblance to our own; but of course they can have none of those intellectual impressions which, in us, follow so immediately after the sensal perceptions, that we cannot say with precision where the one ends and the other begins. As sensation is their highest endowment, and indeed the most elaborate and elevated power—the farthest removed from the mere properties of dead matter, and the greatest departure from the laws of that matter, so the gratifications of the senses must be the highest enjoyments of these animals; and as they, in their very nature, stand the most in opposition to the laws of matter, their production and the maintenance of their being must demand the greatest effort. This is the reason why, in them, the germs of life never can bear to remain apart in a dormant state, ready to be called into action by the operation of external causes; and for this reason, again, they cannot work to the contingencies of the system, but must be the served, and not the servers, in nature's economy.

Taking them as a class, the mammalia, in this respect, stand higher than any of the other classes even of vertebrated animals; but when we take the orders and genera of which the class is composed, we cannot arrange them in the order of precedency, and say in what way one order is, upon the whole, superior or inferior to another. Each has its proper place, and its proper locality, from the whale in the ocean to the chamois on the mountain rock; each is the foremost of material beings in its own proper place; and while none of them are the servants of any other race, we cannot say that any of them are the servants of others.

Thus from the very lowest stage of animal life, we can follow the chain upwards to this the highest one; and in the vegetable kingdom it is the same. But when we come to the highest, they all appear to be objectless and detached. There is no dependency, and no reciprocity of use, between a fox and a sheep, or between an oak and a beech. Many of the mammalia, no doubt, eat the flesh of others: wolves eat sheep, and lions and tigers prey indiscriminately on very many of the animals of the desert and the jungle. But still we cannot say, that the ultimate purpose of nature is accomplished when those carnivorous animals are fed,—that the purpose for which sheep exist is simply that they may be eaten by wolves,—that the purpose for which wolves exist is to eat sheep, or that the more formidable beasts of prey were made for no other purpose than that they might rend and devour the other animals of the wild woods, or that these other animals have no other purpose than that of being rent and devoured by those powerful carnivora. The system of growing and living nature is all too mighty in its extent, and too wonderful in all its parts, for admitting us to believe, even for one moment, that the climax of the whole of it is, that a lion shall be fed in the wild woods of Africa, or a tiger in the jungles by the Ganges.

This would be but a sorry conclusion to so long and so splendid a series; and yet, if we look no farther than mere matter, in the utmost perfection of organizing and endowment in sensation which it can possibly possess or receive, this is the only conclusion at which we can arrive. And if we come only thus prepared, and proceed thus far, the *cui bono?* will stand up like a lion in our path, and demand of us, "Wherefore all this display of wisdom, of power, and of goodness, which bears the indelible and unconcealable impress of divinity upon its every step, if the ultimatum to be reached is nothing more than the feeding of a ravenous beast in the wilderness?"

Nay, with such views we find that the system breaks down with us before we arrive even at this conclusion; for if sensation, which we must regard as the highest merely animal endowment, is actually to be taken as such, the lion is vastly behind very many of the other mammalia, and the reputed king of the beasts is a cruel, a stupid, and, unless when goaded on by necessity, a crouching and cowardly tyrant.

Even if we include man, and view him as wholly made of the same clay with the rest, the question remains as stubborn, and as urgent for an answer as ever; for of what avail is it that man should be born, and toil and fret for three score and ten tedious years in this world, and then go to mingle for ever and wholly with the clods of the valley. Assuredly this does not remove the doubt, or clear up the difficulty; and the chalice of annihilation is in nowise sweetened by being presented to our own lips.

There is but one way, but that way is straight, open, easy, and sure; the purpose of Almighty God in the fulfilment of his own pleasure toward a rational, immortal, and accountable creature, according to the revelation of his own word. All this creation is for him—for instruction and for use; and it is so rich, so varied, so completely inexhaustible, that, notwithstanding all that has been known, and all that has been done, unnumbered ages yet run their course, with increasing knowledge, and multiply enjoyments, and yet the bounty of the Creator in that world which he has given us as our heritage in life, may be as fertile in new knowledge and fresh enjoyment as ever. And that it is given to us, not as food is given to an animal, or holes to foxes, or nests to the birds of the air, but given to us as intellectual and as moral creatures, for self-instruction and self-government, is proved by the fact, that no enjoyment of the world will remain ever fresh, and ever acceptable to the mind, save the enjoyment of the knowledge of it. A little more ambition, and honour is degradation; a little more avarice, and wealth is poverty: but knowledge is of heaven, and the freshness of immortality plays around it with a radiance which no reverse can cloud, and death itself cannot extinguish.

CHAPTER IV.

THE ARMIES OF AUTUMN.

To muster the whole array which Autumn brings forward for effecting the restoration of nature, and of vegetable nature, and the substances necessary for its support, especially and more conspicuously than all else, to that condition which is requisite for reposing with safety during the winter, and starting with due energy and advantage in the spring, would be equally long and laborious,—a labour which no single individual of the human race could possibly accomplish, which could not be done with proper unity and effect by the joint exertions of any number, and which, even though it were done, could not be perused with due attention during the period of an ordinary life, by even the most voracious and insatiable devourer of books. In passing, we may observe that there is a curious correspondence between the literary glutton and the gastronomic : both are, in their several ways, thin and cadaverous; and as the man who gorges himself to intemperance with food, is deficient in health and strength, so the intemperate reader is invariably sadly wanting in thought and reflection; and in proportion as he indulges to excess, he actually brings himself nearer not only to the condition of absolute ignorance, but to the incapacity of receiving instruction. This seems paradoxical at first sight; but it is nevertheless true, and a very little consideration will suffice to show that it cannot but be true. We make this statement with great deference, and with every desire to do honour to those seats of learning, which kept the lamp glimmering during the ages of ignorance, after inordinate luxury had quenched it in the monastic cell; but we cannot have been mistaken in the invariable feeling, that "college sophs," who live in and upon the library, are more guiltless of thought of all kinds than any other set of the human race. We do not blame the institutions for this; for almost all of them number among their resident members the noblest ornaments of the human race; but these are invariably men who shun the ever opened book, and the emanations of whose minds go fresh, free and original, to the contemplation of material nature, of man, and of the revelations of God whether in his works or in his word. If such is the case with those who have had the advantage of the technical rudiments of science, how much more pitiful must be the condition of those inordinate and indiscriminate readers who launch upon the ocean of books without having even the guidance of such glimmering stars as technical "courses," in which there is scarcely one appeal to reality, or one loophole through which the system of nature and its workings can be seen from the dungeon of most profound but most unusable erudition.

But we mention this only in passing, though it may serve, if not as an excuse, yet as a sort of "saying," why we have not attempted an impossibility, and also why the attempt would not have been desirable, even though the impossibility of the case had been removed. The duty of an author is not to furnish thoughts, but means, or rather opportunities, of thinking; for a communicated thought is not a thought at all to the person receiving it. It is a mere story, and as such, a sensible reader will not receive it as truth without carefully weighing the evidence, the labour of which is many times greater than if the party were to think for himself. This is the real secret why inordinate readers are most deficient thinkers; and it also shows the force of the aphorism of the wise man, that "a great book is a great evil."

We have this, however, to guide us, with regard to the armies of Autumn, that they are in every case perfectly regulated, both in numbers and in strength, to that which they are appointed to accomplish; and thus they always succeed, and their success is always attended with advantages. What they are, how they work, and when they work, are, however, matters of very variable and indefinite character. It is the action done, and not the time or the agent, that determines it to be Autumnal; and the result of that action, in so far as it is brought about by those agents which we have called the armies of Autumn, is always the reduction to an elementary state, or a state in which it is material and not a work, of something which has performed a seasonal, or periodical purpose, in some portion of time longer or shorter, and which is never again to perform that purpose, until it has passed through a succession of changes, which are often very protracted in their occurrence, and generally beyond the range of our observation. In the case of vegetables, even those which are the longest lived, the same individual parts never have a second summer action; and in animals, though the same parts continue to act during the whole time that the animal is in the same state of development, yet the matter of which those parts are composed, is continually changing, so that we cannot say positively that any one particle of material substance can sustain the action of animal life beyond the lapse of a single and indivisible instant of time. Now all passages from organized and living being, back to the state of dead or inorganic matter, in what beings, what manner, what times, or what periods they may be accomplished, are essentially and properly Autumnal actions, and the agents by which they are brought about are included in the armies of Autumn.

Those armies, in whatever manner they may carry on their operations, are all either animals or vegetables; and as they come only at the times when, and in the places where, they are specially wanted, and retire when their labour is accomplished, they belong to that grand division, whether of the one kingdom or the other, which we have described as serving, not as being served. The decomposing power of the atmosphere, and that which is produced by the chemical action of the component parts of a substance upon each other, do not come within the class of Autumnal agents, or form any part of the armies of the season. The instant that the action of life ceases in the whole, or in any part of an animal or a vegetable, the substance thereof is under the physical laws of matter, and of course obedient to them. It will be borne in mind, from what we have stated, that, in the tropical countries, the action of the elements, together with that of the component parts of the substances themselves, is sufficient not only to reduce to dust, but actually to dissipate so as that it is not easily found afterwards, all that part of the production of vegetable growth which is strictly seasonal; and that the auxiliaries to these powers in the slow decomposition of more permanent matters, are chiefly animals. But as the difference of season increases, and the annual destruction or decomposition becomes greater, the decomposing power of the elements becomes less, and hence the proper Autumnal agents are called into existence, and the proportion which they bear to the whole, increases with the latitude and difference of seasons, until the utmost limit is arrived at.

As the spring and summer destroyers, or rather regulators, of vegetation are chiefly animal, and as the Autumn is in its more important character the reverse of these seasons, we may take it for granted that the proper armies of Autumn should be vegetables, and actual observation shows us such is the fact. They are not the only agents which are most active in the Autumn, but they are the most conspicuous; and we cannot distinctly state that there is any large and distinct class, though there are a few genera and species of animals which come into activity, only, or chiefly, in the Autumn; and there are Autumnal changes in many animals. Such animals as merely undergo an Autumnal change from their habits at other seasons of the year, cannot, of course, be classed among the armies of Autumn; and the animals which, in such climates as that of Britain, come into activity at this season only, will be better described in separate notices, and thus the section of the Autumnal host which most prominently demands our notice here, are the Autumnal vegetables.

Those vegetables are, generally speaking, the Fungi, a very peculiar race, simple and cellular in their structure, generally soft, tender, and perishable in their consistency, wonderfully rapid in their growth, almost equally so in their decay, often of extreme minuteness in their size, and possessing powers of reproduction, which are altogether astonishing, and quite unequalled even in the case of fishes or insects, or even the most productive of the flowering plants, though among these there are instances to be found of such fertility, as more than five millions produced by a single mother in the course of a single year. The germs of all the fungi are very small, and those of the more minute ones are quite invisible to the naked eye, or even by the help of glasses of no ordinary magnifying power: they are thus among the minutest things of which we have any idea of having separate existence. Small as they are, however, each one is the depository of a distinct and specific life, far less liable to be injured than a germ of larger volume, and perfectly ready to come into action whenever circumstances demand its appearance. The extreme minuteness of the germs, or sporidia, of many of these fungi, renders it necessary that we should speak with great caution respecting their numbers; but according to the estimates made by those who have examined them with the greatest attention, and the assistance of the best instruments, we are led to conclude that in some species there are ten millions of germs in a single cell; and that more than fifty millions, not of germs but absolutely of cells, are produced in the course of a single minute. It is, therefore, no exaggeration to say that a single fungus is capable of producing in one hour a greater number of germs of being, than are produced by the whole warm-blooded animals upon the face of the earth, in the course of an entire year. Wherever there is great power in nature, there is always an equally great use or necessity for that power—upon the obvious principle that nature, or in other words the Author of nature, does nothing in vain. Consequently when we find that plants, which are strictly Autumnal in their appearance, their characters, and their functions, have this extraordinary prolific power above all other growing or living creatures, it impresses us with much more exalted notions of the importance of Autumn in the economy of nature, than when we look upon it merely as the season at which mankind gather in the fruits of the earth, and hunt the beasts of the field.

The fungi get their name from the cellular or spongy texture of their substance, which never consists of firm or lengthened fibres; and as they appear above the surface of the earth, they have no distinction of stem, leaf, and flower, like ordinary plants. They do not even resemble these in their chemical composition, for many of them contain the same component parts as animals, and resemble animal substances not a little both in taste and in smell. Mushroom ketchup, for instance, when of the best quality, is, with the exception of the spices used to flavour it, composed entirely of certain species of fungi; and a ketchup can be made, and is understood often to be made, from bullock's liver, which so nearly resembles the other, that it is not easily detected, either by the taste of the epicure, or the analysis of the chemist.

Even among cellular plants, the fungi form a most peculiar province; and though they are not flowering plants, in the common acceptation of the term, the parts of them which are most conspicuous above ground, or external of the substances upon which they grow, are a kind of flowers; that is, they are parts whose chief office is the production of germs, which are called spores, or sporules, and which bear the same relation to the fungi which seeds do to common plants. As is the case with plants themselves, these are, however, much more simple in their structure than seeds. The greater number of them are inconceivably small, and, therefore, difficult to be examined; and the examination of them is subject to all the imperfections, which are inseparable from examinations carried on by means of glasses of high magnifying power; but there is no perceptible distinction of germ and cotyledon, or seed lobe of any kind, and the spore or sporule appears to be equally instinct with the vegetable life with which it is charged throughout the whole of its volume.

This is a very curious property of those germs; and when we have seen a little more of the functions which these curious plants perform in the grand system of nature's economy, we shall find that the wisdom of the Creator is as wonderfully displayed upon this, which, to our comprehension, seems the very verge of nothingness, as it is in the most magnificent production of the earth, the earth itself, the solar system, or even the universe.

In consequence of their extreme minuteness (and many of them are so exceedingly small that they are dispersed through the atmosphere, not like smoke merely, but like invisible vapour), these germs appear to be proof against almost every description of mechanical injury. How it may stand with them in regard to chemical decomposition is not so easily ascertained, although it is highly probable that, against the ordinary chemical actions which take place in nature, they are very powerfully guarded, by that simplicity and minuteness which present so little that can be acted upon. In many cases metallic salts, and other caustic substances, destroy the developed fungi, and prevent future growth on the same spot. But from this we cannot infer the destruction of the germs, by even the most active of those substances; for in the case of every vegetable, the destruction of the growing plant is one thing, and that of the germ another and much more difficult one.

The fungi themselves show, perhaps, the most remarkable instance of this; and both tendencics adapt them for the performance of those Autumnal labours for which they are immediately, and, to common observation, spontaneously called into existence and action, at the particular times, and in the particular places and numbers, which are required. The rapidity of growth and brevity of duration in a mushroom are quite proverbial, though they do not apply in their full force to the esculent mushrooms, properly so called; but still, the whole even of these, in their ordinary exposures in wild nature, are completely gone in the course of the season; and they come one knows not whence, and go one knows not whither; for the whole of the race melt away, and there is not a wreck or memorial of them to be found. Some of the species, especially those which grow upon matter which is warm with putrefaction, attain a considerable size, and yet their duration is limited to a few hours; and they yield to we know not what, without the attack of any destroying enemy, or any considerable change in the state of the atmosphere. Upon the rest of vegetation around them, the most observant eye cannot mark the slightest change either for the better or the worse; but in the morning, a considerable breadth of surface shall be spotted with these more evanescent of the fungi; and if their office is accomplished without a succession of crops, not a trace of them may remain when the sun has gained its meridian height.

This power of growth and rapidity of decay place vegetable life in a very extraordinary light; and when we consider that the thousands—in all probability the millions of offspring, which this evanescent thing has committed to the keeping of nature, are, in their own minuteness, hidden from every foe, and thus far more safe than the acorn, the cocoa-nut, or any other more mailed and fortified fruit, we are taught, to the utter confounding of all our philosophy, that the causes by which great actions are performed in the economy of nature, set at nought the line and the balance, and rise immeasurably above all our powers of calculation.

We can easily see, however, that this perfect readiness to come when the state of things renders them necessary, and to yield without effort, or without demanding the labour of any other productions of labour, when their work is accomplished, are precisely those properties which especially fit them for being the armies of Autumn, in the decomposition of those vegetable substances which have performed their functions as portions of organic nature, and ready to be turned into simple materials or elements for new combinations.

But though Autumn is their appropriate season, and their numbers increase according as the climate is more seasonal and the Autumn more brief, yet they are not confined to the Autumnal months, neither is the decomposition which they effect that of vegetable substances only. It may be in any place—in the fields, or in human habitations, or at any one season of the year, and it may be any part, external or internal, of an organized substance, animal or vegetable,—only let destruction be required, from the state of the substance and for the well-being of the general system of nature, and the fungus is instantly there in any number that may be necessary, and in numbers and individual power, exactly appropriated to the work they have to perform. Is there disease of any of the membranes which line the seed-cells of an apple, in the rind of which there is no visible perforation ?—a mould comes in myriads upon the diseased spot. Is there any animal or vegetable substance whatever that begins to putrefy under circumstances where the ordinary action of the elements, or the labour of insects, is incapable of reducing with that rapidity which is required ?—then it is speedily covered with its appropriate fungus, although the same species of fungus may never have previously appeared in the same part of the country, and may never so appear again. Have the beams of a dwelling, or the timbers of a ship been constructed of materials injudiciously selected or prepared, or unskilfully placed, so as to want that wholesome ventilation, which is essential to the durability of almost every kind of timber, and there is the very first dawning of incipient disease ?—there, the various fungi, indiscriminately called dry rots, marshal their hosts, and bring destruction in the most fearful and often the most fatal manner.

These are but a few out of innumerable instances, and one or other of which must have been noticed by every reader; but we shall not swell the catalogue, as we shall have occasion to advert to some of these, and a few others somewhat more in detail, in consequence of their interest in a practical point of view. In some of these the fungus does not come upon the plant or portion of the plant, till after its seasonal labours are at an end, and it is no longer useful in the growing world. They come upon it in early stages of its growth, and their effect, to ordinary observation, is to lessen the quantity and deteriorate the quality of the harvest—and not merely to perform the apparently kindly office of preparing the waste for again running its course in the living circle.

Hence, it has sometimes been said that fungi occasionally assail living plants or living parts of plants, and even living parts of animals, as well as those which are in a state of incipient decay. This is a very nice point; and one upon which it is necessary to speak with great caution; but the analogy is strongly against the fact of any fungus attacking either an animal substance or a vegetable one, while that substance is under the healthy and vigorous action of the life of that to which it belongs, or indeed under the action of that life at all. That the parts attacked by the fungus may extend their own unwholesome condition, and the fungus along with it to other parts, is highly probable, for canker in a tree, and gangrene in an animal, have a similar power of extension. It also may, and often does happen, that the fungus shall produce a sort of increased action, and the plant which is attacked shall, for a time at least, appear to grow more vigorously than a sound plant; but even this does not show that the fungus lives upon, far less that it is originally called into action by the healthy growing matter of the plant. Of this we have also an analogy in the bodies of animals, as well as in those of plants, when there is no fungus in the case. Ill-conditioned wounds, and other sores, often have their inveteracy greatly increased by those growths which are sometimes called "proud flesh," and which are said to be of a fungous texture; and those branched enlargements which sometimes grow in the nasal and other passages, and prove exceedingly troublesome diseases; and yet they are produced by diseased action of the systems alone. There are also innumerable fungous productions upon plants, some of them arising from the irritation of insects, and some from disease in the plants themselves. The gall-nuts, as they are called, which are formed on the leaves of the oak, the willow, and many other trees, often attain considerable size; but they are not the growth of fungi, neither are they in any way productions of the insect as part of its own system, nor are they indeed animal matters, or matters having the slightest approximation to animal composition in any sense of the term. They are purely vegetable matter, the product of the plant itself; and if that plant contains any remarkable vegetable principle—as, for instance, gallic acid in the oak,—that principle is always more highly concentrated than in the healthy parts of the plant; which is the reason, by the way, that the galls of the oak answer so much better for making black ink along with iron than a much larger quantity of the wood or any other part of the tree, and also why galls formed in warm climates are much better for producing black colour than galls formed in cold climates.

Excrescences of this kind are formed on very many plants, and all of them enclose first the eggs and then the larvæ of small four-winged flies, which are called the *Cynipidæ* or family of gall-flies. Some of them are very singular in their appearance, and none are more so than the Bedeguars, which are formed on the twigs of rose-trees, and especially on those of wild roses. These are often equally singular and beautiful, representing a thick tuft of slender vegetable fibres, often measuring two inches in diameter, and of a delicate green or pink colour. Any one not aware of the fact would naturally suppose that these are parasitical vegetables, growing on the rose-tree, instead of results of diseased action in the tree, brought on by the puncture of an insect not nearly the tenth part of an inch in its longest dimension. These, and many other fungous appearances upon plants and also upon animals, which are occasioned either by diseases, the real causes of which are not very often perfectly known by us, or by the operations of insects, and also various diseased formations upon animals, have at times been confounded with the fungi. These are produced upon the living substance certainly; but they are also produced by diseased action of the life of that substance; and although the beginning of the diseased action may be the puncture of an insect, or any other injury, mechanical or chemical, the agent in that operation does not, and cannot, elaborate one particle of the unnatural production.

Thus, in no one of these fungous appearances is there the least shadow of proof that any fungus grows upon that which is alive; nor is there any clear proof of this in any one case to which reference can be made. Indeed, that a fungus should so grow, is so contrary to the proper character and appointed function of this department of the vegetable kingdom, and so contrary to the general analogy of nature, that before it could be received as a general truth, very numerous and conclusive proofs would be necessary.

It will be borne in mind that the proper function of the fungi is the final decomposition of organic matter, or the reducing of it to such a state as that, generally speaking, it shall pass to the general store of inorganic matter, without the assistance of any specific destroyer. Other than this, we know of no general class or division of beings, which thus come into existence and activity, obviously for the service of the system, and not for the multiplying and continuing of their own kind, which are the evident purposes for which all the rest work. No doubt very many of the animals live upon vegetables, indeed all of them that do not live upon animal matter; but it is not clearly made out that any one vegetable lives directly upon the substance of another vegetable or of an animal, until that substance has been disorganized and decomposed. That any one of them should so live is contrary to the general physiology of vegetables, as none of them have any system or any organ by which disorganization can be performed, or matter taken into their structure, in mass, as food is taken into the stomach of animals.

There has always been, on the part of some at least of the propounders of opinions of these matters, a disposition to deny, or at all events to overlook, this grand physiological distinction between animals and vegetables, and hence those averments (to give them their gentlest name) which have been made in very recent times, about vegetables giving out to the soil a certain refuse of their food, something in the same manner as is done by animals, which refuse renders the soil unfit for the healthy support of the same kind of vegetables, and hence the advantage of a rotation of crops in farming. But the case here, besides being at violence with all that has been clearly ascertained in vegetable physiology, is not even true to that loose analogy with animals from which it is attempted to be drawn. Suppose (which is a mere unproved supposition,) that a plant does draw from the soil a certain specific aliment, it needs no conjurer to tell us that the rejected discharge by the plant, if any such there were, would not be fit for being returned to it again, as a pabulum, either in what we have called the essential or the vehicular part. If such were the case, either with plant or with animal, it would show an imperfection in the working of nature capable of being detected by human ingenuity; and this is so perfectly contrary to all that we know of the system, and all that we believe of its Author, that no human being, of ordinary understanding and reflection, can possibly entertain it for a moment. If the ejected substance is immediately fit for the purposes of nutrition, then both the ejection and the reception of it would be labours without an object, and thus a direct variance, an indirect violation of all that we know of the system and economy of nature. But that that which is ejected should be injurious in the preparation of the proper food of that by which it is ejected, whether plant or animal, is not only not proved, but the whole experience we have, which of course applies to animals only, goes to establish the opposite as a general truth.

Even in the case of some of the fungi, and of flowering plants, we have a very clear and satisfactory instance of this kind in those fungi which formed what are called fairy rings upon dry commons, and which in the days of ignorance were supposed to be trodden down by the imaginary elves, after which they are named, in their midnight dances during the summer months. We are not so well versed in fairy lore as to be able to say what was supposed to become of those light-footed gentry during the inclement season, whether they migrated like birds, or hybernated like toads; but we believe their nocturnal dancings were suspended during the cold season; and it so happens that the rings or circles upon the sward, which were supposed to be trodden down by their twinkling feet, are covered with much more luxuriant grass during the Autumn, the winter, and the spring, than the rest of the sward upon which they are marked. This fact in natural history is embodied by the great poet of nature in his allusion to the fairies; and there is far more of the essence of genuine philosophy in it than in many treatises which are laboriously composed, with the express intention of being profoundly philosophical. He says,

> ——— "the demi-puppets that
> By moonshine did the green sour ringlets make,
> Whereof the ewe not bites; and those whose pastime
> Was to make the midnight mushrooms."

These fairy rings, which at one time caused a good deal of speculation among the observers of nature and inquirers into natural causes, afford one very pleasant means of explaining the functions of some of the fungi, and the relations between them and some of the flowering plants, more especially the grasses. They occur only upon dry and warm places, which are covered by a short and kindly sward. If the surface is level, they are perfectly circular; but upon an uneven surface they move less rapidly up hill than in any other direction. Some are a mere spot, without any opening in the centre, and others are a good many feet, or yards, in diameter. The spots open in the second year of their appearance to the extent of from half a foot to a foot, which is about the breadth of the ring, and also the rate at which it expands in all directions in the course of the year. We had daily opportunities of noticing them for more than twelve years in a place where they were numerous, and where their progress was interrupted, both by obstacles and by their interference with each other. One advanced to a foot-path, where for a season or two it was interrupted; but a segment at length made its appearance on the opposite side of the path, where it gradually advanced, but as a segment of a smaller circle than the portion which remained on the other side. In another instance two met; and at first they seemed to have bent each other inwards to a chord, where they came in contact. This chord soon parted, however; and the result was a figure composed of the greater part of two circles. Each of the points of junction appeared, however, to march with more celerity than the rest of the circumferences; so that in time it became a sort of oval; and by the time that we ceased to have the opportunity of observing it, it had become nearly circular. Some advanced upon marshy spots, and others toward the rocky pavements or the shingly beaches. The situation was near the sea, and when they came to the shore the part was obliterated, and the circle gradually became an arch. There were other interruptions, such as the meeting of three; but we never observed one formed within the circumference of another, or two coming in contact, without the obliteration of both when they met.

Electricity, and various other means, have been resorted to on purpose to explain these rings. Electricity is, however, a very suspicious means of explaining any phenomenon, except such as we actually see produced by lightning; and though in all probability some casualty happening to the grass gave origin to these rings, there is no doubt that they were continued by the fungi, afterwards to be noticed. Every cause by which the grass was burnt up did not, however, produce them; for upon the same ground there were often burnt-up patches, which produced no fungi, and led to the formation of no fairy rings. What was the difference of cause in the burning up of the spots was not ascertained, and is probably not ascertainable; but whenever the fungi came upon a burnt-up spot at the same time as upon the rings, then those spots were sure to be ultimately converted into rings. In this part of the matter there is certainly something which we are unable to understand, and of course to explain; for though the burning up of the grass and the appearance of the fungus are both connected with the fairy ring, yet neither the one nor the other appears to be in any way the cause of its first formation. One of the fungi that make their appearance on the rings is the common field, or esculent mushroom, *Agaricus campestris;* but so far from a ring being the consequence of that mushroom wherever it appears, there is not one ring for many thousands of mushrooms. We cannot, therefore, in any way, look upon the mushroom as the primary cause of the ring, but rather must consider the burnt-up spot, from which the ring begins, as the disposing cause to the appearance of the mushroom.

Of this there is a very obvious confirmation in the well-known fact, that fungi grow much more readily in places where vegetables have been burned by ordinary fires than they do upon ground of the same description, where no combustion has taken place. This is the case, not only with those fungi which rise (in their blossoms) above the surface, but also in those that remain below ground in all their stages, as the Morel, for instance. This fungus is a favourite in most countries, and it is particularly so in Germany, where the peasants collect it in great quantities, as a regular and profitable article of trade. Observation taught them that morels were to be found more abundantly in places where there had been fires, and that they could be found there at times when there were none any where else: therefore they were in the habit of burning the weeds in patches, as a means of cultivating morels. But the fires which they kindled often extended so as to be most mischievous and dangerous;

and they were in consequence prohibited under severe penalties. This fact, which is established by practical experience, without the slightest reference to any theory, not only confirms the truth of the origin of the fairy ring being an affection of the herbage antecedent to the appearance of the fungi, but it throws considerable light on the general function of these plants, and may be borne in mind till we come to the summary statement of that function.

And here, before we return to the particular consideration of the rings, it may be both useful and gratifying to remark how beautifully one part of the system of nature sheds light upon other parts, when we pursue the inquiry without the bias of any theory, and with due allusion to the general relations. We have already remarked that the fungi are specially constituted for yielding an immediate and perfect obedience to circumstances, by the universal distribution and the indestructible nature of their germs, as well as by the great rapidity with which these germs are developed, whenever they are necessary, or, which is the same in fact, when circumstances are favourable to their development. Their adaptation to their purpose, of which the general view is clear, notwithstanding the obscurity of the details, is one of the most striking instances of perfection of design which we meet with in the whole range of material nature. The absolute number is not known, as the fungi of many parts of the world have hardly been noticed, and the knowledge of them is imperfect every where; but we are within the limits when we say that the species consists of many thousands, and the average of germs to a species of many hundred millions. Here, then, is an army outnumbering millions of times without number all the armies that man ever brought into the field, always ready at a moment, and every member instinct with powers for the full and perfect discharge of its duty. The design shown in the adaptation of any organ to its office, or of any animal or plant to its place in nature, is beautiful; but they are small in comparison with this gigantic adaptation. And, mighty as the muster is, the wonder stops not here; for the whole of this Autumnal host act in accordance with the beams of the sun, and the motion of the earth in its orbit. In this we find one of the links of that golden chain,—that chain made without hands, and inscrutable by every created power save mind, by which the heavens and the earth are, without material connexion, bound together in perfect and perpetual harmony. But the subject addresses itself as powerfully to our gratitude as it does to our admiration. It is wonderful that such adaptations should be; and it is delightful that we—"children of the dust," and "crushed before the moth," as we are in the mere body, and the temporal life and possessions, and all their pomp and pretence—are mentally so endowed by an all-bountiful God, as that we can understand and appreciate these things, and that this, the most refined and exalted of all our pleasures, should remain with us unimpaired and unshaken by all the vicissitudes of life, to which, as beings of finite perception and capacity, we are of necessity subjected. Nor does it stop here; for the feeling of immortality is strong in the thought; and as no power in nature is given in vain, "three score and ten years" in a world of contingency—certainly not "a world of woe" to the wise, let life or fortune change as they may—cannot "trammel up the consequences" of these glorious glimpses of the attributes of Him who is from eternity to eternity. He, who has so ordained that the mushroom, "which springeth up in a night," and the sun of the morning beats upon it, and it is gone, never appears but to perform its appointed work, has not, contrary to the law of every other portion of his works, made man in vain—given him a spirit meet for immortality, without the immortality along with it. It is not—it cannot be: the whole of creation stands witness to the contrary.

But we must return to the consideration of the fairy rings; and they who have not felt how forcibly the proper contemplation of any one portion of nature leads to the relations of all nature, and the connexion of nature with nature's God, may perhaps wonder why "the green sour ringlets of which the ewe not bites," should lead us to the revolution of the earth in its orbit, and the more mighty zone of the mind's eternal duration. Yet there is one little consideration which may be satisfactory to them in this matter, and instructive in other respects. In the ages of ignorance the formation of those rings was attributed to supernatural agency. Now, however erroneous this may have been, and however absurd, in the judgment of reason, the fancied agent in this, or in any other case, may appear, there is a witnessing for the truth involved in it; and wherever ignorance calls in the aid of supernatural influence, philosophy, guided by the light of revelation, will find the impress of divinity peculiarly strong. And such must be the case; for the mythology, whatever it is, is really the effect of the benighted mind groping for that God which it feels but cannot see, for want of the only light whereby the true God can be revealed.

Whenever a mushroom crop appears upon the burnt-up spot,—and they are, generally speaking, *agaricacæ*, or fungi of the mushroom family, of some species or other, and mostly esculent, or at all events harmless ones, as they grow upon dry and kindly places,—they disappear with the Autumnal rains, and their disappearance is followed by a more rank and vigorous vegetation than there is on the surrounding surface. This continues till March, or till later in the season, according to the nature of the place, and the character of the year; and while it continues in the full vigour of its greenness, it is avoided by cattle, and especially by sheep, and stands a luxuriant spot in the middle of a closely-nibbled surface. But the fact of this rankness of vegetation having been preceded by a crop of fungi, has really no more to do with the ewe's abstaining from biting than the fairies have; for any one may observe, that all rank spots, from whatever cause they may be produced, are avoided in the same manner. Nor is it difficult to ascertain why the cattle and sheep should prefer the herbage around to these rank spots; for one has only to taste the grass on the two.

That upon the spot merits the character of "sour;" for there is an acerbity about it, while the finer and more fertile grass on the rest of the surface, ripened as it is by the summer action, has a saccharine taste, and contains much more nutritious matter than that which is rank in growth. This, by the way, runs very generally throughout nature; for we find that the insects do not begin their attacks until there is a partial stop, or, at all events, weakening of the vegetation; and at whatever stage of the annual progress of the plant these attacks are made, they are always made on the youngest part, because that is the most susceptible, and consequently the most liable to temporary checks from partial changes of the weather. The conduct of the aphides, on what plant soever they appear, is a proof of this.

In the following summer, the spot upon which the rank grass appeared after the mushrooms, diminishes in its vigour, though it remains for some time of a darker green than the rest of the surface; and as long as it does so the sheep prefer the less vigorous part of the pasture. But in the course of the warm and dry weather it subsides into the same tint as the rest.

But before this takes place, there is a change of appearance in the margin around the spot. Earlier or later, according to the degree of warmth and drought, the grass upon a ring round the spot becomes pale and sickly, and in the extreme heat it withers away, and leaves the surface as if it had been scorched. In the later period of the drought, this sterile circle is the only visible part; and after the midsummer rains it becomes covered with fungi, which often form a complete ring, varying, as we said of the rings in general, from half a foot to a foot in breadth. The Autumnal rains put an end to the fungi; and after this the grass again appears in the Autumn, the winter, or the spring, according to circumstances. The ring thus begun, shows a rank and dark green vegetation in the early part of the season, the same as was shown by the spot; and as the season advances, tbis ring is surrounded by one of parched surface; that is, succeeded by fungi, and the fungi, again, in proper time, by rank and dark green vegetation. The same succession is repeated year after year, and the ring enlarges, until it meets with interruption in one or other of the ways that have been stated.

That this is the progress of the ring, we have observed in very many instances; and we believe that there is no established case of a ring, or arch of a ring, having been formed on the first instance. They all proceed from centres; and if any portion of the circumference shall become obliterated, it is in consequence of unfavourable ground being reached.

The absolute duration and the specific use in nature of these rings, are as much involved in obscurity as their original cause. In those which we watched during the period before alluded to, there were differences of appearance in years of different character; but we do not feel warranted in saying that there was any indication of increased vigour or of decline in their action. From the curvature of fragments in some places a diameter of 500 or 600 yards may be inferred, which at an increase of sixteen inches on the radius in the course of each year, would indicate a duration of, about, from 500 to 700 years; but the data are too vague for allowing this to be positively asserted. Those which we observed as entire circles were of much smaller dimensions, but no note had been taken of the date of their origin or of their progressive history.

The use is even more obscure. That they do answer some purpose in the economy of nature must be taken for granted, for if they did not answer a purpose they would not have a place. This may be held as a general truth in every part of nature; but whether we shall or shall not have any knowledge of the use, and whether the use that we conjecture in these abstruse cases is or is not the right one, are very different matters. If we were to give an opinion upon the matter, we should be inclined to say that the surface over which the ring has passed, is rather more vigorous in its vegetation, and more kindly and free from the admixture of mosses, than that over which no ring has made its progress. This, however, is a mere opinion, and not a truth which rests upon any thing like evidence.

The progressive extension of the ring admits of far more satisfactory information. When the fungi have once occupied the surface, they have performed the whole of their work in the season, so that the surface upon which they have grown does not require their growth, and thus is unfit for calling them into action. But the ground external of the ring, as long as it remains of a certain character, of the nature of which we have no knowledge further than that it must neither be too arid nor too humid, still requires them, and of course it is fit for their reception. These facts are proved by the annual increase of the ring in diameter. The fungi of course shed their spores or germs in the same abundance toward every side of the place where they grow, and of course the same number of them fall inwards as outwards. Indeed we may suppose that the numbers which fall are equal and distributed to equal distances upon every inch of the place where the fungus grows. But they do not grow within the ring; and thus we must conclude that the ground there has, in consequence of having produced one crop of fungi, become unfit for the production of another. What the change is we have no means of ascertaining; but there is no way of accounting for the fact of the increase of the ring, but by supposing that the same ground cannot produce a crop of the same fungus in two consecutive years. How long it may retain this incapacity is a point which we cannot decide; because one year would explain the fact of the fungi never retreating inwards, or that of both rings becoming obliterated where two meet: and as the progress outwards is only from half a foot to a foot in the course of each season, we cannot suppose that the dispersion of the germs in any direction is to a greater distance.

But, whatever the distance may be, it is obvious that there must be something favourable to the growth of the fungi in the state of the ground outside, and something unfavourable to it in that inside,—inasmuch as the progress is always the one way and never the other; though in what the difference may consist, is a point which we cannot, in the present state of our knowledge, determine. After the ring is once begun, there appears to be something in the spores of the fungi which conduces to the burning up of the next ring, though what it is we cannot tell, as the very same fungi, when they grow in their ordinary detached manner, do not occasion any burning up of the grass in the drought of the ensuing season. On the other hand, the work which the fungi perform must tend to make the ground more fit for the growth, not of a new vegetation, but of the very same plants, the grasses at least, that were there before the ring passed over it; but what specific action is performed there are no means of ascertaining. Where we have examined them, the grasses and the flowering plants generally, seemed to be the same within the fairy ring as without; and though we are inclined to think so, we cannot positively state that there was any diminution of the small mosses and the ground lichens within the ring. The general conclusion, though it is not one of the most satisfactory nature, is that there is much of the philosophy of the fungi to be learned from these fairy rings, but that we must have much more information than we at present possess, before we can turn that philosophy to use.

The three hypotheses of the action of under-ground larvæ, the mixing of the droppings of horses with the soil, and electricity, which have been mentioned as the primary causes of fairy rings, are all equally unsatisfactory. We have seen the grass destroyed by larvæ over very considerable surfaces, without the least appearance of fungi; we have seen fairy rings in places where there could not possibly be any droppings of a horse, while we never saw a ring originate from any substance of the kind. Fungi no doubt make their appearance there if the substance is in a humid place or after rain; but they are of a much more evanescent nature than those which appear on fairy rings. Then, as for the electricity, it is so well suited for being appealed to by those who find it necessary to say something, and yet do not know what to say, that it always calls to our recollection the case of a very virtuous but very ignorant old woman who was the keeper of a dame school. One of her duties, and indeed the chief one, was the most praiseworthy task, or pleasure rather, of teaching the children of the peasants to read the Bible; and as far as ordinary words, and a very pious and by no means unappropriate commentary, considering the nature of her audience, were concerned, Marion was not unqualified; but the proper names were sad posers to her. By some means, however, she had learned the sound of the word *Naphthalim*, which she used for every proper name that came in her way; and the repetition of this word in some of the genealogical chapters, as for instance, "Naphthalim" ninety times over in the first thirty-four lines of the tenth chapter of Nehemiah, had a most monotonous effect, though it was as solemnly received by the whole school, and probably was just as useful to children of tender age, as if Marion, instead of rendering the second verse "Naphthalim, Naphthalim, Naphthalim," had pronounced it, "Seraiah, Azariah, Jeremiah." Marion's well-meant blunder (for it was well meant,) lay in the desire of reading the Bible "all through," without any regard to her own capacity or that of her scholars. It is much the same with those philosophers—and others, who will needs read the book of nature "all through;" and Electricity has often been, and in some instances is still, a most convenient "Naphthalim." In the case of those who are utterly ignorant, such a subterfuge may perhaps do just as well as that of Marion did with the infants, and it may even afford some little amusement to those who are better skilled in the matter. But, at a time like the present, when knowledge is what is most appropriately styled "diffused," that is, spread over a great breadth of the public with most lamentable disproportion in depth, the mischief done by the dissemination of a false or inadequate cause for any one phenomenon is incalculable; and both the original propounder of such an error, and the wretched compiler who lumps books together, for the sheer lucre of his hireling fee, and haply under the sanction of some literary appellation profanely bought for money, who aids in circulating cheaply the falsehood which cost him nothing—save the peculation,—deserve to be held up to the most reproving obloquy of the friends of true knowledge and of man; and he who has the opportunity of doing this and neglects it, from indolence, from false delicacy, or from any other motive, is no friend of either in deed, whatever he may be in desire.

Whenever the cause cannot be assigned upon principles which are clear in themselves, and consistent with all the great laws of science as established by well-grounded experience, the candid plan is to confess the truth at once, and point out in the most careful manner, and with direct reference to all the established truths that bear upon it, where the difficulty lies; because this misleads nobody, and it shows where the subject should be taken up by future inquirers. The case of the fairy rings is a good illustration of this, and the fact of its being so is one of the reasons why we have dwelt upon it to a considerable length. We know from direct observation, that when the fungi make their appearance upon a burnt-up surface, the result is a fairy ring, which extends in future years, and the limit of whose extension we do not know. It is also obvious, that, in this particular mode of their action, the fungi do not depart from that Autumnal character which is so peculiar to them, inasmuch as they do not spring up until after the death of the other vegetation. It is clear therefore that there is something to be decomposed which requires their action; but it is not easy to say whether that something is more immediately in the refuse of the plants which have been burnt up, or in the soil or surface, independently of that refuse, to which latter the action of the sun and air is admitted by the burning up of the herbage, so as to prepare it for the action of the fungi. We mentioned the case of morels growing abundantly after fires in the German forests; and any one who has been in the habit of observing in this country, must have often seen that after a shower has fallen upon a spot where vegetables have been consumed, as for instance upon that where a gipsy fire has been, that there was a growth of fungi upon the margins. The same happens in the case of the droppings of animals, and of many substances prone to ferment and putrefy; but in no one of these instances is there the least tendency to the formation of a fairy ring. The fungi, whether of a more short-lived or a more permanent description, vanish when they have run their course, and no succession of them has any tendency to spread over the neighbouring surface in future years as happens in the case of the fairy ring.

This lets us see where the difficulty of the subject lies. We can observe the burning up of the herbage, the succession of the fungi, their disappearance, the increased verdure for a season, and sometimes longer, of the space which they occupied, and that these follow each other as the ring extends; but of the original cause of the decay of grass on the central spot, or of that on the successive rings, we are entirely ignorant. We cannot suppose that the fungi are primary agents in the matter, and that their incipient growth causes the grass to wither; because that would be contrary to their very nature, and lead us completely astray upon a subject whereon information of a more perfect and connected kind than any which we at present possess, is highly desirable, as well for the practice of the cultivator as for the inquirer after natural truth.

We have been thus minute in the mention of these rings, because there is much to be learned from the study of them, and because they are found in places the visiting of which is highly conducive not only to the mere health of the body, but to the tuning of it to that ready obedience to the impulses of the mind, which makes observation something higher and more worthy of a rational and immortal being, than the mere sensual exercise of the bodily organs, how pleasant soever that exercise may be for the moment. They are never found upon humid meadows, in the shade of woods, or upon rank and shaded places of any kind. The grassy down, and the open common, when not too high and bleak, and especially where stretching onward to the sea, are the situations in which these phenomena are to be looked for; and perhaps there are no spots on the surface of the earth, the visiting of which is better calculated to give health to the body and expand the mind in those trains of thought, the progress whereof is toward immortality.

In the remarks which we have made, and which are necessarily of a desultory cast, both from the nature and from the novelty of the subject, we have endeavoured to show that, as the appropriate armies of Autumn, the fungi appear to disorganize those organic substances which have ceased to be useful, and which do not yield to the common action of the elements, or are not disintegrated by small animals. In doing this we have endeavoured to point out the limit of their functions, namely, that they never make their appearance or assail any organized body, or portion of such body, so long as it is in the healthy exercise of its own proper life, however appearances might lead partial and careless observers, or those who do not take the general principle along with them, to come to an opposite conclusion. In this view of them, which we are fully convinced is the right one, we find that the use and action of those plants are illustrations of their nature. They are passive, never invading the rest of the world as a host, but abiding their time and yielding the most implicit obedience to circumstances. Even those which come upon plants early in the season, and destroy that produce which a healthy plant would yield, form no exception to the general nature and functions of this Autumnal army.

That which we are to consider as being Autumnal action in the decomposition of organized beings or their parts, and especially of plants, which are the principal subjects of our present inquiry, or expatiation (if any one think the former word too assuming), is not confined to time of the year, or to period of the life of the vegetable. It is true that in countries which are strictly seasonal, and in the case of plants which have run what we may call their full course in a state of uninterrupted health, we look for the fungus only in the Autumn; and where the annual course has been perfectly regular, the fungus does not appear to be essentially necessary. In fact it seems to be a general law of nature that there shall be some deranged state, some departure from the ordinary course, in order to render the fungus necessary. The condition in which it makes its attack is that which, in ordinary language, is not inappropriately termed "dead and alive,"—that is, no longer fit for living action, and yet not ripened for what may be called the maturity which passes naturally into death. We shall have occasion to revert to this in a subsequent chapter, when we come to speak in some little detail of blights and dry-rots; but it is necessary to keep the principle in mind, in every inquiry respecting the action of Autumn.

If there were no contingency, that is, no departure from perfect uniformity, in the weather, day after day, and in the seasons, year after year, then the labours of the fungi might be wholly dispensed with, and the rest of nature might go on without their interference. But the daily and yearly variations are necessary parts of the action of so extended and complicated a system; and it is in them that the compensations are to be found which secure the preservation of the whole. To unreflecting minds this may seem an imperfection; but it is in reality the very highest perfection that can be imagined, and one of the strongest proofs that the system of nature is the production of infinite wisdom.

If it were not for this balance, this means by which every state involves in itself the power of producing its opposite, just in the same manner as the recession of a planet from the sun toward its aphelion involves the return again to the sun in perihelion, and this return involves the recession. Thus, all the parts of the system, while they work each apparently for itself, work mutually for each other; and though many of the parts are above the reach of our knowledge, we can feel and admire the beauty and the harmonious working of the whole.

In the vegetable kingdom especially, the fungi are the only agents which perform what we can properly call an Autumnal labour in the decomposition of the organic structure of other vegetables; and, at whatever time, or in whatever manner they may perform their offices, we have no reason to believe that they ever come into activity, until they are called to do so by incipient death on the plants, or parts of plants, upon which they make their appearance. There are, however, some plants belonging to another department of the vegetable kingdom, which, like the fungi, are cellular in their structure, and, in the common meaning of the word, flowerless, which are apt to be confounded with the fungi, both in nature and in function; and thus it may be as well to point out in what the distinction consists.

The plants which are most liable to be confounded with the fungi, are a few of the mosses which grow upon the surface of plants, and especially the *lichens*, which are more frequently found in the same situations. Of the mosses we shall have occasion to speak at some length in our volume on WINTER; and therefore we need not mention them farther at present than to say that the decomposition of other vegetables, living, dying, or dead, is no part of their office in nature.

The same may be said of the lichens, which are plants of a very climatal nature, though they have no specific seasonal office, or, at all events, not an Autumnal one. The word *lichen*, literally means that which has a rough surface, something resembling the *papillæ* with which the tongue is covered; and when the plants are large enough for displaying it, they certainly have this character. They belong to a larger division of the vegetable kingdom, which have been called *Algæ*, or *Algares*, and popularly *flags*, though in common language, the term "flag" is not applied to the whole of them, neither do they include all plants to which the name of flags has been given.

These *Algæ* are more general in their habitats than any other of the grand divisions of the vegetable kingdom; but although this causes a great deal of variety in their external appearances, they still have some very important characters in common, and it is impossible to have an accurate understanding of the rest of the vegetable kingdom, or indeed of the working of nature, especially its seasonal working, without some knowledge of them, if it were only for the purpose of drawing lines of distinction.

The *Algæ* occupy three very distinct localities, and their organization and habits are of course adapted to these. The first are the *Fuci*, or sea-weeds, which are distributed over the ocean in every part of the world. They follow the general law of land vegetation, in being most numerous and most luxuriant in the tropical latitudes. As is the case with that element which they inhabit, the fuci have not much of a seasonal character, and in our latitudes they belong to the winter vegetation more than to any other, and consequently do not come within the scope of the present volume.

The second division chiefly inhabit the fresh waters, or have the principal times of their appearance or growth when the earth or the air are humid. They are known under the general name of *Confervæ*, because the greater number of them are formed in jointed pieces; but some of them (to which we shall have occasion to advert, in order to prevent them from being confounded with the fungi, with which they have no function in common,) are among the most simple of all vegetables, and can hardly be said to be organized, though they are living productions, and the principle of life in them seems to be remarkably tenacious. They are very decidedly seasonal plants; and they are most abundant in those countries in which the seasons are most marked. In the sunny lands of the equatorial latitudes, though in respect of animal life and of vegetable life in some others of the grand divisions of the kingdom, "the waters bring forth abundantly," yet the confervæ are less plentiful in them than in the high latitudes. The rivers and tanks of India, and of tropical climates generally, are much more free from this sort of vegetation than the pools and streams of Lapland. In our own country, the waters of the cold uplands abound much more in confervæ than the rivers of the warm valleys and the plains; and the tracing of a river from the sources of its feeders on the most elevated places, to the first locality of sea-weed in its estuary, affords a tolerable view of the climatal distribution of those confervæ which inhabit the running waters. In the rills which distil immediately from the snow, they are not very abundant; neither are they in the dark waters which find their way from the more elevated peat-bogs; but in those places where the seasonal springs "well out," and the seasonal pools settle, they are very luxuriant. While the water remains, they are green and vigorous; but when the drought comes and the water is evaporated, they become white, dry, and matted into a substance resembling coarse pasteboard, broken into patches, which cover the whole extent upon which the water has been stagnant. When the wet again sets in, they become green, and put out a new vegetation, which is repeated, in situations favourable to them, until the beds of the waters are, to a very considerable extent, filled up.

Some of the plants of this section or order of the *Algæ*, may be regarded as standing on the extreme verge of vegetation, in respect both of the simplicity of their structure, and of the circumstances under which they vegetate—such vegetating as it may be called. The *Nostocs*, so called because, after vanishing we know not whither, they *return* we know not whence or how, are the most remarkable in both respects. They make their appearance when the atmosphere, or the place, or both are humid; and in the drought they disappear to our observation, though we cannot say that they are entirely gone. They come upon all sorts of surfaces,—upon rocks, upon the leaves of plants, upon the waters, and even upon the snow, with which they are mingled in its fall; and such as are so probably grow, or, at all events, have their rudiments floating in the air. These last are called "red snow," "showers of blood," or "gory dew," according as they are accompanied by a frozen shower, a shower which is unfrozen, or unaccompanied by any shower in either state. In the case of the snow, there is little doubt that they fall along with it; but in the absence of frost it is probable that the humidity merely excites them on the surface. On damp and shaded spots, some of the family are pretty permanent, and hence, in the ages of superstition, they were regarded as blood which had been foully shed, crying from the earth for vengeance against the perpetrators of deeds of cruelty; and the supposed showers stained with blood, especially those of snow and hail, were regarded as omens of the most fearful character. Some of the species grow in the interior of gloomy caves in wild and lonely places, and others on the damp walls of the dungeons of old castles, or in the crypts of ruined abbeys; and though they are very simple things, being nothing more than vegetable jelly with the mere rudiments of organization in it, they have led to the formation and the belief of most direful stories.

Such as have no sanguineous hue, have got names of quite another kind, being called "flowers of heaven," "fallen stars," "quenched *ignes fatui*," and various other things, with no one of which they have the least connexion. These names have been given to such as appear upon the ground or upon plants; and those that appear upon the waters are frequently called "scums." Of both there are probably some that descend in their rudimental state along with the showers, as it is in moist places and during showery weather that they make their appearance. Some of them occasionally mantle the pools with a complete covering, which however is of a very evanescent nature, and is brushed away by the wing of the first dry wind.

Many of them are Autumnal in their seasonal appearance, but they come at the beginning; and the fact of their being observed at the times when *ignes fatui*, shooting stars, and other luminous matters are most frequently seen, no doubt led to the erroneous opinion that they are the remains of such meteors after their light has burned out.

Simple as these plants are, we can nevertheless trace a shadowy sort of resemblance between them and the more complex, or, as we call them, the "higher orders" of vegetables. It may, at first sight, seem a little arrogant, on our part, to make distinctions of higher and lower, where all is perfect, and where the *proto-coccus* in the polar snow-shower is just as well adapted to its purpose as the most stately tree in the equatorial forest. But such is not the fact, our comparison being merely that of the different degrees of vegetable action, and in this respect we find not only the difference specified, but a very strong proof of our most rational theory of vegetable life, namely, that in proportion as vegetable action is less vigorous, it is less easily destroyed. The simple plants of which we are speaking have little distinction of parts, and those parts are very minute; but they can grow safely on the snow, and ride secure upon the snow-cloud, even in those latitudes where it falls in an almost impalpable powder.

Plants of this order may be said to consist of only two parts, a *thallus*, and threads and vesicles. Thallus literally means that from or in which there is sprouting, and, in the general sense, any green or growing expansion whatsoever; but we apply it to that part of the simpler plants, which answers to root and stem, or root, stem, and leaf, compounded in a single organ.

In like manner, when there is a part growing upon a thallus or root, and combining the characters of stem and leaf, we call it a *frond*, as in a fern or a sea-weed; when these two parts are distinct, we come to the leaf *(phyllum)*; and when we have the final state in the vegetable development, we have a flower-leaf *(petalum)* which means an expansion as well as the others, but does not necessarily involve the idea of greenness.

Thus the thallus in those very simple vegetables is the "plant;" and the filaments or vesicles, or both, are the parts of fructification, or those which answer to the flowers of those plants which are of more complicated structure. The *spores*, or *sporidia*, are the seeds (that which is sown) which are in some instances enclosed in a *sporidium*, and in others naked in or upon the thallus. A thallus is thus the very simplest plant of which we can have any notion; and, as the seeds of all plants are more simple structures than the plants themselves, the sporidæ of such plants are the very simplest forms in which vegetable life exists, and for this reason they are the least destructible—the least subject to decomposition. Some of these plants appear in various fluids—as for instance in fermented liquors; and it is probable that the most minute animalculi are supplied with vegetable food by others so minute that our most powerful magnifiers cannot detect them. This however is the extreme limit of both kingdoms of the vegetable world, and thus it is not the proper field for popular speculation. Some species which admit of being examined, and which consist of vesicles which part and form separate plants, appear to have such limited power of vegetable action, that they are not able wholly to resist the common laws of the matter of which they are composed; and accordingly their vesicles are, in part, filled with crystals.

But though, in these cases, we have an action of dead matter and an action of living matter, or rather a law of dead matter and one of living matter, embodied within the same volume, and that a very small one, we must be careful not to confound them, or to imagine that the one can, in any way, be converted into the other, so as that crystallization can change to vegetable life, or vegetable life to crystallization. The magnitude of the subject is not an element of the distinction, neither is the proximity of the dead state and the living. It has, we believe, been ascertained by careful and satisfactory experiments, that if an atom of carbon and an atom of water are intimately combined, the compound is a jelly soluble in water, and possessing the chemical properties of the general material of which, making allowance for their particular products, the tissues of vegetables are composed. But that does not make it a vegetable or part of a vegetable, any more than the grinding of flour or the baking of a loaf of bread makes that loaf of bread part of the body of a man. We know that the matter of the loaf goes to the nourishing of the body; and we can follow it as food to a certain extent in the system, and find it as an animal fluid in another; but there is a mystery between, which we cannot understand, nor can we say positively at what stage of the process the food becomes part of the living body. The case of the minute confervæ is not easier than this one; and thus though we do know that a certain compound of charcoal, or carbon, and water, may form a jelly similar to that of vegetables, we are not acquainted with any chemical process by which the said jelly can be made a vegetable. All that we have arrived at is, that the materials of nature are fit for the purposes of nature, a truth which stands in need of no philosophic investigation. Here therefore in the very simplest case to which we can have recourse, we find nature as faithful a witness for its author, as in the most complicated of all possible cases. So far as they are at all understandable, all the cases are indeed equally simple ; and the only difference is in the number of steps in the investigation, which is merely a question of time and labour, and not one of understanding, one way or another. The difficulty is the same in them all ; and other than a distinct creation of every species, it admits of no variation. Introduce this, and the whole of nature is simple, beautiful, and perfect ; reject this, and it becomes any thing that any body chooses to fancy,—and all are in the wrong.

We have been drawn on to such a length with this order of the algæ, that we can spare no room for treating of the lichens. Another occasion will occur, however, and our present object is not to treat positively of this class of plants, but to show that they ought not to be included among the armies of Autumn ; but that though some of them have slight external resemblances, their natures are different, and their functions diametrically opposite.

The whole class of the algæ, whether their habitat be the sea, the fresh waters, or the air, are less seasonal than any other class in the vegetable kingdom ; and in so far as they are seasonal they are a winter vegetation rather than any thing else. They are not scavengers in any sense of the word. They are producers, not destroyers ; and they have the merit of working in places and under circumstances where other workers there are none.

Some, as we have remarked, float on the waters, and others ride on the winds and the clouds; but the greater part have fixed localities, rocks and stones in the sea, the banks and beds of the fresh waters, the surfaces of rocks, the bark of trees, the summits of mountains, places where there is no food even for a moss, are among the situations to which the algæ give the benefit of their labours.

But upon what surface or substance soever, any one plant of the class may have its locality, it draws no part of its nourishment from that substance; and the lichens which cover the pole of an aged tree, are no more nourished by the substance of that tree than the lichens which cover the face of a rock are fed upon the substance of that rock. It is true that they do not come upon the smooth bark of young and vigorously growing trees in such numbers, or so readily as they do upon trees of feeble growth or upon dry wood; but it is the greater security of the resting-place which favours them, and in all cases their function is not directly to turn that upon which they grow into soil, but to collect soil upon it. That they have an indirect tendency to stunt the growth of those trees on which they are abundant, and in some instances to decompose the rocks on which they grow, is true; but the injury to the tree is occasioned by the exclusion of the air, and also by the soaking of the water and the cold produced by evaporation. To rocks and stones they afford protection from the influence of the air, and this in part explains the meaning of the common saying, that "a rolling stone gathers no moss," for it is worn away both by the friction of the motion, and by the influence of the atmosphere. Mountain rocks are no doubt, generally speaking, of firmer texture than those in lower and more sheltered situations; but they have much more severe vicissitudes of the weather to encounter, which in great part corresponds to their firmer texture; and thus they owe much of their safety to the lichens.

A direct proof of this may be seen in any old tower which has long stood the weather, unexposed to smoke, which is unfavourable to the growth of lichens. The stone of which the tower is built may be all from the same quarry, but still it will be found that, while the parts near the foundation are rarely time-worn, especially toward the south-west, the marks of the chisel are fresh upon those near the top, more especially on the north-east side, where the lichens are always most abundant. It is the same with the *fuci* and the *confervæ;* for the rocks and channels that are covered with them, are not nearly so much worn as those that are bare.

The mosses have a different form and function from the algæ; but, like them, they are no direct destroyers or preyers upon the substance of other plants. Thus they do not form part of the Autumnal host, but belong to the winter vegetation in their general character and the greater part of their numbers. Their presence is no doubt unfavourable to the growth of many plants, and the soil which they form is of a peculiar character; but they are accumulators of soil; and the antiseptic or preserving power of those accumulations is clearly established by the perfect state in which both animal and vegetable remains are found after having been buried in peat-bogs for hundreds of years. We must, however, refer to our volume on WINTER for some notice of the office of those vegetable conservatives in the grand system of nature. Linnæus, whose fancies often embody far more knowledge than other people's facts, called the algæ, *Vernaculi*, or home-born slaves, and the mosses or Musci, *Servi*, or drudges; and both names are well descriptive of their leading habits; for the algæ do not wander far, that is, their sporæ are not conveyed to any very great distance; and the mosses, if supplied with sufficient humidity, drudge on in their growth all the year round.

The *Fungi*—the appropriate troops of Autumn, in the performance of its field-labours—have been already stated to be the very reverse of all this. They wander every where, according as their presence and labours are required; the greater number are of very brief duration; and though some of them spread very fast, and continue for a considerable time in their successions, there is not one that has a second season of growth in the individual plant. For this reason Linnæus bestowed upon them the name of *Nomades*, or wanderers.

CHAPTER V.

SHORT NOTICES OF SOME PLANTS APPARENTLY AUTUMNAL—THE BYSSINÆ.

We have already described the fungi as the appropriate armies of the Autumn, in the conquest over that part of nature, and more especially of vegetable nature, which has performed the whole of the function for which it was called into existence, and thus is of no more use in the organic world, until it shall have been reduced to the condition of merely elementary matter. This they do by decomposition, and not by mere disintegration—by chemical solution of the substance, and not by merely tearing it asunder; and they either convert it into their own very perishable substances, or they so destroy its organic structure, that it becomes an incoherent powder when dry, and a plastic dough when wet. At whatever time of the year, or stage of the growth of a plant or part of a plant, this is performed, it is always an Autumnal action, and the work of an Autumnal agent; and it is in the following out of this into its details, that we obtain a proper view of the characteristic labour of Autumn in preparing materials for a new action of life. That either the fungus itself, or the vegetable or other matter which it disintegrates, is instantly fit for being the food of any one species of plant, we do not mean to assert. The food of plants is a very obscure matter; and he would be a very bold theorist who ventured to say that any one substance which can be examined separately, is the food of any one species of plant. Considered in their relation to the rest of the vegetable kingdom, the fungi are not, in any sense of the word, the nurses of the new vegetation, they are merely the destroyers of the old; and before the new comes into operation, they have ceased to exist. Their business in nature is to deliver up to the store of inorganic matter, and to the dominion of the laws by which that matter is governed, the substance of what has previously organized, but which the action of those laws is of itself insufficient to reduce in the requisite time without the assistance of the fungi.

This is the final and appropriate action of these plants, though we cannot fix the stage at which it begins, nor take up the history of the decomposed matter the moment that the fungus has done with it, or trace it to any new structure into which it may enter. We have stated it as a matter of probability, and as being in perfect analogy with the whole system of nature, that the appearance of the fungus should be always preceded by a diseased state of that upon which it appears. Indeed, if vigorous health in a plant is not sufficient to protect it from the ravages of the fungi, it would be very difficult to assign any reason why the fungi have not, ere now, extirpated every other race of plants from the face of the earth. At the other end of the succession we are met by another and a more insurmountable difficulty; for, as plants have no visible or probable means of assimilating food, as animals have, we cannot see how that which is prepared by the fungus can be in substance applied directly to any other plant.

Hence we must use no small degree of care upon this subject; and, in looking at the cause of the appearance of fungi, either generally with the season, or more locally at any season, we are upon the only tenable ground when we suppose that the state of the plant, or part of a plant, or other substance upon which a fungus appears, is the disposing cause which calls the germ of that fungus into activity. It is obvious that this disposing cause may vary. It may be what we call natural decay, or the plant's being no longer able to contend against the common laws of matter; and we know that when this is the case, there are many instances in which the action of those laws is quite competent to the effecting of the decomposition, without the assistance of any fungus. It may also be a change in the physical circumstances of the situation which renders them too much for the faculty of resistance in the plant, of which we have many instances, whether they be or be not accompanied, or rather followed by fungi, by insects, or by any other destroyers. It may also result from the action of other plants of a parasitical nature, which, in an indirect and secondary manner, weaken the action of that upon which they grow, or even mechanically divide its substance. These are the chief classes of the means by which a plant may be reduced to such a state that fungi may grow upon it; but each of them evidently admits of variation in so many ways, that it would be impossible within our limits to enter into the details.

What we said generally of those lichens which grow on the bark of trees, having a secondary tendency to produce a diseased action in those trees, will, of course, apply here; and so well does it apply to some families of the lichens, that they have not unfrequently been classed among the fungi, some of which they *appear* to resemble both in their external characters, and their apparent uses in nature. When we scrutinize them closely, the difference in their natures and functions become plain enough; but as they are not completely so to popular observation, we shall briefly notice some of the leading ones. Those to which we principally allude are the *Byssinæ*, or *Bysso-lichens*, so called, because they are, in the more characteristic species, composed of fine fibres like those of flax, cotton, or wool. Some of them perform operations which tend to prepare plants for the attacks of the fungi, though only by attracting damp, or by mechanical division.

Some of these plants are very curious, and a few are scarcely less brief in their duration than the fungi, and like those they have their germs very generally distributed, and so very minute, that there are few places from which they are excluded. But they appear in situations where no fungi do or can appear, and they agree with the lichens in deriving their nourishment from the medium in which they grow, and not from the substances upon which they are found. Many of them occur on the leaves of plants, and in or under the bark of trees; but they also occur where there is no animal or vegetable matter to be decomposed,—as on the walls of mines, in ink, and in various other situations, where no one would expect to meet with a single specimen of the fungi. They are also rather permanent in their duration if the circumstances continue favourable to them; and as they do not appear in any way to consume the quantity of matter of that upon which they are situated, their disappearance, when they do disappear, is measured by a change in the state of the atmosphere or other medium in which they exist. As they are dependent on the state of the atmosphere, they must be in so far seasonal; but they are more generally found in close and damp places where there is little atmospheric change in the course of the year. In such places they are perennial plants, having little seasonal change; and thus they cannot be admitted among the army of the Autumn, properly so called. They are fibrous in their texture.

They form a sort of series, from a resemblance to the *Verrucarinæ*, or wart lichens; but we cannot say that the termination of the series (in so far as the termination of so obscure a series can be said to be observed,) makes any nearer, or, indeed, so near, an approximation to the character and office of the fungi, as those at the other end of the series which have the most resemblance to the last of the more typical lichens. They lead us out of the vegetable kingdom, or at all events to the extreme limit of vegetation, and leave us not a little in doubt what sort of productions we have to deal with. We find them at greater depths under the surface of the earth than any other vegetables; and they are also understood, in some of the final races, to vegetate in the air. Both of these are understood to emit light under peculiar circumstances; and it may be possible that some of the luminous meteors which are seen in the air, are in some way or other occasioned by these filmy vegetables. In all of them, indeed, we find so close a connexion with the state of the atmosphere, as to leave little doubt that they are dependent upon that element.

There are two distinct forms, or types, of them; and many varieties of each. The first get the name of *Rhizomorphaceæ*, or root-formed—"root-moss"—in some of the more common species. They are small plants, which creep along in thread-like thalli, with short lateral branches, sometimes single and sometimes double; and these are the fruit, or receptacles of the spores or germs. They are an obscurely inhabiting race; and although, as we have said, they derive their nourishment wholly, or chiefly, from the air, they share the free atmosphere and the beams of the sun. They are found under the dead bark of trees, especially pine-trees, in dark cellars, among sawdust, and on the interior surfaces of mines; and the darker the place is, their growth appears to be the more vigorous. Those which are found upon trees, appear to have their chief office in stripping of the bark, which they do with much rapidity; but they merely loosen it from the wood without decomposing the substance of either. Their labour, however, admits the damp of the air and the rain to the wood, by which means the albuminous or external layers begin to decay, and then the fungi make their appearance and perform the work of decomposition, generally attacking the barkless stem, at the air-line, or the place between the earth and the atmosphere, and so felling it as certainly, though not so speedily, as the axe of the woodman.

Many of the plants are what is called phosphorescent, that is, they give out light, though whether the light which they give out has or has not any connexion with the substance called phosphorus, is a point which has not been ascertained. Those which grow in mines have this property in the highest degree; but it is not confined to them, for it is also found upon those which grow under the bark of decaying firs and other trees. In lonely situations, in some parts of the country, they sometimes occasion no small alarm to those who go under cloud of night, to pilfer sticks in woods, especially fir woods of small and stunted growth, where the trees are in progress of decay. When they break down the decaying stems, the bark separates, and gleams of a pale bluish, and to them very alarming light, are given out. Also when they tread off the loosened bark with their feet, or detach it with their hands, they find that the same suspicious lights attach to themselves, and many of the rustics living in the neighbourhood of such woods, are scared from committing depredations on the same, by those luminous appearances, which they not unnaturally suppose to be of supernatural origin. We are no friends to superstition in any form that it may possibly assume: but we have the experience of direct observation to convince us that the superstitious terrors of the rustics in some of the remote and simple provinces of the country, operate to no inconsiderable extent in restraining them from the commission of many of the minor, and even of the major crimes of the night, against which the equally or probably more grossly ignorant populace of other places, have no defence save the fear of human punishment. That we may not be misunderstood, we repeat again that we are no friends to superstition, in any form, or to any degree that it may exist; but really, from what we have witnessed and carefully examined in the witnessing, of the totally uneducated, where those superstitions existed, and where they did not, we feel not only inclined but compelled to come to the conclusion, that a very heavy and indeed criminal responsibility lies upon those who go about to destroy the superstitions of ignorant persons, without substituting something better in their stead.

This is a point of no small importance, and as it is contrary to the dogmas of the modern improvers of mankind by human legislation and other human means alone, it may not be amiss to devote a single paragraph to the farther consideration of it, the more especially that it involves no weak argument, for both the truth and the necessity of a light from Heaven to lead and guide men in the true path of their duty as rational and social beings, to say nothing of their higher hope of their being heirs of immortality.

If any one doubts the truth of this, let him test his suspicions by the evidence of unprejudiced experience; and if he himself is not more deeply imbued with prejudice than the parties to whom we allude we feel perfectly convinced that the very first ray of the light of this observation will clear away his suspicion, and establish him in the truth.

Compare the state of rude nations, as they are described in the writings of their most able and impartial observers, or those who, in our own country in the present day, are in a state of ignorance in different places and under different circumstances, and you will invariably find that those who are the least free from superstition are invariably the lowest, both in the intellectual scale, and in the moral. In what we are in the habit of calling the savage nations, there are always some glimmerings of civilisation and some displays of the social affections among those who have a system of superstitions; and the more elaborate and complicated that system may be, how absurd soever it may appear to those who have the light of inspiration to illuminate their paths, the intellectual and the moral and social condition of the people are not only the higher, but the people themselves are more easily brought to the perception of the truth, and to obedience to it as a system, than those who have no mental system of superstition or mythology, and thus are entirely under the guidance of their merely animal appetites and passions.

We are disposed to include, and indeed we must include, in the category of the ignorant, or if you will of the savage, all nations which have been, and which are, without the knowledge of the divine revelation, and also all members of other nations, who, though they may have the verbal knowledge of this revclation, are without the spiritual feeling, the living principle which regulates the conduct. We are, we say, not only disposed but necessitated to number all such with the ignorant, whatever their acquirements may be in other respects, because they are without that which alone can give due development and proper effect to the immortal spirit in man. In this state of ignorance, there have been the highest attainments in the arts, and there have been bold and valuable steps taken in science; but it is a remarkable fact that, even in the science of matter, there has been no arriving at any thing like a general principle, until the light which guided the investigator was a light from Heaven: and there is perhaps not a more forcible evidence of the value of christian truth, as declared by the Saviour himself through the medium of his Evangelists and Apostles, than the fact that the great doctrines of philosophy were reserved until the dawn or the day-spring of the Reformation, when the pure doctrines of the word of God were substituted for the dogmas of mere men, who laboured to make the semblance of Christianity a fetter for all the nobler energies of the human mind, instead of that glorious liberty—that freedom from mental slavery and mental fear, which it is in deed and in truth. The moral lesson to be drawn from ignorant human beings which have superstition, as contrasted with those which have none, is a very important one. It shows clearly that there is in them an emanation of the spirit,—an uplifting of the immaterial and intellectual principle, which cannot be satisfied with mere matter, or the philosophy of matter, even in its utmost extent and its highest perfection. If there were no proof of divinity but this it might well satisfy any candid mind, and that a strong argument has not been grounded upon it may seem a matter of especial wonder. Whatever name may be given to the system, or whatever may be the imaginary beings of the mythology—demi-gods, genii, fairies, or whatever else, they all stand witnesses for immortality, and for an inheritance and enjoyment to man, beyond the gratification of the senses and the fleeting endurance of the body. They are the natural longings of the spirit for immortality—the breathings of the natural mind for the enjoyment of its God; and as there can be no sophistication in them, they furnish irresistible evidence that if the mind of man is in the least awakened, and he is any thing more than the mere animal, a feeling of the Godhead and of eternal things presents itself to his mind, whether he is or is not in possession of that knowledge which can guide it to the true and profitable result. Thus the unbeliever stands reproved by that which he affects to despise; and he who has the knowledge of the true faith, has that faith strengthened by the involuntary testimony of those who are still ignorant of the nature of its revealment, and the foundation upon which it rests. There is scarcely one superstition which might not be brought in proof of the doctrine which has now been stated, and proofs of this kind have an especial value that does not belong to any others; but although this is a subject of much importance, and withal very delightful, we must leave it, and return to our more humble but more appropriate subject of the *Byssinæ*.

Some of these plants which grow in mines are very luminous, and have a very brilliant appearance. The coal-mines at Dresden in Saxony are not the least celebrated in this respect. Mr. Erdman, the commissioner in superintendence of these mines, speaks of them in the following terms: "I saw the luminous plants here in wonderful beauty; the impression produced by the spectacle I shall never forget. It appeared, on descending into the mine, as if we were entering an enchanted castle. The abundance of these plants was so great, that the roof and the walls and the pillars were entirely covered with them, and the beautiful light they cast almost dazzled the eye. The light they give out is like faint moonshine, so that two persons near each other could readily distinguish their bodies. The lights appeared to be most considerable when the temperature of the mines was comparatively high."

The luminous property of the plants of this family has not hitherto been explained upon any of the known principles of phosphorescence, but it is by no means improbable that some of the meteoric lights which are displayed in the atmosphere may be occasioned by some of the smaller members of the family floating in the air; and that thus, though the jelly-like plants formerly alluded to are certainly not shooting stars of which the light has been quenched, yet those meteors may be owing to vegetable substances. This however is an extensive, as well as an intricate subject, and it is one upon which, for obvious reasons, we cannot enter.

There is a regular gradation of these Byssinæ from the Rhizomorphæ, which have the spores contained within an envelope more or less perfect, to those which are exceedingly simple, and which in some of the genera proceed chiefly by offsets, or have the spores so minute that they hardly come within the range of observation. In such of these as approach the more typical Byssеæ, the spores when visible are external, and some of the plants are of very singular forms. Among these we may mention the *Racodidæ*, or rag-moss leathers, so called from their having an appearance somewhat intermediate between worn tatters of leather and shreds of cloth. They are obscure-growing plants, abounding in cellars and other places from which the light is excluded, and which have but little circulation of air. Some of them are very common in cellars where wine is kept, where they creep over the casks and bottles, and also along the roofs and walls, with wonderful rapidity, and often present very singular appearances. What connexion there is between those curious plants and the juice of the grape has not been ascertained; but it has been observed that, in cellars which have been long used for the storing of wine, the plants abound in the places where the wine is kept, whether in cask or in bottle, and even in those places enjoying a better light, where the process of bottling is carried on, but they rarely appear where the empty bottles are stored up, though the situation is, to all appearance, just as favourable for their growth as the others.

The plants which make their appearance, as "moulds," as they are usually called, upon the exposed surfaces of liquors or the vessels containing them, and also upon decaying fruits, and various other substances, belong to this family; and they do not make their appearance until that upon which they appear has obtained a certain age, or has at all events undergone a certain degree of decomposition. Some of them are very beautiful in their structure, but so minute in the individual plant that they cannot be examined without the help of glasses. These very minute and simple plants appear upon an almost endless variety of substances; and some of the substances upon which they appear are of such a nature as to show that the plants cannot derive any part of their nourishment from them. They appear on the surface of ink, and of other solutions containing metallic substances which are unfavourable or absolutely poisonous to ordinary vegetation.

One of the most familiar, and therefore the best adapted for studying the habits of the race, and becoming acquainted with their office and use in the economy of nature, is the mould on cheese—*aspergillus glaucus*. This appears only in a particular state of the cheese, but not when that substance is in a state of putrefaction, neither does it appear in any way to hasten the decomposition. Fraudulent dealers often attempt to produce an imitation of it, by sticking into the cheese brass pins, which are soon in part converted into verdigris, and so produce an approximation to the colour of the aspergillus or mould. The fraud is, however, easily detected, even by the colour, which inclines to green, whereas that of the mould has a greyish hue; and the offensive coppery taste of the verdigris is not to be mistaken. Another means of procuring—not the coloured imitation but the mould itself—tends to show the connexion which this little plant has with the rest of the family, and in so far to point out the physiology of the whole family. The cheese is perforated, and a portion of wine, brandy, or some other fermented or distilled liquor, introduced; and this seldom fails in bringing the mould much sooner than it would naturally appear; and yet no plant of the family makes its appearance in the mass of either wine or spirits, notwithstanding that they are so prone to come upon the vessels in which these are contained.

This single fact, and it may be seen in the case of very many of the Byssinæ, is quite sufficient to let us see their place, and understand their functions in nature, so as that we may separate them from the fungi, as the proper agents of Autumn in the work of vegetable decomposition, and associate them with the lichens to which they more properly belong. They appear upon substances which are in a state of decomposition, or decay, by evaporation or some other means; but still they come not as destroyers, but as conservators. That they actually tend to preserve the solid or the fluid upon which they appear, in the state in which it is at the time of their appearance, we do not mean to assert; but they do not drain its juices, or decompose it. They follow the habit of the lichens, properly so called, and extract their subsistence from the air by their general surface, in a way which, however, it is much more easy to imagine in thought than to explain in words. Their appearance and growth are favoured by damp; and while they languish or disappear in a dry atmosphere, they revive again on the application of moisture.

The facts of their appearance in wine cellars, and not in similarly situated places in which there is no fermented liquor to give out a portion of its substance by evaporation,—of their appearing on decaying fruits, on the surface of paste, when it begins to ferment and decompose, and in the cracks and crevices of cheese, into which a fermented or a distilled liquor has been introduced,—throw some light upon their economy and their office, though many circumstances connected with them are yet of so obscure a nature that we must speak of them with great caution. It seems that they have their *situs* upon organized substances only, and that though they do not act directly in the disintegration and decomposition of those substances, yet that they, as it were, wait upon the progress of other decompositions, and avail themselves of the gases or vapours resulting from them as soon as they are set free. In their own substance they are more or less decomposable, some of them melting into a liquid with a mere touch, and others being of a fibrous, tough, and comparatively durable nature; but whatever may be their own texture, they all appear to have one common office to perform—namely, that of fixing the volatile parts of other organized bodies, so that they may go to the common mass of materials out of which the vegetables, and through them the animals, are supported.

The office which they perform is thus intermediate between the office of the lichens, properly so called, and that of the fungi. The lichens are the primaries in point of succession; they come in situations where there is no vegetable, and not even a vegetable mould; and they elaborate such a mould out of the inorganic aliments, by acting upon the atmosphere and the moisture that is contained in it; and in many situations they continue their labours until they have produced a soil in which plants of higher development will grow, giving place to these as soon as they make their appearance. But if by any means—and the means are often far beyond the range of our understanding—the plants of higher development give way, the lichens again make their appearance; and as long as they have the necessary supply of moisture, they contend with the powers of desolation. It is this, rather than the time of their growth, which leads us to consider them as a winter vegetation, they being anterior in the succession to what we may call the flowering plants, while the fungi always come after, or after organized substances of some kind, and in some way or other contribute directly to the decomposition of these.

The *Byssinæ* have neither the primary character of the lichens, in bringing a vegetation upon places where none previously existed, neither do they perform the decomposition of organic substances by their own growth, as is done by the fungi. We never find them making their first appearance upon the bare rock, or upon any other surface when it is absolutely dry. They always require a certain degree of moisture in the atmosphere, though none of them are decidedly aquatic in their habit.

In respect of the times and manner of their appearance, they agree more with the fungi than they do with the lichens; and many of them resemble the fungi in the frailty of their structure, and the fleeting period of their duration; though in all these respects they vary greatly, according to the different offices they have to perform. The specific nature of these offices is but little understood; though it is chiefly through them that we can arrive at any knowledge of plants which are so exceedingly simple in their structure, and which differ so much in tbeir modes of growth from the plants which are most open and most attractive to general observation. Their history is so confused, that those well skilled in the vegetable kingdom have referred hem to different classes, and generally to the fungi, until very recent times that the functions of plants have begun to be investigated along with their external distinctions, their nomenclature, and their real or supposed medicinal or other artificial uses, to which the labours of the earlier botanists were in a great measure confined. This step is a most important one in the progress of vegetable science; but it is one the taking of which is attended with many difficulties, and much liability to error; because the very knowledge of which we are in quest must, in many cases, be the chief means of its own discovery.

That which has been just now stated may seem a paradox to those who are conversant with learning at second hand only, and who have no idea of any lesson being acquired or acquirable, or even in existence, unless it has been prepared and modelled by some human teacher, after the same routine fashion as the common technical lessons of the schools. But if such parties will but pause, and think for a little how mankind took, or still take, the first start from ignorance, and also how any addition, great or small, is made to the general stock of knowledge, they will be constrained to admit that the subject of that knowledge is the only instrument which the mind could or can use in the acquirement of it. It is for this reason that observation, especially of the productions and phenomena of nature, is so exceedingly valuable, and that the progress of mankind in every useful art, and every means of rational and social enjoyment, has been so rapid since observation became so general. The grand superiority of this prosecution of study, this devotion of the powers of the mind to that investigation of nature in which they have been so successful as to prove to a demonstration that for this purpose they were given by our bountiful Creator, consists in this,—that the philosophic pursuer of any one line of investigation marches across the range of his subject, shedding light upon, and for the benefit of all around him; so that, in the proper investigation of any of the more general departments, some light is struck out, which is available to the student of every science, and the practiser of every useful or ornamental art. The individual by whom all this is done, may be quite regardless, and even unaware, of the great and general advantages which are resulting from his labours. Indeed, the more successful that he is in this way, he has the less chance of being aware of it. The stimulus of his own subject captivates his mind, and he has no desire but to ascend from discovery to discovery, and takes no note that every new footfall of his in the path of truth scatters the seeds of knowledge and improvement wide over the nations.

This is the noblest and most exalted occupation in which a human being can be engaged, and it has this delightful and peculiar distinction from every other human pursuit—that it works altogether for good, and for good to all, without the slightest mixture or possibility of evil. We have no room to go into the details of the evidence, but the record of history is open to every reader; and if the general condition and progress of the whole people, under the influence of sound philosophy, and genuine Christianity—and as systems these are inseparable — in modern times, is contrasted with that in the brightest periods of ancient science, or under a system nominally Christian, but without reason and without philosophy, such as that which existed in the middle ages, he will find the truth which we have stated to be altogether irresistible.

In consequence of the great services which these general investigators of natural phenomena and their laws render to the whole of society, and also in consequence of the many difficulties and uncertainties with which their labours are beset, the errors into which they fall deserve to be treated more lightly than the errors of ordinary men; and, indeed, to be treated in a manner entirely different. It is in the misstatement or misrepresentation of facts that the mischievous errors lie,—in detached matters, as it were, which are open to men of all capacities,—while the reasonings, founded upon those facts, in which alone philosophical errors can be committed, are themselves open to the judgment of every one who comes to the consideration of them duly prepared. The single fact is a matter of time, not involving in itself any reasoning, but depending entirely upon testimony of some kind or other; and thus, if it is of such a nature that it cannot be repeated, if an error is made in it, that error is perpetuated beyond the power of correction. But a theory or hypothesis, of whatever kind it may be, is always open to revisal and correction. From the very nature of the case, too, no theory or hypothesis, however probable it may be, can be regarded as established, farther than the facts bear it out; and as we never know how many facts remain to be discovered upon any one branch of science, especially of natural science, we are never certain that future discovery may not overturn that which appears at the time to be based on the most probable foundation.

Thus we can never regard any one general theory in the philosophy of nature as any other than a convenient instrument in the farther study of the department of nature to which it applies, always liable to be modified according as new truths may arise. But this justification of rational theories, which are necessarily to undergo successive changes, is no reason why overstrained and visionary hypotheses should be indulged in by persons whose knowledge is limited,—and yet they are more prone than others to indulge in such hypotheses.

It appeared necessary, or at least expedient, to make these few general remarks, preparatory to offering a guess—for after all it can hardly deserve a higher name—at the probable use of the Byssinæ in the general system of nature, and the distinction between this use and that of the fungi, regarding the latter as the appropriate armies of Autumn. The Byssinæ do not, as we have said, appear directly to attack the substance of any organized body, and to decompose it; but from the places where, and the circumstances under which they make their appearance, it should seem that they lay hold of the gaseous and evaporizable elements of substances the instant that these are disengaged by the operation of certain other decomposing causes. Thus they tend to prevent dissipations of matter which would otherwise take place, when that matter is in a state in which the scattering of it to the winds cannot be prevented by the action of any other bodies.

This is, at least in so far as observation has been hitherto made, the leading function of these plants; and though it is rather an obscure one, it is by no means unimportant. Much has to be learned, however, before we can speak of it with any thing like certainty; and this is the reason why we have thrown it out as a mere hint, and not even as an hypothesis. If it were possible carefully to collect all the states of substances upon which, and of the atmosphere when, these plants make their appearance, we should be at least in a fair way of arriving at some foundation upon which to ground a theory of their functions.

We know that fermentation in vegetable substances is one of the states of bodies which calls these plants into activity; that a humid atmosphere is much more favourable to them than a dry one; and that, though many of them are luminous in themselves, the action of light, which is so necessary for most other tribes of vegetables, is rather unfavourable to their growth than otherwise. We also know that a temperature rather warm is agreeable to them, though they can ill bear any great extreme either of heat or of cold. When we have stated these few particulars we have nearly exhausted the whole of our general information concerning them, and thus it amounts to comparatively little.

It does not even enable us to assign them a decided seasonal period; but, according to the most rational conjecture that we can form, they are Autumnal rather than any thing else, though, as we have said, they do not directly form any part of the Autumnal decomposition. Taking them in their whole extent and variety, they cannot be said to be very much under the control of any season, because such as are found in subterranean places enjoy but little of the varying action depending on the heat of the sun or the length of the day. Speaking of the time of the year in as far as they can be thus spoken of, we would be inclined to say that the period of the Autumn, the alternate drought and wet, when the decomposition of organic substances is going on most rapidly, by fermentation, or other action of the substances themselves, is the chief time at which they display themselves abroad in wild nature; and that they lay hold of the products of these decompositions, and, by retaining them, prevent them from being dissipated, until a change of the weather ensues, and they render up the matter which they have preserved to the general store of materials; but the way in which they do this, and the particular changes which they effect upon any kind of matter, are points upon which we have not any certain information; in fact, we are obliged to speak of the greater number of them by negatives—by saying what they are not rather than what they are. This, however, is a step in knowledge, though a very elementary one; because when we can take any subject apart and consider it in itself, we are much more directly in the road to the knowledge of it than when it is blended and confounded with other subjects.

The consideration of these humble and apparently insignificant plants may, by some, be regarded as possessing little interest. This, however, is not only a mistake, but a very unphilosophical and a very injurious one. If we would understand the revolutions of the year, or any other portion of the successions in the system of nature aright, we must be especially careful to examine well the dark places of it. It is in them that the difficulties always lie; and if we do not at least grapple with those difficulties—if we cannot overcome them—it is in vain that we dazzle ourselves with the more conspicuous and brilliant portions.

In studying the year this is especially necessary. Taking the average for a considerable period at any one place, one year is so like another in all its principal appearances, that the labours of doing and undoing must bear, upon the whole, though not in the individual instances, a pretty constant and equal ratio. The spring presents us with nearly the same buds, the summer with nearly the same flowers, and the Autumn with nearly the same fruits, year after year. It is the same in other departments of wild nature. The same birds come and go, migrate within the country, or remain stationary in the same place, one year with another; and a common observer can see but little difference in their numbers, except such as are easily explainable by the particular character of the year. It is the same with the different races of small life, the greater part of which we know to perish in the winter months in countries where that season is severe. There are no doubt gradual changes which take place in long periods of time, and by which the state of things is at least greatly altered; but these belong to the progressive history of our globe in the centuries of its duration, and not to any thing which comes within the brief span of an individual human life.

Now, seeing that the productions of the earth, in all the ordinary departments of nature, and where they are not affected by human culture, are the same year after year, within moderate periods of time, it must follow that year after year they are composed of exactly similar substances. In seasonal countries, with annual productions, and indeed with all productions according to their periods, the annual produce is immense, and the materials furnished in a state fit for the action of those powers by which the several productions are elaborated must be correspondingly great. Thus the bringing of the materials of organic nature back to the state of passive or elemental substance, is as wonderful in itself, and as strong an evidence of Almighty power, as the beauty and activity of the same matter while it is obedient to the principles of life. In some respects it is more instructive; because when we arrive at the mere matter, we approach those laws of action that guide us in many of our arts, more especially such as depend upon chemical principles; and we have far more control over these than we have over animals and vegetables, obedient as both of these are to the hand of skilful management. Thus, until the years of its duration shall be numbered, the annual decomposition of the leaf, the stem, and the other seasonal produce of the year, is only one of the modes of that beautiful revolution, which brings every thing in its season, and distributes the bounty of the Creator equally over all the vicissitudes of the most varying year.

CHAPTER VI.

NOTES ON SOME OF THE MORE INTERESTING FUNGI.

Having endeavoured to draw the organic and functional distinction between the fungi properly so called, and those plants which approach the nearest to them in some of their characters, and apparently in their uses, though in reality in their situations only, we shall endeavour to complete our outline of this very curious and important, but very difficult branch of the subject, by a few short notes on the fungi as a class of plants, and on some of those individual members of the class which, either for the good or the harm which they do, are more peculiarly interesting to the public generally. The smaller fungi, many of which attack other vegetables in the early stages of their growth, are known popularly by the names of blights, blasts, and mildews; and those of larger growth are known as mushrooms, or more popularly as toadstools—paddockstools, that is frogstools, in the northern parts of Britain. In former times, when the belief in fairies, or pyxies, as they were called, was general in the country, the mushrooms, especially the short-lived ones, which spring up during the night, and melt away before the sun has gained its meridian altitude, were called "pyxicstools," and they are the "midnight mushrooms" alluded to in the quotation which we made from Shakspeare in a former chapter.

There is something very curious in the origins and uses which the fanciful people who are without true knowledge, and therefore prone to superstition, ascribe to different natural productions. In the Highlands of Scotland, for instance, all majestic things, such as basaltic dykes, columns, caverns, vast masses of rock, apparently detached from their original situations, and the remains of forts and other structures, the construction of which is anterior to the period of recorded history, are ascribed to *An Fion*, or the Giants—which, however, may also be translated "the winds,"—so that the real assertion is that these things are of unknown and uncertain knowledge. Small matters again, and things of inapparent origin and brief existence, such as the toadstools which the first rains of Autumn call forth upon the green-sward, are ascribed to the *Bhodachian*, or fairies. This term is just as puzzling and uncertain in its meaning as the former one; and all that we can say of it is, that it expresses a minute power as contrasted with the majestic one by which the more magnificent and durable structures are fabled to have been reared. The word "Bhodachian" literally means "the little folks;" and it is somewhat remarkable that the remains of the ancient Caledonians still left in the Scottish Highlands, who now generally merit the appellation of little folks themselves, should apply it to the Romans and the Picts; and there is no doubt that the name Pyxies, given to the fabled fairies, is derived from that of the latter people. There is even a colour in history, for a superiority of personal dimensions on the part of the ancient Caledonii, sufficient to warrant them in contrasting themselves as Fion, with the Romans as Bhodachian. The historian of Agicola says of them that they were men of great stature, and correspondingly powerful in the onset of battle—*Magna corpora et tantum ad impetum valida.* This is a curious coincidence between the statement of the Roman historian, which we have no reason to question, and the application of the popular names still retained in the Highlands; and there is no doubt that if it were followed up with due research, it would lead to some curious results; but though some reader may probably think it worthy of investigation, it is not a matter which bears upon the main scope and subject of the present work. One curious part of the matter is, that after the fungi were removed from under the dominion of the "little folks," by what name soever they were called, they should have been transferred to that of the reptiles; and that the toad in the one end of the island, and the frog in the other, should now usurp the mushrooms as thrones.

For popular purposes, the fungi may be very conveniently divided into three groups, under the common names of Blights, Puff-balls, and Mushrooms. The members of each of these vary greatly from each other; but still there is a distinctive character to each of the groups, and all the members of the same group have something in common, both in their appearance, and in the circumstances in which they appear. The blights are chiefly found upon the leaves and other annual productions of plants; and though their office is unquestionably an Autumnal one, not a few of them make their appearance, and perform their labours before the Autumnal season, according to the calendar. The causes of this appearance are exceedingly obscure; but there seems little doubt that, in whatever stage of the growth of the plant they appear, they are always consequent to what may be regarded as an Autumnal state of the plant, that is, as a suspension of its energy, of which the fungus takes advantage in consequence of the general law of its nature, namely, that of such a stagnation or suspension of the action of life in the plant, as places it, in whole or in part, in the category of that matter which is disorganized and reduced to the simple or elementary state by the proper operation of the Autumn. These are, generally speaking, very minute plants, but remarkably prolific, affording some of the most extraordinary instances of the vast number of distinct individual lives which can be accumulated in an exceedingly small space. Some of the most able and credible investigators of this obscure department of nature have ascertained that a square inch of surface will contain more than two millions and a half of full-grown plants of some of the species, and seven millions eight hundred and forty thousand of some others, while each plant, even in the case of the latter, contains a progeny of more than ten millions of spores; putting these together, and allowing for the two thousand eight hundred layers of the plants, which it would require to fill up a cubic or solid inch, we have a number at which even the imagination itself is bewildered, and which, though nobody can exactly comprehend what it means, it may not be amiss to express both in numerical characters and in words, in order to show the reader what mighty power the Almighty can concentrate within a very trifling space. It will be recollected, that the space of which we are speaking is only a cubic inch, or about the extent of the first joint of the fore-finger of an ordinary person, in length, breadth, and thickness, and yet the number of distinct germs of vegetation in it, when stated in figures, is 219,520,000,000,000,000; and named in words, it is two hundred and nineteen thousand five hundred and twenty trillions, a number not only greater than that of all the human beings, but of all the warm-blooded animals that have ever lived upon the earth, since the moment of its creation; and all this, as we have said, within the small space of a single cubic inch.

We cannot say that the spore of the fungus in this case is a simple elementary atom of matter; for, though we cannot speak positively about substances which are so exceedingly minute, the analogy of all those parts of nature which we can examine with any thing like accuracy, leads us to conclude that every germ charged with the preservation of a life, whether animal or vegetable, is a compound body, because the action of life, in every instance in which we can observe or understand it, is the result of a union of parts. Nor is it the result of a union of atoms merely, but of a union of masses, both of which are probably, and indeed necessarily, compounds, inasmuch as we cannot suppose the individual atom, beyond which there is no division of matter, to be possessed of any sensible property.

Thus the germs of these minute fungi lead us far more deeply into the principles of things than their exceedingly small magnitude would lead us to believe. Even in them we are unable to reach the final boundary at which matter exists—simple, original, general, and without having the properties of any one nameable substance, living or dead, organic or unorganized; but in them we make one of the nearest approaches to this wonderful boundary which can be made; and a very little exercise of imagination carries us to the boundary itself, and brings before the mind, matter in so simple and elementary a state, that it is under the influence of no law save the law of universal gravitation, which is inseparable from the very idea of matter; and as the power of this law upon it is always in proportion to its quantity, its influence upon the atom has necessarily the same incomprehensible verging upon nothing as the atom itself. In consequence of this reduction of the power of gravitation over the primary atoms of matter to a mere infinitesimal, we can at once see that matter in this state is ready to yield a perfect obedience to any power under whose influence it may be brought, if the strength of that power is any thing more than what to us is infinitely small.

Viewing it in this light, we obtain some faint notion of one of the most extraordinary displays of Almighty wisdom and power which is presented in the entire system of creation; and though it is purely a mental view, and one in which sense can add nothing to the thought, it is not upon that account the less instructive or the less delightful. When our senses are taken captive by subjects which make strong and startling impressions upon them, we probably yield a more ready obedience to the conviction of a present God in all the works of nature; but when the subject is such that sense is entirely excluded, having no subject whereupon to work, the mental perception is loosened from the chariot wheels of time, and we are immortal in the feeling of our Maker.

When matter is traced upwards to this perfectly elemental state, it may, to use a homely phrase, be said to be fit for any thing, and may become a portion of the body of any one animal, vegetable, or mineral, without the slightest means or power of resistance upon its part. Thus the powers by which things are organized, crystallized, aggregated, or otherwise conjoined into masses to which we give names, as specific in their nature, have only an infinitesimal existence to overcome in their first beginnings; and as we have demonstrations around us every day that weight and measure are no elements of power, we must conclude that in those perfectly elemental cases, the power of life, or whatever power it may be which acts upon matter, is to our understanding infinite over the atom. This, if we can arrive at it, is the grand evidence of divinity in the system,—an evidence which no sophistry of the sceptic can overturn; and the man who can once raise his contemplation to this pitch, may, and must, turn round and pity the ignorance of those who deny the Creator so luminously set forth, and grope in the dark for an unreal and imaginary origin of the system of things.

And we find this view of the primary working of nature fully borne out by the whole system. In the course of this volume, or of the other volumes of our series on the Seasons, we have had occasion again and again to refer to the fact, that the more complicated in structure, and the larger in size any one production of nature is, the life, whether animal or vegetable, with which that portion is endowed, is always the less safe from contingency—the more liable to be diseased or destroyed. This fact may be observed by any one who chooses to exercise ever so little of the faculty of observation; and this is exactly the stage of our disquisitions upon natural subjects at which we can most easily see and understand the reason. In the case of the atom, the power of life, growth, or whatever else it may be, is to our understanding infinite; and this infinitude (to our comprehension,) is necessarily a maximum, or quantity which cannot be exceeded or even equalled under any other circumstances. Hence, as matter is increased upon the life or the other action to which that matter is subjected, the abstract power of the life over matter is diminished in the same ratio.

It is impossible for us to tell the number of primary atoms which are in any one portion of matter; and probably those in the very smallest—as, for instance, in the spores of the fungi under consideration, which spread through the atmosphere in viewless vapour—

may be more numerous than we could understand, or even number by means of our arithmetic; but it is certain from the evidence, as well as clear from the analogy, that in proportion as the quantity of matter is increased in any one single living or growing being, the frailty or destructibility of that life is increased in the same ratio.

In consequence of this, the smallness of the spores of those fungi which we are considering renders them proof against most of the contingencies to which larger vegetable substances are subjected, and to some of which at least the fungi themselves are liable after they are developed. What degree of change in temperature, either upwards or downwards, they are able to endure, we cannot know; but it is not unlikely that they can withstand every degree both of heat and of cold, to which they are or can be exposed, in the ordinary circumstances of any climate upon the earth. Their durability in time, depending on the same property of their extreme minuteness, is necessarily as great as that of their resistance to contingencies; and though we cannot say positively for how many years, or how many centuries, the spore of one of these small fungi will retain its vegetative power, yet we cannot say that it is positively shorter than any period which we can name, other than the unnumbered one of the duration of the globe.

But it agrees with the analogy that these spores should be as independent in space and situation as they are against contingency and time; and the facts show us that such is really the case. There is not a single substance, animal or vegetable, upon which one or another of these small plants does nót make its appearance, when that substance is brought into a state of autumnal decay, either in Autumn, according to the calendar, or in any other season of the year, and from what cause, soever that state may be brought about. With the exception of the greater number of the fungi whose offices are similar to their own, and of many of the algæ, especially the lichens or terrestrial ones, whose office is diametrically opposite to that of the fungi, there is hardly one organic substance, animal or vegetable, upon which some of those small fungi does not make its appearance to facilitate that decomposition and decay which appear, however, to be begun by other and very different means. Therefore the fungi cannot be regarded as the instruments of death, but merely as the agents of decomposition, after death, or a deadly state, in the whole plant or in part of it, has been induced by other means. From the spores or germs being so exceedingly small,—so perfectly viewless by eye or by instrument,—it should seem that they can circulate in every fluid of the living subject, whether animal or vegetable, and also ride upon the wings of every wind which animal or plant can inhale as the breath of life. This extreme subtlety of penetration, together with their minuteness, render these the most extraordinary works in the material creation; and it is especially worthy of our most profound consideration, that in proportion as the weight and incumbrance of mere matter is thrown off, the impress of the Godhead is even the more conspicuous. This subject strongly encourages our contemplation a little farther than the extremest boundary of matter, and beckons us onward to the purely intellectual state of existence in which the free spirit shall hold communion with its God, and enjoy the knowledge of his work and workings untrammeled alike by space and by time. This is a subject upon which the embodied mind can dwell long, and upon which we hope the free spirit will dwell for ever, after the mortal has put on immortality; but we must leave it, earnestly recommending it to the contemplation of the reader, and proceed to our more humble but still very instructive subject.

The simplest division of the fungi, or those which consist simply of detached sporidia, unconnected with any thallus, and thus being, according to the common mode of our speaking of vegetables, really nothing but flowers or fruit, according to their age, are those to which the name of *Mucedinales* is given, from their forming what we in general call moulds upon the surfaces of organized bodies. In their appearance, and even in the substances on which they appear, and also in the fleetness of their duration as individual plants, and the number and indestructibility of these spores, they bear a considerable resemblance to some of the byssinæ, and this is the reason why the two have sometimes been confounded with each other. The line of distinction between them, obliterated as it often is to common observation, is always perfectly clear in a physiological point of view. The byssus, which belongs to the algæ, makes merely a resting-place of the substance on which it grows, and though it most generally appears upon organic substances, and such substances when in a state of positive or incipient decay, it is not absolutely necessary that it should so appear, because its dependence upon the substance is not for nourishment, but simply for locality and support. These byssæ are called moulds indiscriminately with the fungi, and the external resemblance is so great that they are sometimes apt to be confounded with each other. But the byssus never directly causes putrefaction or decomposition of the substance on which it grows, and it never has any deleterious property itself, neither does it indicate any such property on the substance on which it appears. Its tendency indeed is rather in the opposite direction, and mould without corruption is generally understood to add to the sanative quality of that on which it appears.

With the fungus-moulds it is very different. They always corrupt that on which they appear, and they are generally, if not invariably, attended with poisonous qualities either in themselves or in the substance upon which they act. There is another distinction; all the fungi approximate to animal matter in their composition, whereas the algæ, even those which most resemble the smaller mouldy fungi, are purely vegetable, and composed of carbon, oxygen, and hydrogen, without any admixture of nitrogen, which latter substance is contained as abundantly in some of the fungi as it is in substances which are decidedly animal in their nature. Hence, when the byssi are in a state of decomposition they never give out any very offensive odour, and never produce any injurious effect upon the animal system; while with the fungi, even those which have the greatest resemblance to these harmless vegetables, the case is very different. For instance, mouldy cheese produced by the byssus, is not only harmless but stomachic, and it is free from any offensive smell; whereas if the same cheese become so far putrid as to produce a fungus, how much soever that fungus may resemble the byssus, it has a poisonous quality, either in the fungus itself, or in the putrefying substance upon which the fungus grows. This is the broad distinction between the fungi and those other plants which they most nearly resemble in appearance,—the fungus is always in some way or other a minister of death, and communicates deadly qualities, either in itself or in that upon which it grows and tends to putrefy; while the byssus has no tendency of this kind one way or another. It would far exceed our limits to go into the details of all the members of this very numerous family; but there are some of them so interesting, from the mischief which they do in rural economy, however useful they may be in wild nature, that we cannot pass them over without notice. They are known by various names, such as those of brands—or burnings, blasts, blights, mildews, and moulds; and one or other of them has engaged the attention of mankind ever since they began to cultivate the ground. In the earlier ages of human history, and indeed after civilization had in many respects made considerable advances, men found it impossible to account for the origin of these small but formidable destroyers, upon any principle of the philosophy with which they were then acquainted, and therefore they referred them, as they did all other matters which were beyond their comprehension, to supernatural agency, and sought to avert their evils, not by scientific means, but by supplications and sacrifices to some imaginary divinity, which they fancied to be the ruler of these vegetable pests.

Those ancient nations which had made some progress in human learning and in the practice of common observation, were in the habit of referring every particular department of nature to the charge of a particular god. To us, this appears not only false but absurd; and yet it was the natural and necessary condition of a people whose minds were awakened to reflection, and who were without the knowledge of the true God. We need take no credit to ourselves for being differently situated from those nations; for had we been, like them, without the light of Divine revelation, a light which can come only from Heaven by the grace of God, we should certainly not have been in a better state than they were, and most probably in a worse one. These ancient nations regarded the different blights, brands, and mildews, as malign influences, shot down from the sky by malevolent powers; and the Romans, who considered the blighting as an act, without knowing any thing of the blight as a substance, gave that act the name of *Robigo*, regarded it as under the care of a divinity, *Rubigus*, to render whom propitious they kept *rubigalia* or feasts for propitiating the god, about the time when the small fungi in question make their appearance—or rather begin their attacks, for some of the most mischievous of them do not appear externally—upon the growing crops. These feasts generally took place in the month of May; but we have no account of any correspondence between the strictness with which they were celebrated, and the absence of blight and mildew upon corn.

As was the case with very many of the ancient superstitions, the notion that the blighting came from the atmosphere was continued; and by many it was regarded as an emanation shot down from the stars; and thus in the darkness of the middle ages, the astrologers continued to fill the place of the priests of Rubigus. The common names by which these very minute, but often very mischievous plants to the farmer, are still called, show that the popular belief has every where referred them to celestial influence, of some kind or other, and there is generally some allusion to burning or scorching.

And though those blights are certainly not occasioned by any influence of the stars, any more than they were ever prevented by Rubigus, yet it does appear that the atmosphere is at least one of the disposing causes to their appearance, and probably the chief one, in whatever form or on whatever plant they may appear. We cannot say that it is the temperature, the moisture, or any one single quality of the atmosphere, which affects the condition of the plant by that sort of premature action of Autumn which favours the excitement of the extremely small spores of these fungi, nor can we say that it is a quality of the whole atmosphere; as in passing over a field, for instance, different species attack different plants, and they attack different individuals of the same species, and different portions of the same individual. All these circumstances, together with their extreme smallness, and our inability to examine them in their early stages, make this one of the darkest subjects in the whole science of cultivation.

Very few plants are wholly exempt from the attacks of these diminutive foes; but the different ones are restricted to their own genera, or, at all events, families of plants, by laws which appear to be very perfect in their operation, but which are of difficult investigation, and consequently ill-understood. This is a difficulty inseparable from the study of all those productions of nature which are so very small that they cannot be examined but by means of microscopic glasses of great magnifying power. Those high powers cannot be so constructed as that they shall not give both refractive colours and refractive distortions in shape, to the objects which are seen through them; and it is quite impossible to separate these fictitious colours and shapes occasioned by the instrument, from those which belong in reality to the subjects examined by means of it. Thus it is necessary to use extreme caution in speaking of the details of subjects of this kind; and even with all the caution that we can use, they are hardly subjects for popular disquisition.

We have said that they are restricted by very perfect laws to the plants on which they make their appearance; and we may add, that the laws which restrict to states of plants appear to be equally perfect. It belongs to them, indeed, in their general character of decomposers of matter which has ceased to be useful, not to come into action until circumstances render that action necessary for the well-being of the whole system. They do not come as active and general destroyers, like the locusts and sundry others of the insect tribes, which indiscriminately consume every green thing in their march of desolation. They are not borne along on wings, or on the currents of the air as these are; for we have every reason to believe that their spores are equally abundant in all the juices of every plant, whether circumstances call them into activity or not; and thus, however injurious they may be in the operations of art, their office, as a portion of nature, is a beneficial one. There is, we believe, no instance of even the most abundant and destructive of them attacking all the plants of a field of corn, but only particular ears, and sometimes particular grains in an ear, all the rest of which are sound and good.

The reason of their appearance is most obscure; and therefore the means of preventing which have been resorted to, are most uncertain in their effect, and in great part imaginary. Seed that is infected is generally believed to produce a growth more prone to infection than seed which is not; but even this is somewhat doubtful. A good condition of the ground, and a climate in season ascertained to be favourable to the species of grain cultivated, are unquestionably the most certain preventives of the mischiefs of these fungi; and of artificial applications in the preparation of the soil, a moderate quantity of lime appears to be the best that has yet been used, though it is said that in places where seaweed is attainable, a dressing of it is still more effective.

We shall pass over the *Œcidiums*, or dust-blights, which appear upon the leaves of very numerous plants, and have often a very beautiful appearance; and also the *Pucciniæ*, or tuft-blights, and confine our notice to those which are seriously injurious to cultivated vegetables: remarking only, that the dust-blights actually grow within the leaf or other part of the plant, and raise for themselves a thin pellicle of the epidermis, which they rupture when their spores are matured, and thus the damp is admitted, and the leaf decays. The tuft-blights again appear in little tufted dots external of the plant; but they also rupture the epidermis and let in the water.

The most destructive, or, indeed, the only seriously destructive ones to ordinary cultivation, belong to the genus *Uredo*, which is the Latin name for the blasting or burning by means of these fungi. This name is of course derived from the Latin verb *Uro*, "I burn;" and it was no doubt applied for the imaginary reason which has been mentioned. Two species of this genus have been long known to farmers,—*Uredo segetum*, usually called the "smut," or dust brand; and *Uredo caries*, which is sometimes called the "canker brand," or bladder brand; though these and a number of other names have been indiscriminately given to both of the species in different parts of the country. The smut is much more general than the other, and it is met with on all the corn-plants indiscriminately; whereas the other, hitherto at least, has been discovered chiefly upon wheat. In some places *Uredo segetum* is called the rust; and the name smut is given to the other. Their distinctive characters, in the manner in which they appear, as well as in the mischief which they do, are, however, not to be mistaken.

The smut (*Uredo segetum*) is the species to which we formerly alluded as containing such a vast and countless number of spores or germs in the space of one cubic inch. In the early stages of their growth these plants do not make their appearance externally, and the stems of corn upon which they have established themselves, instead of being sickly appear to be more vigorous than the rest, as if they were stimulated by some preternatural cause of fertility. And there seems to be not a doubt that, up to a certain stage of their growth, their irritation occasions an extraordinary degree of living action in the plant on which they grow, by which that plant increases the quantity of matter upon which they subsist. This is by no means unusual in the case of parasites upon plants; for many of the gall insects, and others, cause, by their irritation, an extraordinary growth in that part of the plant wherein they take up their abode. We have previously mentioned the galls and bedeguars, as remarkable instances of this; the former sometimes acquiring the size of small apples, and a consistency little inferior to that of solid wood; while the latter display the appearance of a tuft, consisting of quite another vegetable, than the wild rose or other plant, by the action of which it is formed. This smut attacks indiscriminately all parts of the plant, in which respect it bears some resemblance to the rust or blight, which is a puccinia, and often appears upon the grain plants as well as the smut, and is very destructive to the culms or stalks, and to the leaves, though it does much less injury to the young grain than the smut. Though the smutted plants seem more than ordinarily vigorous for a time, they turn pale and sickly as soon as the fungus makes its appearance, which it first does like a brownish or reddish powder, adhering to the surface; but it darkens as it ripens, and the black colour which it imparts is the principal reason why the name smut, which means soiler or blackener, is given to it. It often occupies the entire volume of the grains, and is also interspersed through all the tubular part of the culm and the vessels of the leaves; but it ripens and sheds its spores before the unaffected portion of the corn is ripe; and in consequence the smutting ears are shrivelled, and the plants altogether stunted in their growth. There is no esculent substance in the grains which are thus affected, and smutted and also blighted straw is substanceless and insipid, and useless as food for cattle. Fungi much resembling this in appearance, in size, and in office, infest peas, beans, hops, and, indeed, almost every cultivated plant that can be named; and whenever they appear in numbers they do a vast deal of mischief. None of them possess any offensive odour, and we are not aware that they have any of those poisonous qualities which so many of the fungi possess in their own substance, or appear to communicate to that upon which they grow; but they greatly reduce the quantity of valuable matter in the plants, and still more the quality of that which remains.

We have said that the causes of their appearance are both complicated and obscure; and though the abundance of the spores in the soil or upon the husks of the grain used for seed, may be one means of *affording* that appearance, there seems to be something necessary in addition to this, either in the character of the season, or the improper adaptation of the plant and the soil to each other. Damp situations, and crops which come up very thick, appear to be favourable to the growth of the fungus; a rainy Autumn also tends to the production of smut upon wheat sown in that season; and alternate sunshine and showers in the early summer, just before the plants come to form their flowers, are said to have the same effect. Various plants that are peculiarly subject to the ravages of these parasitical fungi, the common barberry among others, have been accused of communicating them to grain; but there does not appear to be any ground for the accusation, as the fungi are not of the same species, and as it appears that the spores of the fungi are taken in by the spongelets of the roots, and not absorbed by the surfaces of the stems or leaves. We can readily understand how the rains may wash their exceedingly minute spores into the soil, so as to bring them into contact with the absorbing parts of the roots; and also how the varying sunshine and showers may alternately excite and check the growth of the plant, until that unhealthy state which is favourable to the growth of the fungus is brought on; but altogether, the subject is one of very great obscurity. The appearance of those fungi greatly reduces the quantity of nutritious matter in the same weight of the substance of the grain, in slight cases not less than about a third, and in more serious ones more than two-thirds; but of course the average cannot be taken. When smut decidedly attacks the ears, the substance of the grain is actively destroyed, and its place occupied by the remains of the fungi, the dispersed spores of which adhere so closely to the grains which are sound, that they cannot be detached by any known process.

In wet, cold seasons, especially upon thin and poor soils, and the poor and retentive clays in exposed situations, more than upon any others, the corn is very subject to smut; and the flour which it yields does not sponge, but remains tough like dough; or if a firmer consistence is attempted to be obtained by farther baking, a portion of the exterior becomes as hard as timber, while there is a lump of shrunken dough in the centre. The colour also is dark, the taste insipid or unwholesome, and there is but little nourishment as compared with bread made of sound wheat.

The fungus which produces this sort of disease in bread-corn, has in itself no offensive smell, and the taste which it imparts to the bread is negative rather than any thing directly offensive; and though there is no doubt that it renders the bread less wholesome, as well as less sightly and nourishing, yet it does not appear to occasion any very decidedly poisonous quality. Thus it must not be confounded with mildew, which is a fungus of different form and character, produced under different circumstances; and though not poisonous in its own substance, yet producing a poisonous quality, always attended with injurious and but too often with fatal effects. We shall have occasion briefly to notice this mildew in a future paragraph.

The canker-brand, *Uredo fetida*, is a much larger plant, although still a very small one; and it attacks the corn in a different manner. It never appears on the stem or the leaves, but always within the glumes or husks, and even in some cases the proper tunics of the grains. The external appearance of these changes but little, so that a field may be very much infested by this fungus, without the fact being suspected by any but a very experienced observer. The diseased ears very often appear larger and better than the sound ones; because the fungus does not shrink in ripening, which the grain always does to a certain degree. When however the diseased grains are opened, they are found not to contain a single particle of the farina of wheat, but to have its place occupied by the fungus, which is of a sooty black colour, greasy to the feel on account of the smallness and adhesive nature of the spores, and having a most offensive smell like that of fish in a high state of putrefaction. Being protected within the grain, this plant does not shed its spores, at least not so readily as the smut does. In threshing and preparing the grain, the fungous ears are broken; and the countless number of little spores which they contain, are dispersed all over the sound grains, and they are so small and attach themselves so firmly, that they cannot be cleared away by any process which has been hitherto discovered. If very numerous they darken the colour considerably, so that experienced judges can know grain which is much affected, though a lower degree, which hardly any one can distinguish, may produce very serious mischief.

It is to be understood that those grains which do contain farina, and thus are fit either for grinding into flour or using as seed, are sound in themselves, unless in so far as the appearance of the fungus may indicate a feeble and imperfect action of the whole field, as arising from unfitness of the soil for the kind of grain, an unfavourable season, or both of these causes united. But in every case, the fungus utterly usurps the place of the kernel of every grain which it attacks, and thus the remaining ones are internally free from it. This is, however, no advantage, because the spores which adhere externally mix with the flour in the operation of grinding, and the product is an article of very inferior quality. There is nothing deleterious in the flour itself; and notwithstanding the very offensive smell of the fungus, it has not been proved, and is not indeed very probable, that it has any poisonous quality, especially in the spores, which are the only parts which mingle with the flour. It does not appear that any positive disease ever resulted from the use of bread tainted by this fungus; and there is evidence, as far as analogy can give evidence, of the perfect harmlessness of these spores, in the fact, that the spores of *Ergot*, (afterwards to be noticed,) have been ascertained to be wholly innocuous, while the tunic in which they are contained is a poison capable of producing the most direful effects.

From the fact which has been established by carefully repeated experiments in the case of the ergot, we have every reason to believe that how poisonous soever some of the fungi may be in other parts of their substance, the spores of the whole of them are perfectly innocuous. That it should be so the reflective reader will not fail to perceive from the general analogy, nor will he fail also to perceive in this one of those instances of wise and benevolent design, which force themselves on our contemplation at every step of our progress in the study of creation and its laws. In order that they may be always ready to perform those offices for which they are appointed, the spores of the fungi, in one or other of the species, exist in the fluids of every animal and of every plant; and not only this, but, light as air, or at all events having individually so very small gravitating influence, that the very slightest attraction between them and the atmosphere, is sufficient to enable them to ride on the currents of that fluid, upwards, downwards, or laterally, with the same obedience to its motions and their causes, as the particles of water when they are in a state of invisible vapour. It is well known that the more elevated and therefore rarer portions of the atmosphere receive the vapours of water more freely than denser air at the same temperature; and there is every reason to believe that it is the same with the infinitesimal spores of the smaller fungi. Thus they are inhaled with every breath of every creature that breathes, and absorbed by every absorbing pore, however minute; nor is it until we come to the mysterious membrane, so frequently alluded to in the course of these volumes, which, by absorbing at the one surface and secreting at the other, divides matter down to the primary atom, that their entrance is forbidden.

These extreme faculties of mobility are necessary, in order that the germs of the fungi may be at their posts whenever the slightest casualty requires that they should be developed and perform their functions; and it will be at once seen that this universal admission into the substance of animals and plants renders it especially necessary that these germs should be so perfectly simple and innocuous, as that their presence may not do the slightest injury to the finest organ of the most delicate life. Their province is not to cut down the strength or impede the healthy growth or action of any one production of nature; for that would display an imperfection in the system altogether inconsistent with and unworthy of its divine origin. It is only when in consequence of some local or temporary cause that some organic being, or part of an organic being, is in excess above what the healthy condition of its species can bear, in the proper balance of the system, and where, otherwise, unwholesome putrefaction would ensue in it, and produce either a poisoning or a waste, that the spore of the fungus awakens to its duty. Perhaps there is no part of the whole system of nature more truly wonderful, or more clearly demonstrative of Almighty wisdom and power and goodness, far above our finite comprehension, than the distribution and nature of those spores,—that the *vis medicatrix naturæ*—the healing power of nature—should ride upon every wind, enter at every pore, and circulate in every fluid, without disturbing the most tender function of life, until the wholesome state of the system demands its action, is a subject of contemplation both long and delightful. Nor is it the less so, that the material substances, the offices of which we have here to contemplate, are so immeasurably small. It was well said by the illustrious Hook, to whom experimental inquiry into nature is so deeply indebted, that he "admired Nature's watches far more than her clocks;" and if we descend, or rather, if you will, ascend another step in the analysis, we shall be constrained to admire the spring and the balance far more than the watch,—and this, because it is one step nearer the Almighty *primum mobile*—the Eternal finger, which touches the elements of the system with the mystery of life.

There is one other general point, for the introduction of which the present is perhaps the most convenient opportunity that we shall have in the present volume; and though it is one which we believe has hitherto been seldom if ever mentioned, it is probably not the less interesting on that account. It is this: It is well known, and has been too fatally established by the experience of those who have wounded themselves ever so slightly, while engaged in scientific examinations of the human body in a state of decomposition, that the matter of probably every body, animal or vegetable, when in a state of putrid decomposition, is one of the most fatal poisons that can be applied to the same species in the living state. This has been proved to be true, not only in the application of the putrefying substance of a body wholly dead, to one of the same or of an allied species which is living and healthy; but it is equally true, of a corrupt, or rather corrupting, and a wholesome part of the very same individual. There are so many instances of disease and death brought on by local gangrene in man and other animals, and so many fruit trees and other plants are killed by canker-spots of local situation and comparatively small size, that we can have no doubt of the poisonous effect of decomposing matter upon the living subject of the same or of analogous species. It does not apply to the whole range of any one of the great classes either of animals or of vegetables—for several of them find their food in the putrefying remains of the others; and much less does it apply to the insects and the fungi, which are especial decomposers of putrid matter both animal and vegetable. But still in those which very much resemble each other in their organization, there is an indication of the general truth, even in the cases of those which subsist upon the putrid remains of the others. Thus, among the warm-blooded vertebrated animals—the hyænas, and others which feed more exclusively on carrion; and also among the birds—the vultures and others which perform similar offices—have a curious antiseptic power in the stomach, by means of which the carrion which they gorge is brought back from putridity, and restored to not an unpleasant smell, in the process of being converted into chyme, before it leaves the stomach, and enters the intestinal canal to undergo that final process of digestion which fits it for being taken up by the alimentary absorbents of the system. The case is the same with those reptiles which take their food in a putrid state, or retain it in the gullet until it becomes putrid; and as this fact is general in all the cases in which we can properly examine it, we have very strong analogical reasons for supposing that it is universal. But there remains an important fact to be noticed: In that stage of the digestive process during which the food is brought back from putridity, the functions of life in the animal sink very low, and in most instances it is dull in sensation and incapable of motion. Thus, though these animals are fitted for the consuming of putrefying remains which would otherwise be injurious, they obviously hold this power at a temporary sacrifice, and thus give evidence that before the putrefying substance of any one organized body can be safely applied to the substance of another, even as food, there must be a very considerable difference between the natures of the animals; and even in their cases if the putrid matter is taken into the system by a wound, its effects are always injurious and sometimes fatal.

This brings us to the main point which establishes the grand use of the fungi, in all cases where matter in this putrefying and poisonous state cannot be decomposed by the agency of animal destroyers, or by the mechanical and chemical operations of the elements. The putrefying substance of any one species, whether plant or animal, is a poison to that species if applied to the system; and in the case of such animals and plants as do not come within the list of the scavengers of nature, whose special office is to destroy putridity, the food, whatever it may be, is a poison if taken in the putrid state; and it is to prevent the deleterious effects of this poison, that the insects and the fungi, according as the general physical circumstances are more favourable to the action of the one or the other, invariably hasten to convert this poisonous matter into a simple and wholesome pabulum.

This not only shows us very clearly what an important office those little animals and plants perform in the grand system of nature's working, but it explains in a satisfactory manner the ground of the mistake into which those have fallen who suppose that plants, in the course of their natural operations, give out to the soil a certain matter which is a poison to succeeding plants of the same species. It is not any thing given out by the living and healthy which has this effect, it is the decomposition, or rather the putrefying decay, of that which has performed its functions, and requires to be converted into elementary matter before it is again available for the vegetation of the same species.

This explains in a very satisfactory manner why the general vegetation of tracts of country changes after the lapse of years, and changes more readily in places where there is a great annual "fall of the leaf," than in those where there is not,—in the deciduous forests of the temperate climates, for instance, more than in the evergreens of the equator or the pines and other coniferæ of the polar latitudes and the cold uplands. To take a familiar instance: What may be called the aboriginal forests of England, of the lowlands of Scotland, of the Welch hills, and of the whole of Ireland, are gone. It may be said that, in all of these countries, and more especially in the last-mentioned one, the woods have been destroyed, both by the torch and the axe. But even the wanton burning or cutting down of a forest is not in itself an extirpation, but the very reverse, as long as the soil continues favourable for the growth of the same species that have been removed. Many years of cultivation, after complete burning and rooting out, do not secure an upland field in the bleak moors of Scotland from being again overrun by heath, if it lies only a few years in pasture; and in India, no length of time under cultivation seems capable of defending the surface against the invasion of the bamboo jungle, if the soil is favourable for the growth of that extraordinary plant. Even in an oak coppice, which is periodically cut down for the sake of the bark and the charcoal; or in an osier bed, there is a longer duration of the stools, and a much greater and more vigorous annual growth, than if the oaks or willows were allowed to remain undisturbed. This no doubt, in part, arises from the suckers having much of the condition of young plants; but it also arises, in part, from the absence of decaying matter in the fall of the year. A wide field would here open itself for considering the most profitable cultivation upon woodlands, and upon lands under every species of crop; but it is a field upon which our limits do not permit us to enter, and so we must confine our remarks to the humble but still very instructive subject of the fungi.

CHAPTER VII.

PRINCIPAL FUNGI BY WHICH GRAIN PLANTS ARE INFESTED.

In the case of the fungi, as parasitical upon and destructive of the cereal grasses, or grain plants, there is a distinction to be made, according as the fungus consumes any part of the structure of the plant in the course of its formation, or as it destroys a full-grown and matured portion, or at least a portion near maturity, when in a state of incipient putrefaction. In the former case the fungus belongs properly to summer in its time, though it is Autumnal in its action; but in the latter case it is Autumnal in its time also. The smuts, cankers, and rusts belong to the first of these divisions; though the rusts, as coming upon the matured or nearly matured stems and leaves, are much more Autumnal than those species which attack the grains in their formation.

Agreeably to this part of their character, the influence of external causes in the producing of rust, is much more obvious than in the smut and brand. If showery weather sets in about the time that the bloom is on the wheat, or soon after this, rust is very apt to be the consequence, even though there is not the slightest fault either in the seed or the cultivation. Indeed, the better the condition of the soil, and the warmer the weather has been previously, rust is the more likely to appear; and so is it also if the showers alternate with warm sunshine. The reason is easily seen: it is the cold resulting from the great evaporation, which chills and checks the vegetable action of the culms and leaves; and the injury done by this is always the greater the more that this cold alternates with a warm temperature. If this occurs in the early stage which we have mentioned, the injury to the crop is often very great, because the nourishment of the ear is then in the progress of elaboration by the action of the whole plant, from the root upwards. But as the grain approaches maturity, the danger from this cause lessens; for the lower part of the culm, which always has to bear the severest part of the struggle against the alternating cold and heat in these cases, is the first portion that ripens, or passes into the Autumnal repose of healthy straw; and thus, as the grain advances to maturity, the ear is thrown more and more upon the resources of its own absorption, and the action of the culm and the leaves gradually ceases. Thus the final ripening of the grain is an operation performed wholly in the atmosphere, without any connexion with the ground; and, indeed, any action that the ground can have upon it after this, except in the radiation of heat or moisture, would be an injurious action, namely, either germination, or such a state of incipient decay as would bring a fungus upon it—one of those usually called moulds or mildews, of which we shall have to take some notice by-and-by, as plants which always communicate suspicious, and often deleterious qualities to any alimentary substance, animal or vegetable, upon which they make their appearance.

This progress of the ripening, or cessation of vegetable action in the culm and leaves, may be regarded as the proper Autumnal stage of the grain; because, as soon as the action of the culm has totally ceased, both the corn and the straw are preservable by simple drying; whereas, if vegetable action in them is stopped earlier than this, they are apt to ferment and rot. Nor can we help admiring that beautiful tempering of the plant to the weather, which makes it always the more secure against injury, the nearer that it is to perfection. Thus it is always an advantage, in as far as the quality of the grain is concerned, that the midsummer rains should set in late in the season, only, if they are too late, there is some danger of their also being too copious. Even in this, however, there is a very beautiful compensation; for the long dry summer makes the culms short and firm, so that they are able to bear the ears erect and secure, in spite of the floods of St. Swithin.

There is one remark more, which may not be irrelevant to this very important subject of the Autumnal state,—the Autumnal hazards, and the Autumnal protections of the grain-crops, as depending upon the activity of nature, and without reference to those arts by which man endeavours to work and to second the operations of nature in his behalf. It is somewhat curious, but it has not hitherto been much, or even at all investigated, though it appears to be one, the investigation of which would be fertile in knowledge of the most useful description. It is this: the progress of ripening, even in the annual plant, is always upwards, while the progress of decay is downwards, unless some fungus, or other agent, comes in to bear a part in the bringing about of that decay. In proportion, too, as the part of the plant near the ground proceeds in a healthy ripening, the upper part of the plant is more secure against the ordinary contingencies of the elements. After the lower parts of the culms of corn are once fairly ripened, their stiffness prevents it from being injured by rains, which would suffice to lay it flat while the culm is in the growing state; and this diminished flexibility renders the grain less liable to be shaken by the winds than it otherwise would be.

There are, however, so many, so complicated, and so varied subjects, each demanding the exercise of a train of thought, and all of them highly interesting and profitable for instruction, which present themselves when we contemplate a field of wheat waving in the golden beauty of its Autumnal state, that we have space only to persuade every reader who has the opportunity, to go into the fields, and see with his own eyes, and know of his own knowledge, the wonderful displays of Almighty wisdom and goodness, in the annual supply of bread to the children of men.

The inhabitants of Britain lie under especial obligations to know these things, in order that they may feel becoming gratitude for the pleasant places in which the lines of their heritage are cast. There is not another people on the face of the earth, whose staple bread-corn, even in the middle ranks of their society, is wheat; perhaps there is no country, in which, in all probability from the abundant supply of animal manure, the wheat is of such nutritive quality; and there appears to be none in which both that and all the other cultivated plants are more exempted from the ravages of destroyers, whether insects or fungi. There is no doubt that we owe much of this to the insular situation of our country, and to its diversified surface, by means of which the little winds are made to sport blithely over its surface during the whole season of growth and ripening; but we also owe much of it to our improved mode of cultivation, which is the result of knowledge, and the foundation of that knowledge unquestionably is the early and general distribution of the Book of Revelation.

We know not, with any thing like precision, the exact state of the productions of nature in the more early ages of our country, especially with regard to the fungi which attack and injure our grain-crops; but from what we know, by modern experience, of the injurious effects of some of those fungi, it is highly probable that some of those periodical diseases called Epidemic, which used to carry off such numbers, and of which few traces now remain, were owing to the bread being tainted by the admixture of some of those fungous plants. We may mention in passing, that the word "epidemic," as applied to disease, means something which falls, that is, occurs or happens "upon the people," from some external cause, in opposition to "endemic," which means a disease of infection, or one which is "of the people" themselves, and not from any external cause.

One of the most dangerous of the fungi infesting grain, as at present known, is that which is called by the French the Ergot or Cockspur. This is not absolutely confined to rye, the plant upon which it is most abundant; but the other plants upon which it occurs are the pasture grasses, rather than the grain plants, upon which, with the exception of rye, it is almost unknown. There are but few parts of the British islands in which rye is cultivated for any purpose, and none of any extent where it is cultivated as the chief bread-corn of the people. Where it is cultivated, too, it is always upon lands which are the very best adapted for it, namely, those which are too light and too dry for bringing any more valuable crop to maturity, and thus the rye which is grown in this country is but little affected by ergot.

On the continent, the case is very different; rye is a staple grain in most countries, chiefly because there are not domestic animals enough for allowing such a breadth either of wheat or of green crop as there is in Britain. Accordingly rye is cultivated upon various soils, and among the rest upon many that are cold and retentive, as well as upon the thin dry sands; and it is chiefly upon these retentive soils, or when rains are more than usually abundant and cannot get into the ground, that rye becomes spurred, sometimes to such an extent as that the effects of it upon the people are really dreadful.

Acinula clavus, or *Secale cornutum*, is the name of this fungus. It commences within the grains of the rye, and renders such as it attacks completely abortive, in the same manner as the canker brand; only it does not remain concealed within the husk as that does, but projects, and protrudes in a lengthened, bent, and pointed substance, bearing some slight resemblance to the spur of a cock in miniature, (the French name for which is *ergot*,) and thus our word spur is exactly synonymous with theirs. This is the fungus in its mature state; and although it is distinctly visible, it is not very large. Only one appears upon a single grain, and all the grains in the ear are seldom affected. The fungus is nourished entirely by the substance of the individual grain, and thus it ripens about the same time that the uninfected grains ripen, and of course comes to its full size at the same time that they do; and between this attaining of the full size and the perfect ripening is a very important stage in the growth of the spur, inasmuch as it depends in a great measure upon the state of the weather during this period, whether the spur shall become a fearful poison, or a substance unsightly and unpleasant merely, without being to any extent deleterious. It consists of a solid nucleus, containing the spores, and a peridium or covering, which is at first of a soft and clammy nature, and soluble in water. Thus if rains come before this external part hardens, it is washed away, and as it is the part containing the poison, the interior, or berry as it is sometimes called, though far from a desirable admixture in food, certainly is not a deadly one. On the other hand, if the weather during the period alluded to is fair and dry, the peridium hardens upon the berry, and its poisonous quality is great in proportion to the drought and warmth of this particular period.

Too much humidity, about the time that the grains are beginning to form, is the principal cause which stimulates the spur into action, just as it is in the case of smut or canker in wheat; and it is more apt to make its appearance when the crop is apparently in vigorous growth than when the action of the plants is more feeble. It is a general law, that plants are most liable to be injured by vicissitudes of the weather when they are in vigorous growth; and plants under artificial culture form no exception to this law. One can easily see why, even supposing equal growth and therefore equal susceptibility to the weather, the influence of untimely rains should be more injurious upon soils of some strength than upon light and sandy ones; the rain speedily sinks into the latter, while it remains on the surface of the former and produces cold by being evaporated. Up to a certain degree, this cold is favourable to the healthy growth of the cultivated crop, because it prevents the plants from being parched at the roots; the effect of which parching often is the strangulation of the ears in the husks. This takes place the more readily, the more congenial a rich soil is to the plant; and upon many of the very light lands where rye thrives well and is entirely free from spur, wheat, barley, and even oats would be choked in the husk.

From the scope of these few observations it will be seen that the grain-destroying fungi—or rather grain-preventing fungi, are most likely to be developed in seasons when the midsummer rains set in too early and in too great quantity; while, in the case of the spur, the poisonous quality is, in part at least, corrected by a continuance of the rain after the spur has come.

The spur, or ergot of rye, if it comes to maturity in dry weather, is very valuable as a medicine, if administered with proper skill. Given to females it produces very powerful effects upon the uterine system; and thus both mother and child are sometimes saved by ergot of rye, when otherwise the case of one or of both is become hopeless. It is a desperate remedy, however; and, like all other desperate remedies, it ought never to be administered until the requisite necessity has arisen; and as the determining of this, so as neither to inflict unnecessary agony nor delay relief until too late, is one of the nicest points in the whole practice of medicine, it should never be tampered with but by persons of the greatest skill and experience.

When mixed with food, the effects of the poison upon the system are very dreadful, and one of the forms which is best known is that which is called by the name of dry gangrene. It is very remarkable, but nevertheless true, that the effects of this fungus when mixed with food, are quite different from the specific medical effects above alluded to. It appears not merely to accumulate in the system, as is the case with foxglove and some of the other vegetable poisons, but it accumulates locally, and on the extremities rather than on the vital parts. It often does not appear to be attended with much fever, or inflammation, or pain, or any symptom that would lead to the supposition that the body was in a diseased state. In time, however, it affects the extremities, to a greater or smaller extent; first with numbness and cold, and then with emaciation and drying up, until they at last become as brittle as touchwood, after which they separate from the rest of the body. We are not aware that there are any means of saving the limb or part of a limb, after the gangrenous symptoms are fully confirmed in it; and if the mutilation once fairly begins, it is not easy to say where it may stop, or how extensively the disease may spread. A joint of a finger is of course the slightest injury; and it may extend in other cases to the withering of a leg till it parts at the hip-joint, or of an arm till it separates at the shoulder. Sometimes the parts are merely withered by the disease stopping in its early stage; but we believe that, even in these cases, the use of them is seldom if ever recovered. Delirium and death are not unfrequently the results of very severe cases; but they appear to be secondary, and indeed the whole action of this extraordinary poison is as mysterious as the effects of it are distressing.

In consequence of the particulars formerly stated, the occurrence of disease from the ergot is rare in this country. There have, however, been instances, and some of these from the fungus upon wheat, though in these it has not, we believe, been accurately ascertained whether the fungus was the same species as that on the rye, which has so often been fatal on the continent,—most of them, indeed, occurred before the nature of the ergot was properly known, and there is reason to suppose that the fungus, in some of these cases, was not the spur, but one of the moulds or mildews, though which species is not known; and it is probable that some other diseases, which have been ascribed to the mixture of the seeds of the charlock or wild radish, and to those of other plants, were really occasioned by small fungi, though quite different ones from the ergot.

One of the most serious, and also the most clearly detailed cases of dry gangrene, occurred in the county of Suffolk in the year 1762; and it is worthy of the more attention, that the fungus occasioning it does not appear to have been ergot. A farmer in the village of Wallisham, about twenty miles from Bury St. Edmunds, had a portion of his wheat laid by the rains previous to the harvest. But the precise progress the grain had made at the time when it was thus laid is not mentioned, though there is reason to believe that it was too far advanced for being in much danger from ergot. In order that this damaged part of the crop might not injure the appearance and lower the price of the sound part, the farmer had it put up separately, and it was threshed about Christmas and sold at a low price to farm labourers and to other poor people of the village. This grain began to affect some of the people early in January; and about the tenth of that month its effects became apparent, and it appeared to accumulate by prolonged use, in the same manner as ergot of rye does. One family, consisting of a father, a mother, and six children, used to purchase two bushels of this damaged wheat every fortnight, and they ate no other for a considerable time. In the country, according to the testimony of the curate of the parish and a Dr. Wollaston, this wheat was known as "clog-wheat," "bearded wheat," or "rivets," which seems to show that the people were not unacquainted with it in those days, and that the fungus, whatever it may have been, was some one growing upon and adherent to the grains individually, and not one exhausting the grain in the course of its formation, as is the case with the ergot. The symptoms, however, had a considerable resemblance to those produced by ergot, and the consequences were of the same lamentable character.

After persisting some time in the use of this poisonous grain, the mother and all the six children were attacked within a short time of each other. Violent pains in the lower extremities were the first symptoms that presented themselves; but these subsided in the course of a few days, and were followed by insensibility, cold, and mortification. The following were the consequences, as stated by Dr. Wollaston, in his communication in the Philosophical Transactions:—"Mary, the mother, aged forty; right foot off, at the ankle; left leg mortified, a mere bone, but not off. Elizabeth, aged thirteen; both legs off, below the knees. Sarah, aged ten; one foot off, at the ankle. Robert, aged eight; both legs off, below the knees. Edward, aged four, both feet off at the ankles. An infant aged four months, dead.

"The father was not attacked till about a fortnight after his wife and children, and in a slighter degree: in him the pain was confined to two fingers of his right hand, which turned blackish and withered. Another labouring man in the same parish, who had eaten of this bread, suffered from numbness in both his bands for above a month. They were constantly cold, and his fingers' ends peeled." Some of this wheat was eaten by various other persons; but it does not appear that any lived so exclusively upon it as the family of whose fate Doctor Wollaston gives such painful details; but still it were much to be wished that the specific fungus had been correctly ascertained.

It should seem that the violent pains which precede the mortification in these cases indicate a cause somewhat different from that which is but too well known in France, as positively resulting from the use of rye contaminated by the ergot; and it is worthy of remark, that Raphania, and some other forms of disease, generally understood to be caused by the use of unwbolesome bread-corn, are much more violent, as well as general, upon the system in their primary effects, without being followed by gangrene. Thus it is probable that there may be a series of poisonous fungi parasitical upon the farina of grain, in every stage, from its first rudimental formation in the ear to its last stage of being used as mouldy bread,—it being understood that the moulds alluded to are all fungi, and not the little plants belonging to the algæ, which were formerly noticed. The proper understanding of those deleterious fungi which attach themselves to damaged grain and flour, and impure bread, and to many other articles of food when in a state of putrid decomposition, in places where the elements, or animal spoilers, are not competent to their reduction, is a subject of very great importance. Those which attack bread-corn, or bread, are of especial interest, inasmuch as bread forms so large a portion of the food of the young and of the labouring classes, and as these poisons are apt to undermine the constitution by continued use, even when they are in quantities too minute for occasioning violent and immediate disease. But we must defer the few remarks that we have to offer upon them until we have mentioned a few more of the forms under which they appear.

France is the country in which the ergot of rye has been studied with the most attention; or, at all events, where the disease has attracted the greatest notice. As early as 1676, the connexion between the gangrenous disease and the eating of "spurred rye," was clearly pointed out. From this time the notices of periodical returns of the disease, of more or less malignant character, are very frequent, though we believe that they have not been so common of late years, probably owing to an improved state of agriculture. The fact of the spores and their immediately containing substance being innocuous, where the external perideum has been washed away, caused at one time some doubt as to the invariable connexion between the disease and the fungus. But it has invariably been found that the disease is prevalent only in those years when the spur is upon the rye, and always most virulent in those districts where the grain is most liable to be affected, and among that portion of the people that live the most upon rye.

M. Noel, who was surgeon to the Hotel Dieu, or hospital, at Orleans, for thirty years, witnessed the disease four times, as an endemic, in the course of that period. In these, and in other reported instances, there appears to be very great difference in the degree of fatality in the attack. Sometimes a large majority escape with only a greater or a less degree of mutilation, while, in other cases, an equally great majority are carried off by death. The poisonous nature of the ergot is farther proved by the fact, that animals have a strong aversion to corn which is infected by it; and experiment has shown that, administered in any considerable quantity, it is poisonous to those animals which can eat safely of many plants which are injurious to others. This extends to birds and reptiles, as well as to all the mammalia upon which it was tried in the course of the experiments; and even to such of the invertebrated animals as could be made to partake of it. The symptoms upon most of these were, first, giddiness, loss of the contractile power of the pupil of the eye, paralytic affections, and unnatural excitement of the intestinal canal; and these were followed by gangrene in various parts of the body, and in the majority of instances by death.

The fact of almost every animal refusing to eat rye infested with the ergot, is a conclusive proof of its poisonous nature, even without the corroboration of the direct experiments. Man arrives at his knowledge in such cases by observation and experience, and consequently he is in continual danger of mistakes; but the instincts of the animals are unerring, as being altogether free from judgment on their part; and therefore any lessons that can be derived from them are always lessons of truth.

The part of France in which the rye is most frequently infested by this fungus, to such an extent as to convert it into a dangerous poison to those who eat much of it, is strongly corroborative of all that has been said of the circumstances which are most favourable to its development. This part of France is the district of Salogne, between the river Loire and its affluent the Cher. The soil is a cold and hungry clay, of so retentive a nature that the rye has to be sown on drills about a foot high, in order to preserve it from maceration and destruction by the wet. The crops are poor in all seasons; and although rye is among the least scourging of all the cereal plants, the fields have to be fallowed and rested every third year before they can bear a repetition of the miserable crop. Even at this unproductive rate, of two crops in three years, the land is very soon rendered altogether unproductive for tillage, and has to lie in such wretched pasturage as it affords for a number of years, before it can again produce such rye as is fit even for poisoning the people with the ergot. If upon a district of such wretched character as this there should fall rain at the time when the ears of the rye are beginning to form, there is really no alternative to the ergot appearing upon it; and when it once comes, and the peridia are not removed by subsequent rains,—and it is doubtful whether they are ever wholly reducible by this means,—disease is the certain effect of the use of it. There appears to be just as little certainty of preventing, or curing the disease of the grain, as there is in doing the same for the unhappy persons who are affected by it. With the latter, it is not very clearly ascertained what might be done in the very early stages, before the symptoms of the gangrene come on; but after this there is no safety for the affected part, and none for the patient, save amputation. The only sound conclusion that can be drawn from the most careful study of the case is, that the lands upon which rye is subject to this terrible fungus ought never to be sown with that grain. If there is any efficient remedy, that appears to consist in the amelioration of the soil only; and lime, sand, and animal manures appear to be the ingredients that are best fitted for these purposes. With regard to smut and brand upon the grain of our own country, though it does not appear that any of them is a direct poison like the ergot, the cure is in all probability very much the same; and all of them appear to be warnings to the farmer, that he is cultivating a particular species of grain upon fields which are not in proper condition for their wholesome culture. Alkaline leys and earths are, no doubt, in a great measure, fatal to the spores of these fungi; and if we could be certain that, in all cases, those spores are either attached to the seeds when they are sown, or contained in the soil, the application of the substances that have been mentioned would, no doubt, be of very great use. But from the incalculable numbers, and the extreme minuteness and consequent levity of these spores, we never can know how completely the summer air may be loaded with them; and as none of our curative applications can reach that element, they cannot be regarded in a higher light than that of so many plausible quackeries. They have succeeded, and they have not succeeded; and nobody can say how much of the success may have been due to the particular character of the season, or the situation. There is still much to be learned upon this very important but most obscure page of the book of nature; but it is of so hidden and intricate a nature, that although our abilities were equal to the task (which they certainly are not), our limits, and the main object which we have in view, would equally prevent our entering upon it.

The fungi which we have hitherto noticed as parasitical upon grain plants, whether as simply deteriorating the quality and diminishing the quantity of the farina as food, or as communicating poisonous qualities to the mixture, all belong to that division which attacks the plants upon which they are parasitical, at some stage of their growth, and are excited by diseased action arising from an improper soil, from a more abundant crop than the soil and the season are capable of bringing to maturity, from unfavourable weather, or from a combination of those causes. In so far as the soil is concerned, the farmer is able, in a great measure at least, to guard against those very destructive enemies; but no skill and no experience can guard completely against the contingencies of the weather; and therefore the only plan, or at all events the safest plan, for the judicious cultivator, is to work to the average of the seasons.

It is not upon the corn plants alone that fungi, having injurious effects upon the human constitution, make their appearance, or, more strictly speaking, come in multitudes which are invisible. The disease known under the name of Raphania, which is very common in Sweden, and other countries which like Sweden have a brief and precarious Autumn, subject to great vicissitudes of temperature, is generally understood to be occasioned by the seeds of the wild radish or jointed charlock (*Raphanus raphanistrum*), which infests the corn-fields of all the colder and more northerly parts of the Eastern continent. Very careful investigations, conducted by the Swedish philosophers, have shown that the disease in question, which is a convulsive disease of a very severe description, is not produced by the spur on rye or by any fungus of analogous character, inasmuch as barley is generally the grain by living upon which the malady is commonly produced, and charlock is quite inseparable from the barley of so northerly a country; and hence the seeds of the charlock had been generally supposed to occasion the disease. But charlock is a very common field weed, and is just as abundant in places where Raphania is unknown, as where it is of frequent occurrence. In many parts of Scotland the staple bread of the poorer people used to be made exclusively of barley-meal, and though the general introduction of the potato has superseded it in many places, greatly diminished the use of it in all, and certainly supplied the people with far more light and wholesome food, yet Raphania was little, if at all, known in Scotland. It is true that, from the poverty of the people in the more remote districts, and their strong belief in predestination, which made them equally unable and averse to the employment of medical men, the history of disease is not known. There is however some reason to believe that, in the northern districts, which resemble Sweden in the character of their climate, the violent spasmodic diseases which were endemic, after very rainy harvests in former times, were either raphania or something resulting from a similar cause.

Of late years these diseases, if they have not disappeared altogether, have certainly become much more rare; and though there are other reasons for this improvement of the health of the people, there is no question that much of it is owing to the general culture and use of the potato. It is true that the potato crop is liable to destruction by the early frosts, and the people are, in consequence, sorely pinched with want; but so far as we know, there is no poisonous fungus or other deleterious plant which attaches itself to the tubers of the potato, protected as these are by being imbedded in the ground.

The potato is indeed one of the most curious plants with which we are acquainted. A native of climes almost directly under the Equator, it yet improves in quality in the high latitudes and in the extreme wilds, yielding wholesome nourishment to man under those inclement skies where even the poorest of the grain plants either cannot be grown at all, or are liable to be converted into poisons by fungi.

When we consider the wonderful obedience of the potato to the hand of the cultivator, the range of climates over which it can be grown, and also its native locality in the Andes, we cannot help seeing that it is admirably fitted, and obviously designed for the good of man, under circumstances which render other vegetable food difficult to be produced or dangerous in the using. So far as the facts will enable us to carry the analogy with any thing like certainty, it appears that places where grain plants are liable to be infested by spur or other fungi, are peculiarly favourable to the growth of wholesome potatoes. One of the most remarkable evidences of this is found in the fact, that, in the upper valley of the Magdalena, which lies within three or four degrees of the Equator, and is both wild and elevated, the potato is native; and maize or Indian corn, the chief grain which grows in places so tropical, is very subject to the attacks of fungi. It has been ascertained that the habits of the maize fungus resemble the spur of rye, though the action of the two upon the animal system appears to be considerably different. Like the spur, this fungus forms an elongated mass, in the place of the grains of the maize. Some animals are poisoned by this diseased Indian corn, while smaller doses excite them in a manner resembling intoxication. In others again the hair or fur drops off, the legs become weakened and wasted. The eggs of poultry are produced without shells, in the same manner as they are when the hens are greatly alarmed; and if the inhabitants continue to eat it for a considerable time, their teeth are loosened and their hair falls off: it does not appear however that any of the more violent symptoms produced by the European fungi follow from the use of food tainted by this plant, for no mention is made either of violent convulsions or of dry gangrene of the extremities. The fact of the eggs being produced without shells, leads naturally to the presumption that this fungus is injurious to the reproductive system, but whether it has the same violent specific action as ergot of rye, has not been mentioned.

This fungus upon the Indian corn is by no means rare in the district of country which we have mentioned, and the character of that country is worthy of attention as calculated to throw some light upon the general physiology of those curious fungi. It is near the equator, and so varied in its surface, that while the mountain tops rise into the region of frost, the valleys are cleft down almost to the mean level of the surface; and so near are those extremes of climate to each other, that there are many points where one can take such a position as, almost on any day of the year, to see every tropical luxuriance and beauty on the one hand, and nothing but Lapland on the other.

We have had occasion again and again to remark that the tropical and the polar influences, estimating the extreme of the former by its winter of thirsty desolation, and that of the latter by the intensity of its cold, are the two grand agencies, or which amounts to the same thing, the types of the two grand agencies, by which all seasonal changes are brought about, and a great part of the growing and living world is roused to action at one season and shrouded in death or lulled to repose in another. Now as this is the case, any one can see that when the extremes of those two agencies, and of the states which they produce, are within a few miles of each other in horizontal distance, their struggles and the resulting disturbances must be far more frequent and far more violent than when the agencies are six thousand miles in space, or six months in time distant from each other. The deep valleys are as hot as ovens, while the mountain peaks are chilled by excessive cold. This produces a constant descent of the mountain air upon the valley, and a constant ascent of the air from the latter, reeking with most pestilent vapour, highly favourable to the growth of tropical plants, but destructive of human life. The cold of the mountains too has very different effects both upon animals and vegetables than the cold of the high latitudes. The cold of the latter, whatever may be the degree of its intensity, is a dry cold; whereas upon the summits of the tropical mountains, the cold is a moist one, from the vast quantity of vapour which the rays of an almost perpendicular sun keep continually ascending or descending. Violent storms are the result of this; and in the more elevated tracts no season of the year, or time of the year rather (for there is but little difference of seasons), is safe from variations of the weather quite adequate to the production of fungi upon grain.

This, as we have said, and other places resembling this, along the ridge of the Andes, are the natural habitats of the potato. We believe that no species of grain plant is native, at nearly the same elevation as the potato is found wild; and this, together with the frequent and extensive poisoning of the grain by the fungus, is a reason why attention should be paid to the native plant, and the cultivation of the other diminished or abandoned. The same observation applies to the inexpediency of growing any European grain where it is habitually subject to poisonous fungi; but whether the potato should or should not be called in as a substitute, must depend upon the circumstances of the particular case. Ergot of rye is indicative of a retentive clay soil, and also of a dripping climate; and though, up to a certain extent, the last of these is favourable to potato culture, the first is always very unfavourable, as the tubers are constricted in dry weather, and soaked when it is rainy.

But in the places where barley and oats are no longer profitable culture, whether from heavy rains or from an uncertain Autumn, the potato can always be introduced to great advantage; and, as the grain upon these last extremes of locality, for its growth, may be said to be in a state of living death, that is, a life constantly subject to suspended action, during the whole time that it is upon the ground, it is almost certain to be attacked, and converted into a poison by some kind of fungus, if it escape from the other casualties of the improper situation in which it is attempted to be grown; and if the people will persevere in this improper culture, which, it is to be recollected, may become improper by too long continuance, as well as from the nature of the soil and climate, they must bear the consequences of their ignorance or obstinacy.

There is one circumstance connected with those fungi that are parasitical upon grain in its early stages, and consume it in the instant of its formation, as it were, which is especially worthy of our notice, in a physiological point of view, and as showing an extraordinary coincidence between the animal and the vegetable kingdoms. The ergot of rye, and all the other poisonous fungi which, like it, attack the grain in the earliest stage of its formation, and substitute themselves in its place, forming themselves of substances which would otherwise have been grain, attack vegetable life in its most rudimental state, that is, in the ovary of the bloom, before the act of fertilization; and in consequence of this, though the general action of the plant continues its supply of matter, that matter goes to the fungus and not to the seed as the germ of a successor to the parent plant. Upon the animal system the effect of the fungus, especially in the case of ergot, is upon the first rudiments of life—upon the uterine system of the female; and though it may not be taken in such quantity as to produce the specific action which it has as a medicine, and cannot indeed produce that action except under particular circumstances, there is every reason to believe that it tends to produce barrenness, and also extreme weakness of constitution in such children as are brought into the world. It is a long observed fact, that fewer children are born, more of them die in early life, and females sooner pass the period of fertility, in districts where unfavourable summers and Autumns bring fungi upon the bread-corn, than where it sustains no such injury.

The stationary population of many tracts of cold and upland country, while bad grain formed the principal part of their food, and from which there was no emigration to lessen their numbers, is an incontrovertible proof of this; and we have proof of the opposite, upon the general use of food of another description, not liable to fungal contamination, which may be regarded as an *experimentum crucis*. In Ireland, even in those parts of it where the general privations of the people, and the absence of almost every thing that can be called comfort, are extreme, the increase of the population and even the healthiness of the children, amid all their apparent wretchedness and misery, are equal, if not superior to those in the best fed and most highly favoured districts of the sister island. It has sometimes been said ironically, that the rapid increase of the Irish peasantry is owing to the potato being their staple article of food; and it is by no means improbable that this, like several other ironical expressions, intended only for ridicule, is literally and philosophically true. It is impossible to ground the argument upon the case of Ireland, because we are in want of the other element of the comparison. Up to the time at which the potato became the general food of the humbler classes in Ireland, and for a considerable time after it, that unhappy country was far more the victim of rapacity than the subject of philosophic observation and inquiry. There are some accounts on the record as to the numbers of the wealthier Irish that were plundered, and vague lists of the poorer ones who were murdered; but with regard to the true statistics and state of the country, there is not a spot on which the lightest philosopher, that ever played with the destinies of mankind in mode and figure of scholastic jargon, can rest the sole of his foot.

We are, therefore, constrained to seek the other term of the analogy in other lands; and though our limits preclude us from the details of the enumeration, any one who is sceptical upon the point may turn to the recorded history of Northern Europe, and also to many parts of the central states; and he will find an establishment of the general principle, that wherever the bread-corn of the people is generally subject to attacks of fungi, the population is stationary, and in extreme cases retrograde. It is true that numbers are cut off by periodical maladies, which maladics invariably follow harvests in which the corn is more than usually tainted; and though famine sometimes had and has an influence on them, disease invariably did and does take the lead. But, even in the ordinary seasons, or leaving out those of extreme calamity, which of course brings the remainder above the average, fewer children are born, and more die at an early age, and the constitutions of the people are neither so strong nor so lasting in such countries, as in others in which the food of the people has no fungous taint. The people of Britain, for instance, consume less food which is in any way diseased or tainted, that is, taking them on the average of all ranks, than any other nation whatever; and it is admitted, on all hands, that they are more sinewed for work, better steeled for endurance, and longer lived than any other people on the facc of the earth. This single fact speaks volumes of instruction, even in a selfish point of view, to those who have "the management of mankind," if they would only learn to understand it, and reduce it to practice.

From a careful contrast of the state of the population in countries where spurred grain is used, with that in which the grain is either sound, or the potato is substituted for it, it is impossible to avoid coming to the conclusion that there is an exceedingly rudimental injury done to the principle of life by these fungi, from which the same principle is entirely free in every case where the food has no contamination. Indeed the potato, in this and in some other respects, has, among the humbler classes of the people, especially in manufacturing towns, where the bread is purchased from bakers, some advantages over the bread. Potatoes are dressed at home, and therefore if they are of good quality and properly kept, they are always fresh and wholesome. Bread again is liable to many adulterations; more, indeed, than any other general article of food; and as the parties by whom it is sold—to the poor especially—care nothing for the health of their customers, they are very apt to use damaged flour, or to damage it in a most iniquitous manner, in order to gratify their wretched but only motive for carrying on the trade—that of obtaining the highest price possible for the most worthless commodity. It is not, however, any of the fungi which we have been describing that are the deleterious ingredients in the case of bread; for though fungous flour is often used, and really is a poison in the state of bread, the fungus in general belongs to the division of fungi which get the general name of moulds, and which do not consume the farina of grain as it is formed, but attack that and many other substances, when they are in a state of incipient putrefaction, under peculiar circumstances. Such being the case, the consideration of it can be more advantageously entered upon in our next chapter.

If we had space to follow out all the generalizations to which the subjects noticed in the present chapter would lead us, we should find many of them equally curious and important, and some unexpected, and even startling, but, at the same time, of the greatest importance, in the conducting of practical matters upon the great scale. The alternation of the aerial grasses, which produce human food on the summits of their culms in the air, and the potato, which produces food, having many corresponding qualities, at the extremities of fibres, or flexible under-ground branches, is one of the most remarkable, and the only one of which we can afford any notice. In the localities which we have mentioned as being, and probably as having in the lapse of years become, unfavourable for the growth of grain crops, experience shows that the potato can be introduced with the greatest advantage, and that under very different circumstances as to climate. The margin of a mountain bog in Ireland—even the bog itself, with very moderate drainage; a few mossy sods turned down upon the bare rock, and exposed to the dripping of the Hebrides; or a thin, exhausted, sandy or gravelly soil, such as occurs in great part of the north of Germany, and of Poland,—are all capable of yielding an abundant supply of excellent food, and materials for various other articles of living or of domestic economy, after every kind of grain upon them has ceased to be obtainable, in any thing like a fair crop, or become a poison when obtained. It is difficult to say in which of those countries the general introduction of the potato has been the greatest blessing. It has been a very great one in them all; and although those ignorant persons, who are bold and vain-glorious in their ignorance, and therefore always attributing effects to wrong causes, have sometimes laid the blame of all the wrongs of Ireland upon the potato, that vegetable has been the blessing of the people, not their bane; and, under the pressure of other circumstances, which certainly do not belong to *natural* history, had it not been for the potato, Ireland, instead of overflowing with a vigorous population, who have plenty of sinews if they had kindness and good counsel, would have been reduced to a scattered and famishing remnant, few and far between.

But, prolific as the potato is, under those circumstances which are unfavourable for corn, and chiefly as an abundant population can be supported upon it, there is a limit beyond which it may be forced, and after which it will begin to become an evil. This, like every other bounty of Providence, is given to man for instruction, and not for idleness, either voluntary or involuntary. Man must not sit down and content himself with planting his potatoes, generation after generation, for an indefinitely long period of time, in the hope of always gathering in the same excellence and the same abundance. There is no single species of culture permanent in unbroken succession upon the ground, any more than there is an individual human being permanent upon earth; and where the great breadth of a country is left, as it generally must be left, to the influence of natural circumstances, there is a progressive change to which attention must be paid, and the advantage of one improvement in cultivation is nothing but a stepping-stone in the way toward another. The potato in Ireland has obviously been cultivated beyond the limit; because upon those lands where it has been grown year after year for a long period, the native produce has become to a great extent abortive, and seed has to be imported, to the serious injury of the cottager. The plan, therefore, is to transfer the culture of the potato to the new grounds, and adopt another one, say pasturage and then agriculture, upon those which are exhausted.

CHAPTER VIII.

MISCELLANEOUS APPEARANCES IN AUTUMN.

Autumnal agents, and the appearances which their several actions produce, are so very numerous, and the limit of our volume is so nearly reached, that we must content ourselves with the mere enumeration of a few. In selecting these few, it will be our endeavour to take such as are either not generally to be met with in the popular books, or are of more than ordinary interest; and to hint at the mode in which the transition may be made from them to the analogous races, which we have not room to enumerate.

Foremost among those which we can afford to mention, we may with propriety place the more typical fungi, or those that make their appearance upon decaying substances, and hasten their decay, as distinguished from those noticed in the preceding chapter as attacking plants in the course of their growth, and preventing them from coming to maturity. Of very many of these, the uses are but imperfectly known; and though they all make their appearance upon organic matter in a state of decay, or in the decaying season, and appear to be stimulated by damp and a close atmosphere, there are not a few of them that grow simply upon the ground, so that we are unable to say positively what the specific plants or other substances are which it is their special office to hasten in their decomposition. We shall briefly notice two families or sections of them, which are remarkable for their pernicious effects—and these are, the "mildews," *Mucoraceæ*, and the "dry-rots," which are fungi of very diversified appearances and characters; but all of them highly destructive of timber when it is placed in circumstances favourable to their development.

The mildews, or moulds, as they are sometimes called, (for the latter is a very general, and therefore a very indefinite term,) are exceedingly common, and appear upon almost every description of animal or vegetable substance, when it begins to decompose in damp and confined air. They appear upon ill-conditioned provisions, even though these are cured with salt; and although not probably poisonous in their own substance, at least in all the species, they are always to be looked upon with suspicion; and they generally, if not invariably, indicate poisonous qualities in whatever is infested by them. They also invariably have or communicate an offensive smell, which is different from that of ordinary putridity, and which may be characterized as being more sickening in its nature than directly offensive to the sense. This last property distinguishes them completely from the bysso-moulds, which some of them nearly resemble when seen by the naked eye, though when examined through glasses, they have, generally speaking, the form and texture of miniature mushrooms.

From various cases that have occurred, there is reason to apprehend, that these mildews or moulds are as poisonous as the ergots, formerly mentioned, though they poison in a different manner. They are, also, far more dangerous, and, therefore, they are still more worthy of attention. The ergots are confined in their time, for if the grains of the corn have once begun to form, the ergot never makes its appearance; and whether it shall or shall not appear in any particular case, depends much on the general state of the atmosphere at the time when the grain-plants are coming into flower; and if the grain is safe from those fungi at this particular stage of its growth, it is in no danger from them afterwards.

With the mildew it is very different; for there is no stage of its growth, and no state of its preparation for food, in which the farina of the cereal grasses, and that of wheat in particular, is safe from the attack of this offensive and poisonous fungus, which does not come until there is as much substance in the ear as shall serve it for nourishment. Upon warm and dry lands, and in dry seasons, the grain may be considered as secure against this unwholesomeness; but though it may bloom and ripen in the most kindly and promising manner, yet, if dripping and sunless weather shall ensue, so that the grain cannot be gathered in, or, if it is gathered in in too moist a condition, it is sure to be attacked by the mildew. If this is the case, the nutritious quality, weight for weight, of the flour, is much more reduced than when the grain is attacked in a more early stage by smut or canker-brand; these last two do not impair the quality of the grains which remain sound, they only contaminate the mixture; and, unless their quantity be so great as to render the article wholly unsaleable, they do not lessen its nutritive quality above one-third. The mildew, on the other hand, destroys very nearly four-fifths of the nourishment of the wheat, so that a five-pound loaf contains only as much support for the human body as a one-pound loaf of sound and wholesome bread,—or a quartern loaf about as much as twelve ounces.

This is a serious matter enough, and it is the more serious that it falls chiefly upon the poorer classes of society, by whom, on account of the lower price at which it is sold by unprincipled dealers, this damaged bread is eaten. The reason of this great destruction of the nutritive quality is, that the fungus especially drains the gluten, the quantity of which makes sound wheat sponge so much better in baking, and also renders it such substantial food, as compared with most of the other species. But, bad as this is, it is not the only evil or the worst one; for mildew invariably imparts a poisonous quality to the grain, the flour, the bread, or the other article of food, whatever it may be, which it infests. In consequence of this, it is impossible to say how many of the diseases by which wet harvests were always followed in former times, and are often followed still, are produced by mildew. Instances of this are of too frequent occurrence; and, what adds to the misery and the danger is, that the mildew is apt to come upon the wheat at every stage, from its first formation in the ear, to its delivery to the consumer from the baker, and even after it is in the house, if it has been dishonestly made, or kept too long in a damp and improper place. The poor are in but little danger from the last of these; but they are very liable to suffer from the first, which is by far the more common of the two.

Flour made from mildewed corn, at whatever stage the fungus may come upon it, whether in the field from an unfavourable harvest, in the rick by improper housing, in the granary, or even after it has undergone the operation of grinding, (for it is liable to be mildewed in all these cases, if long subjected to a close and damp atmosphere,) is not only of inferior price in the market, but wholly unsaleable to a respectable and honest baker, or to families who have any knowledge of that important article of food. Therefore it is sold at a very low price, and, on that account, it is eagerly sought after by the unprincipled part of the trade, who are, unfortunately, too numerous, and, still more unfortunately, have the power of compelling the poor to purchase any trash, however meagre in nourishment, or deleterious in its nature, by always keeping them a few shillings in debt, and consequently being able to threaten them with the summary vengeance of that most unwise abortion of law, which, in this free country, gives the creditor more tyrannical power over the debtor, whom he has wheedled or seduced into debt, than the slave-master has over his purchased slave. This sometimes ascends a step higher, and the iniquity is chargeable on the miller, nay, probably on the corn-merchant;—for the first necessary of life, being a tempting article to the cupidity of the unprincipled, is very generally in the hands of monopolists; and a monopolist, let him monopolize what he will, is always one of the worst and most injurious members of society.

Flour from greatly damaged grain of any sort, but more especially from mildewed grain, cannot by itself be made into a loaf, which would be saleable under almost any circumstances; and, on this account, the one fraud of using it necessarily leads to many other frauds. If such flour were used without any admixture, it would not sponge or expand, but remain tough and waxy, if moderately baked, or harden like a brickbat, if that operation were carried to a greater extent. It would also be of a dark and disagreeable colour; and its taste and smell, to say nothing of its deleterious qualities, would be those of earth which is accumulated in damp places, without any free exposure to the air. It would, in fact, be so unsightly as to be unsaleable, and so offensive to the palate, that it could not be eaten.

Those disagreeable qualities are, in all probability, wise provisions of nature, intended to protect the ignorant against the poisonous ones; and it is in order to provide against them that the shameful iniquities of the dishonest tradesman are perpetrated. Colour is obtained by an admixture of what is called "mountain meal," that is, pure clay, obtained from naturally decomposed feldspar, of which, it is well ascertained, that large quantities are exported from Cornwall every year, for the express, though not avowed, purpose of adulterating bread. This substance is perfectly harmless, and, in so far as the acetous fermentation precedes putrefaction and the fungus in bad bread—and it is especially injurious to the digestive organs—the mountain meal is a corrective; but there is no nourishment in it, and the use of it is a fraud, much of the same kind with that of the wine-merchant, who boasted of promoting temperance by selling a mixture of one part wine and nine parts water coloured with logwood.

Instead of the pure clay, common alum, which is a mixture of clay and sulphuric acid, is frequently used. This also gives colour, and, if used in any considerable quantity, it would be very injurious; but, as it destroys the sponging quality, the quantity used must be very limited; but still, small as it is, it tends to accelerate the souring of the bread.

Neither of these substances would in any way tend to make the bread sponge, and, therefore, something which contains starch—if but little gluten, is resorted to. The very worst potatoes, boiled in the filthiest manner, and strained through a searce, with full benefit of the poisonous extract of the skins, is what naturally suggests itself as cheapest; and accordingly it is used in great quantities.

By means of these ingredients, bread from very bad flour, may be rendered as white as that from the very best; but it is a sickly whiteness, and wants the delicate tinge of golden bloom which stamps a genuine wheaten loaf, and which no craft can imitate. Such bread expands in the oven, especially when put into an overheated oven, by the action of which it is burned externally rather than baked through. Thus, one mal-practice of the fraudulent baker co-operates with another; but it leaves a mark whereby it can be distinguished by external inspection; and it may be adopted as a general maxim, that a baker whose loaves are habitually burned on the outside, sells unwholesome bread. The reason of this is easily explained—that is, the reason for using the oven at too high a temperature. This excess of heat causes a much more rapid and violent expansion of the gaseous products of "the mess," than a lower temperature would do, and this separates it into granular portions. Such separation is, however, very different from the sponging of bread made of wholesome and uncontaminated flour. The latter is raised into vesicles, from the tenacious nature of the gluten, whereas the former is merely divided; and as in the division the gas in great part escapes, it requires a much higher temperature; and this renders it necessary to heat the oven to such a degree, as that, generally speaking, it chars the external part of the loaf. When a loaf of this kind is cut, it cannot be cut with a smooth surface, but crumbles before the edge of even the sharpest knife. If kept long uncut, the central parts collapse; and if a cut surface is exposed to the air, it hardens and champs; and in both cases it very speedily becomes mouldy, if placed in damp air, and the moment that it does so, it becomes a poison. Even good flour, if adulterated with the mixtures that have been named, may be converted into unwholesome bread; and thus, in this particular instance, the casualties of nature, and the fraudulent practices of man, are equally injurious to the public.

The mixtures which have been mentioned, do not destroy the unpleasant smell of mildewed flour; and hence certain perfumes are introduced. These do not and cannot impart the odour of wholesome bread, which, though a gentle one, is equally peculiar and grateful; but they conceal the bad hugue, which, unfortunately for the public, answers the same purpose.

We may mention one well-authenticated instance of the dangerous consequences of fungous bread, which occurred in the vicinity of London within these few years, though, unfortunately, it was not traced to its course in the bread so as to determine whether it was owing to bad flour, or the dishonest treatment of good flour. The beadle's wife, in the hamlet, bought a loaf which had been baked on the same morning, ate a slice of it herself, and toasted two for her son, a young man twenty-one years of age. Very soon after eating the bread, both mother and son were seized with violent disorder of the bowels, such as is especially characteristic of poison having been taken. As there was not the slightest reason to suspect that any known poison could have mingled with the food, or, rather, as the contrary was well known to be the fact, the bread was examined. It was found to be of dark and varied colours, and full of very minute fungi, which fungi were the only part of it to which the poisoning could be attributed, as a careful analysis showed that it contained not a trace of any one of the ordinary poisons. The bread was soft, totally destitute of that elasticity or springiness which good bread always possesses, and it was so tough and waxy, that it could be drawn into strings like thick paste when it is sour. Its taste and smell were, also, both offensive. In order to make sure whether the cause of the disease was, or was not, in the bread, a portion of it was given to the dog and cat. It very speedily affected them in the same manner, thus removing every doubt as to its deleterious quality. The next point was, to ascertain whether the poison was in the fungi, or in the substance of the bread; and experiment showed that it was in the latter; for a small bit of the bread, after the fungi had been carefully removed, produced the same symptoms; and the fungi, given in substance to human beings and to domestic animals, produced no bad consequence whatever.

This is a very important part of the matter, and shows that there is a kindness in the growth of this little vegetable, and in the unsightly appearance, and unpleasant taste and smell, by which it is accompanied. We must say "accompanied," for it does not appear that the taste and smell of the fungus itself are any thing different from those of simple and harmless vegetable mould, which, though it would make but sorry food, is unquestionably not a poison, but would pass through the alimentary system, certainly not with harm, and probably with advantage. This fungous mould upon bread appears to give a wholesome warning, and to declare, as expressly as though it were written in words, "This bread is poisonous."

We are not aware that the particular manner in which the bread, in the Hammersmith case, had been manufactured, had been inquired into; or that the quality of the flour from which it was made, or the substances which had been mixed with it, had been ascertained; but an experiment was made which showed that a poisonous quality is imparted to ordinary dough, if kept so long as that the mouldy fungus comes upon it. A quantity of dough was kept in a damp place until covered with the mould; the mould was then removed with the greatest care, and the dough thus cleared of mould made into a loaf and baked. This loaf had the same poisonous qualities as the bread which had led to the experiments; but the mould which was removed from it produced no bad effect whatever, either upon men or upon domestic animals.

These facts show how very necessary it is to be careful in the manufacture of bread, and even in the keeping of it after it is manufactured; and that it would be very desirable to subject those bakers who adulterate flour with sulphate of alumina and other matters, which tend either to sour the bread, or make it retain an undue quantity of water, in order to increase its weight —which is one of the objects of the fraud—to the severest penalties of the law, as criminals of the very worst description.

We have already said, that the pure alumina is not in itself injurious, though, from the tendency which it has to absorb moisture, there is no doubt that it greatly accelerates the poisonous state of the dough or the bread; and as those who are base enough to adulterate flour are not very likely to be particular in the preparation of the bread, the safest conclusion, and probably the most accurate one to which we can come on the subject, is, that all bread adulterated with mountain meal is, in a greater or less degree, poisonous. The sulphate of alumina is far worse, because it has a great tendency to bring on the acetous fermentation, and that is immediately followed by the poisonous state of the dough or bread, as indicated by the presence of the fungus. If the dough is in this condition, the operation of baking has no tendency to correct it, as is proved by the fact, that the Hammersmith bread was baked the very same morning that it was eaten. It is highly probable, also, that the mixture of potatoes with the flour, especially from the quality of this ingredient, and the filthy manner in which the mixture is made, invariably tends to produce the same result; and the conclusion to which the whole of the facts lead us is, that bread should be made of sound flour, in a dry place, and with the very minimum of water, otherwise there is no security that the bread shall not occasion disease;—and it deserves to be borne in mind, that the effects of most vegetable poisons accumulate in the system, undermine the constitution, and, in the end, prove fatal, even though their beginnings are scarcely discernible.

There is a corroborative evidence of the mischief produced by sulphate of alumina, in the starch used for preparing for the loom sail cloths, and other hempen and linen goods, which are used without undergoing the operation of bleaching. It is well known that if such goods are exposed to damp in close places, they are subject to mildew, which greatly injures their texture and strength, and renders them comparatively worthless. This mildew is in all probability not very different from that which poisons bread, as it is produced upon a similar substance, namely, vegetable starch fermenting by moisture. Sulphate of alumina is very often mixed with this starch because it renders it more fluid and ropy, and thus makes it go farther and makes it more easily applied; but we believe that cloth which is dressed with starch of this description, as well as from starch made of damaged grain or flour, or of potatoes or their admixture, is far more liable to mildew than cloth dressed with the starch of wholesome flour. It is true that, in the case of the cloth, there is a remedy. The salts of mercury prevent the growth of the fungus, the red oxide being the one generally used for the purpose; but, in the case of food, this cure would be worse than the disease, and that it is of much real use in the case of the canvas has not been established upon good philosophical grounds; because though it prevents the appearance of the fungus, we have no satisfactory evidence to show that it tends to prevent or even to lessen or retard that diseased state to which the fungus is owing.

In passing, we may remark that there is the same doubt as to the efficiency of Kyan's mode of preventing dry rot in timber, which has attracted, and is still attracting, so much of the attention of those who are interested in shipping. The application of which he makes use is, we believe, bi-chloride of mercury, or corrosive sublimate—one of the most deadly of the mineral poisons; and thus it becomes a grave question whether the saturating of the timbers and planks of a ship with this deadly poison may not be more destructive of the health of the seamen, than conservatory of the said timbers and planks; while it remains to be shown whether this application, even though it should in all cases prevent the appearance of the dry-rot fungi, can, in any case, convert a piece of bad timber into good. Of this, however, we speak by the way only, but we may perhaps revert to it afterwards.

There are various articles of food besides bread which are liable to show poisonous qualities by the appearance of fungi. One of the most remarkable of these is bacon kept in damp places after it is cured, and becomes what is called "rusty"—the rust being really one of the fungous moulds or mildews; and it is of little consequence which one, or whether always the same one, as they seem all equally to indicate a poisonous state of that upon which they appear, and invariably consume that ingredient of it in which its nutritious quality chiefly consists.

There are no recorded instances of the poisonous effects of this description of pork in England, though from the extent to which that article is used, and the disposition of the poor to purchase at the cheapest rate, without any regard to quality, there can be little doubt that it is a fertile source of disease, if not an obvious cause of death. In France the case is somewhat different, probably because the pork generally is of inferior quality to that of England, and probably because the diseased states of it are disguised by those seasoned preparations of which the French are so very fond, and many of which, though they disguise the poisonous quality in the seasoned article, certainly do not correct or remove it. One description of food, the occasionally poisonous nature of which, as sold in France, has been unfortunately but too well ascertained, is that which is called Italian cheese. This consists of scraps of pork, mixed with various other substances, highly seasoned with spices, made into a solid pie or cake, and retailed in slices to the poorer people. In the instances in which this Italian cheese has been ascertained to be poisonous, fungous mould has always appeared upon it, of a bluish or greenish colour, similar to that which occurs on rusty bacon in this country; and whenever this makes its appearance, the article is always to be suspected, though it is probable that, as in the case of mouldy bread, the fungus is merely the sign or the warning of the poisonous quality, and not that quality itself; though in this case the experiment has not, we believe, been made. Little is known of the specific nature of those fungi which appear upon tainted provisions, and operate in decomposing their substance, but the general analogy leads us to conclude that they come to perform what we have stated to be the grand function of the fungi, that is, to decompose and turn into elementary matter, substances which have become noxious in their organic state. We cannot positively say that those moulds are Autumnal in their time; but in a state of wild nature Autumn is the principal period, and at whatever time they appear, their action may be regarded as decidedly an Autumnal one.

Of the larger, and perhaps more characteristic fungi, the puff-balls, the toadstools, and the mushrooms properly so called, we have but little room to speak; and though from their abundance there is no question that they perform an important part in the economy of nature, the part which they actually do perform is, in the case of many of them, but imperfectly understood. The puff-balls, of which there are many species, usually grow upon dry heaths and pasture lands; they are, generally speaking, of a round shape in the peridia or upper portion containing the spores; and when this bursts, the spores or germs are distributed like a smoke arising from the plant, and in consequence of their extreme minuteness and levity they are dispersed everywhere. Many of them have the property of being exceedingly repellant of moisture, so much so that it is hardly possible to wet them with water; but the use of this property in the economy of nature is not known.

Another family, the *Tuberaceæ*, of which the esculent truffle is perhaps the typical species, are remarkable for many having their organs of fructification—though some, as for instance the root-beard, come up to the surface—upon which the peridia lie, under ground, and thus have something the appearance of potatoes. Those which remain wholly under the surface are preferred as articles of food, and as such they are highly prized; but some of those which come to the surface are also esculent. The truffle, *tuber cibarium*, which is the most prized of the family, has so strong and so peculiar a flavour, that dogs, and even pigs (which latter have a keen scent for substances under ground) are employed in finding them out. They are natives of light dry soils, very generally distributed, and apparently capricious in their appearance, but their use in the economy of nature is little known. It is probable, however, that their function, as well as that of many other fungi which grow upon or under the ground, without attaching themselves to and decomposing any particular organic substance, consists in the decomposition of carbonic acid, and probably also of atmospheric air; at least one would infer as much, from the quantity of nitrogen which they contain.

The *Phallaceæ* are another remarkable family of fungi, which are very peculiar in their character, and very Autumnal in their appearance. They sometimes grow upon rotten wood, and at other times upon the surface of the ground; and the circumstances under which they grow, the rapidity and vigour of their growth, and the extremely offensive odour of some of the species, are all equally worthy of remark. In their young state they are enclosed in a membrane, something the shape of an egg, in which state they remain for a day or two, but afterwards, the rising column within bursts the valve or envelope with so much force that it occasions a report as loud as that of a pistol. Previous to this the stinkhorn (*Phallus fœtidus*), which is by no means uncommon in many parts of Britain, especially in thundery Autumns, is by no means offensive; but as soon as the membrane is burst, and the stem rises, the summit of the latter is covered with a slime of a dark greenish colour, the odour of which is more intolerable than almost any other that can be named. It belongs to the same class with that of carrion, or other animal matter, in a state of rapid and offensive putrefaction, only it is still more intolerable; and, like carrion, it attracts those flesh flies which deposit their already hatched larvæ in tainted meat or other animal substances in a state of offensive putrefaction. It seems, however, that the flies do not resort to this offensive slime, as a nidus in which to deposit their progeny, but as a kind of food which is peculiarly savoury to their own palates. Those who have devoted their abilities most ably and most successfully to the study of the fungi, are pretty general in describing a remarkable property of this most offensive and fleeting fungus. When it is kept at a moderate distance it is absolutely intolerable, and enough to sicken one habituated to all the smells of an operative chemist's or colour-maker's workshop; but when brought close to the nose, its intolerable odour is not felt, and it has then a smell somewhat resembling those ammoniacal salts which are used for preventing fainting fits, or for recovering those who are under their influence. It is also not a little remarkable that this, the most offensive to the smell of all the known fungi, is not only not poisonous, but that the white part of the stem which bears this offensive slime on its summit, is neither unwholesome nor unpalatable as an article of food. The slime melts away in the course of a few hours, and as it is the receptacle of the sporæ, these are dispersed at the same time. The more numerous appearance of these curious fungi in thundery weather than when there is no electric action of the atmosphere in Autumn, is a singular matter, but it is one which is without the limits of our present knowledge, and one upon which it would be equally unwise and in vain to speculate, though there is no doubt that they perform some action on the earth which accords with the thundery state of the atmosphere.

The larger fungi, which appear in such innumerable hosts in the Autumn, especially in the temperate and cold latitudes, are of an almost endless variety of shapes. Many of them are exceedingly destructive of timber, especially when it is of imperfect growth, laid in damp places, or a confined air. Some of these, the *Tremellinæ* for instance, are shapeless in their appearance, and so jelly-like in their substance, as popularly to get the name of "witches' butter;" others of more consistency bear some resemblance to a number of ears stuck over the surface of the timber: of which last some have at times been admitted into the Materia Medica; others again are branchy, and resemble tufts of the fibrous lichens, and of these several are esculent and remarkable for their sapient qualities. The *Pezizaceæ* are a curious race, exceedingly numerous, and remarkable for being without any appearance of a stem. Their name implies that they are travellers on foot, and some of them are of large size and grow with extraordinary force. Among them the *Ditiolæ*, or down rots, are, in some of the species, remarkably destructive of timber, by insinuating minute portions between the fibres of the wood and tearing them asunder with very extraordinary force, considering the soft substance of the fungus. The power with which these and various other dry rots rend asunder the fibres of timber, and by thus exposing it to the air and damp, hasten its destruction, is truly wonderful. They penetrate throughout the whole mass of ligneous matter when in a state of decay, and reduce it to dust in much shorter time than one would be apt to suppose. Some cases of the force of growth in these fungi, not against wood, but against stones, which were observed in the streets of the town of Basingstoke, may be noticed. Some stones on the pavement were observed to rise gradually day after day, until they were several inches above their ordinary level, and underneath toadstools of a large size were found, by the force of vegetation in which these stones had been elevated. Upon another occasion, as is mentioned by Mr. Jefferson in the Hampshire Advertiser, in the early part of July 1830, these fungi grew so abundantly under the pavement, that the contractor was thrown into some alarm lest he should have constantly to renew his work. At first a stone measuring twenty-two inches by twenty-one, and weighing upwards of eighty pounds, was heaved an inch and a half out of its bed by the growth of a fungus about six inches in diameter; and within a few weeks after, another stone of about the same size and weight was raised up by two smaller ones. We believe the midsummer rains set in early and rather heavily that year, and thus stimulated the fungi to an extraordinary growth. These facts are curious as showing, that feeble and fibreless as those Autumnal destroyers appear to be in their own nature, they are armed with powers, by means of which they can overcome great resistances; nor are we acquainted with any ligneous plant which could in so short a time overcome the resistance of such a weight as that of these paving stones.

The dry rots, properly so called, whose ravages have, of late years especially, been so formidable to house and ship-owners, do not belong to this family of fungi, but approach nearer to the toadstools properly so called. There are a good many species and varieties of them, and some of them assume very varied forms according to the circumstances under which they appear. One, *Merulius lachrymans*, is so exceedingly destructive as to have got the name of "the dry rot," by way of eminence. These destructive merulii must not be confounded with the esculent morel (*Morchella*), which grows underground, and though it decomposes matter of some kind or other, cannot be regarded as an enemy to timber in any condition, although it is often found in woods.

The characteristic dry rot often spreads like mere cottony fibres, without putting out the proper form of its fructification, though when it does put that out it is exceedingly delicate and even beautiful in the reticulated structure of the *hymenæam*, or portion containing the spores, and corresponding to what are improperly denominated the "gills" of a common mushroom.

The ravages committed by the various dry rots are far greater and more rapid than those who are not acquainted with them could possibly imagine; and the best known and most destructive species well merits the name of *Lachrymans*, for truly it is the cause of much sorrow, if not weeping, to every one whose property it attacks, whether on land or upon the sea. In cold climates, and also in extremely hot ones, at least upon the native timber, it is rare, if not altogether unknown; and a moderate temperature, and humid and confined atmosphere, are the circumstances, of a meteorological kind, which are most favourable to its destructive progress. Examples of this often occur in oak posts, of which the weather-line, or line between the earth and the air, is wholly or partially shaded by vegetation. Some fungus of the kind will make its appearance there, and cut the post asunder, in the course of a few years, or even of a much shorter time, while the parts in the air and in the earth remain perfectly sound. So, also, dead trees are felled by the fungus at the weather-line, while not a single plant of the kind appears either upon the part above or upon the root. When, however, the tree is laid prone, if it is in a damp and confined situation, and one where mosses do not come to its assistance and coat it over, and retain stagnant water about it, the fungi very speedily assail and decompose it in its whole volume.

It is in houses and ships, however, that the destructive ravages of these fungi are most severely felt; and they are, like the pestilence, walkers in darkness, and never make their appearance on the external surface, or where either air or water can play freely around. Hence the mischief is often so confirmed, as to be beyond cure, before its beginning is even suspected. Instances are mentioned of houses having the lower timbers and flights of stairs so speedily destroyed, as to require twice replacing in the course of four or five years; and so insidious is the fungus in these inveterate cases, that it will attack books aud papers, and reduce them to a state in which they crumble into powder upon being touched. Nor can it be got rid of by any well-known process, excepting a thorough ventilation; for, though all the infected timber is carefully removed, and every appearance of the fungus obliterated, it speedily reappears upon the new timber, if placed in the same damp and confined situation. Indeed it is by no means uncommon to commence its ravages while a house is in the progress of building, and the lower timbers have to be replaced before the structure is finished.

In ships, the ravages of the fungus are still more serious, inasmuch as the escape from a rotted ship is a very different matter from that out of a house, from which the timbers are partially rotted. In the mercantile and the royal navies of Britain, the ravages of these fungi have been severely felt; and we may mention one or two instances in the latter, which rest upon undoubted and unquestionable evidence. The Queen Charlotte, a first-rate ship of the line, in the building of which seven years had been spent, was launched at Deptford in the year 1810; and in the course of two years, and, we believe, without having been on actual service at all, this ship was so completely rotted, as to be totally unfit for going to sea till at least twenty thousand pounds were expended in repairs. The Rodney, another new ship, launched in 1809, came home in 1812, so utterly rotted as to be paid off; and the Dublin, launched in February, and put in commission in August 1812, had to be paid off, s totally unfit for service, in the December of the following year. Many other instances might be given of the havoc committed by these fungi; but we can afford to mention no more of them, only we may hint that it is by no means a rare occurrence for vessels to be so much damaged while on the stocks, as to require extensive repairs before they are fit for launching; and that others have barely put to sea before they had to be broken up and sold for firewood, as quite unseaworthy, and incapable of being rendered so without an expense equal to that of building a new vessel.

Besides the decomposition of the timber, which is an effect, there is nothing discoverable except the fungus; and, therefore, the object of those who attempt to cure this disease in the wood, is usually to prevent the appearance of the fungus. But oak and other timber is so frequently reduced, in a very few years, to a paste or powder, according as it is wet or dry, having an earthy smell in both cases, without the presence of any fungus, at least, any one visible to the naked eye, that we must come to the conclusion, that the rot, whether wet or dry, may take place without the presence of any of the fungi which are usually denominated dry rots; from which, again, it follows, by obvious and necessary consequence, that the disease is one thing, and the fungus another, and that the disease always takes the precedence; so that the development of the fungus, instead of being the original cause of the disease, is only a consequence of it, and not a necessary and invariable consequence, but one which requires a confined and damp atmosphere for its development, in addition to the unwholesome state of the timber. The most philosophical conclusion to which we can come, and the one which is most in accordance with the general function and use of the fungi, is, that the timber subject to rot, whether wet or dry, is diseased from its very first evolvement from the acorn, or the other seed. It has been supposed that timber which is felled during the season of growth, or sap-wood, has a proneness to rot, from which timber felled after the Autumnal ripening, and heart-wood, is exempted. There does not appear to be much truth in this, if, indeed, there is any; for though, in diseased timber, the sap-wood certainly rots first, whether the fungus appears on it or not, the heart-part of the same wood does not long survive. We never heard of a single instance of rot, either wet or dry, in the oak-timber of the Scotch Highlands, even when cut as copse-wood for the sake of the bark, which is, of course, always done in the season of growth; while we have seen the most carefully-selected heart-wood, of winter-felled trees, from some of the royal forests in England, which had first been carefully dried and seasoned in the stack, and then kept for more than twenty years in a dry atmosphere, very speedily attacked by the rot, both with and without fungi, when placed in damp and confined air, —sooner rotted, indeed, than the very worst white pine of Canada; and, with the experience of these facts, it is impossible not to come to the conclusion, that the cause of the disease is really the bad quality of the timber; and that, if timber of this description is once grown, there may be a great deal of quackery exercised upon it; but there is no possibility of converting it into good timber, any more than there is of converting the pines of the South Sea, which are rotted almost the instant they are dry, into the sound timber of the Scandinavian Hills. It is true that many saline mixtures, especially the salts of mercury, and pre-eminently among these the solution of bi-chloride or corrosive sublimate, may stay the evil for a time, that is, they may not only prevent the fungus from appearing, but, as long as they give out poisonous effluvia, resist the decomposing action of the atmosphere, in the same manner as they resist the miasma of disease, when used in the fumigation of infected places. It is a grave question, however, whether the injury done to the health of human beings by the exhalations of such poisonous substances, may not far more than counteract the value of their conservation of the timber of ships or houses, which, after all, is but a very temporary one.

We have not space for going into the argument; and indeed the data are not sufficient for giving it a regular form; but it appears to us that the defect of all timber liable to the rot, whether accompanied by fungi or not, is a deficiency of carbon in the original composition; and consequently the only effectual means of preventing this rot in timber, is to devise means for growing it with the proper quantity of charcoal or carbon in its composition. This would demand attention to the climate, the soil, the situation of the seed at its first germination, all of which are peculiar matters, and would not, though we had a perfect knowledge of them, be proper subjects for popular description; though those who are interested may, if they choose, take the hint, and profit by it in their practice. In early times, when only the pine of the north of Europe was used in the timbering of houses, and naturally grown oak in the construction of ships, dry rot was unknown, or, if known, it did not attract attention as it has done in more recent times. The more uniform temperature of the seasons may have some effect in this deterioration of the timber; but probably more injury is done by the forcing of the young plants in the nursery, which may occasion unhealthy wood at the first; and there is reason to believe that, as the tree begins, it is likely to continue.

The Autumnal fungi make their appearance in the woods, especially those of the colder latitudes, in the fall of the year, and obviously for the purpose of decomposing those decayed substances of the season, which defy the ordinary action of the elements in the inclement season of the year. Accordingly they are most abundant in countries where the snow comes down early and lies long; and the Autumn and spring the seasons of alternate rain and drought, and as such the most favourable for vegetable decomposition;—such as the woods of the northern parts of Scandinavia, and of Russia both European and Asiatic. Many of those fungi are very beautiful in their colours; and though, taken as a whole, they are rather suspicious, yet several of them are eaten by the Russians without any bad consequences. Some of these are as much as a foot in diameter, of a most brilliant red when young, but passing through orange to brown as the spores come to maturity. These splendid ones are most frequent in climates which are rather warm; and there are esculent ones among them, but those which have the gills yellow are always to be suspected. One poisonous species, *Anianita Muscaria*, so called from its being used to kill flies, serves the rude natives of Siberia instead of an intoxicating liquor. It is simply eaten in substance, and the effects depend on the quantity taken, and also on the nervous system of the person taking it. The following quotation is from Doctor Greville, to whom we are indebted for so much valuable information on the fungi: "So very exciting to the nervous system, in many individuals, is this fungus, that the effects are often extremely ludicrous. If a person, under its influence, wishes to step over a straw or a small stick, he takes a stride or a jump sufficient to clear the trunk of a tree; a talkative person cannot keep silence or secrets; and one fond of music is perpetually singing." The fungus is swallowed without mastication, it having been ascertained that if that operation is performed upon it, it becomes a poison, even in much smaller quantity than what is required for the species of excitement sought by its use as a luxury. If a very moderate quantity—say the size of a common pea—is swallowed by the hunter when he returns fatigued from the forest, it is said to have the same stimulant and restorative effect as a draught of good ale or a glass of generous wine; but if it is indulged in to excess, the consequences are nearly the same as those which result from excess in these. One large one or two small ones are sufficient to keep up the intoxication for a day; and the effect is said to be more pleasant, and less productive of bad consequences, if a copious draught of water is taken immediately, and thus a singular species of grog made in the stomach of the drunkard. Not the least singular circumstance connected with this intoxicating fungus, is that the liquid discharge consequent upon the taking of it, can renew the intoxication either in the same party or in others; and thus by one man eating a single fungus, a party of five may be kept in a state of inebriety for a whole week. No scientific analysis appears to have been made for the purpose of ascertaining whether the extraordinary properties of this are owing to any peculiar principle which it contains; and the whole history of it would be very questionable if the accounts we have of it did not rest on authority which is above all possibility of question.

Many others of the fungi have most singular properties, and the whole race are well worthy of being carefully studied by every lover of nature and of the wonders of the Creator's works, which are often found in places and substances where we should but little expect them. We have, however, no room left to enter further into the subject, nor can we do more than merely glance at one or two of the remaining very numerous races, which take part in the labours of the Autumn.

Among these, certain species of spiders hold a conspicuous place; and the labours which they perform are often very curious in themselves, and always very important in their effects—far more so than the minute size of the animals would lead us to suppose. As the winged insects, especially flies of different sorts, are seasonal, and always numerous in proportion as the summer is warmer than the winter, their numbers require to be thinned toward the close of the season, because at that period their food begins to diminish. But it is a general law of nature that no class of animals shall habitually be cut off simply by death, without being useful to some other class, by their substance serving for food. Accordingly, when the food of the flies, and consequently their usefulness in the economy of the season, begins to diminish in the Autumn, the spiders make their appearance in greater numbers and variety, and weave their webs in more curious fabrics and with more industry than at any other season. In neglected apartments, and other sheltered places, there are a few all the year round; and so there are in the woods and fields during the whole period of growth; for the spiders are the regulators of the numbers of the flies during the season of their usefulness, as well as the instruments of the increased destruction which the Autumn renders necessary; and in every case, that tribe which is especially set over another for its regulation is at all times prepared for the performance of its work, if such a change of the weather should occur as to render it necessary. Thus, for instance, a few days of Autumnal weather will bring out the Autumnal spiders even during that which under ordinary circumstances is by far the hottest time of the year. If the previous months have been very hot and dry, the Midsummer rains are thereby protracted; the rains, when they come, are more copious; and the evaporation is consequently much more abundant, and the cold correspondingly greater. The cold produced by this evaporation often gives such a temperature, immediately after the rains, that the spiders appear in numbers, and are most industriously employed in the construction of their webs, which are nets for the snaring of their prey. But if, as is not unfrequently the case, the weather should again set in hot and dry, the spiders vanish, and do not reappear until the Autumn has considerably advanced.

These remarks do not strictly apply to spiders of all species; for as these animals are required to perform labours of different kinds, in places of varied character, they themselves must be as much diversified, both in their structure and in their habits, according to that general law by which every production of nature is adapted to its particular purpose, whether we may or may not be sufficiently informed for appreciating the beauty of the adaptation. Accordingly some of the spiders do not spin webs at all, but run along the ground hunting for their prey, some of them by simple speed of foot,—as is done by the dog genus among carnivorous mammalia and others,—lying in wait and springing upon their prey after the manner of the cats. Many spread their webs upon the ground, or rather on the surface of the matted vegetation, with a curious labyrinth, in which the spider remains until the agitation of the web gives notice that a prize has been entangled; and when this is the case the spider hastens to the feast. Some have supposed that the snaring spiders, whether their webs are constructed on the ground or anywhere else, discover their entangled prey by the sight. In the case of the spiders in question this cannot be true; because a spider cannot alter the direction of light, so as to see round a corner, as the Irishman's gun is alleged to have altered the law of projectiles in shooting round one; and we have not only the analogy, but the fact in every observed case, to make us conclude, that though the spider does not "live along the line," it certainly does "feel in the thread,"—that is, every thread of the web;—in the case for instance, of the Great Garden or Sceptre Spider, *Epeira diadema*, which posts itself on a central platform, or closer network than the rest. Every radiating thread which goes from this platform to the extremity of the web, not only brings intelligence to the spider of every thing that comes upon the section of the web connected with this thread, but brings intelligence which no other organ could communicate; and the intelligence thus brought is essential to the safety as well as the subsistence of the spider. Those spiders are exceedingly pugnacious; and their mode of hostility consists in the victorious one swathing up the vanquished in a shroud of the same material of which the web is made; which material is indeed the weapon used against all sorts of strong prey—for these spiders fight for food, and not for fame. The heaviest spider contains of course the greatest quantity of this matter, and is at the same time the strongest. The important discovery to be made by the spider is the weight of the one which invades its territory; in order that it may advance to conquest or escape from destruction, according to the information it receives. It also requires, or at all events the line communicates to it, the fact as to whether that which is on the web is or is not a spider: this may obviously be done by the invader trying the lines; and this is not a species of information that can be communicated by sight, any more than the fact of the weight. This spider is so very common in gardens in the warmer parts of England, especially those near cities and towns, where garden flies are more abundant than in open places, that any one may study it; and the study is very curious and highly instructive. Countless other phenomena and productions of the Autumn would claim attention, would space permit; but as self-information is by far more valuable and more lasting than lessons given in words, we can only conclude by entreating the reader to go into the fields and see with his own eyes the crowning of the year with the bounty of the Almighty Creator and Preserver.

THE END.

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