AN ADDRESS
ON
ELEMENTAL PATHOLOGY.

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EVERY pathologist must have felt that the greatest difficulty in his study is in the manifold complexity of the body in which it is pursued. The living human body is, surely, the most complex mass of matter in the known world. In composition, it surpasses the highest powers of chemical analysis; in mechanism, it is as far beyond the calculations of the physicist; its structures are but dimly seen with even the most perfect microscope; all the known forces of nature are constantly and coincidently at work within it; through circulating blood and a nervous system every part is within swift communication with all the rest; and it includes the apparatus of a mind, from whose influence no portion of its matter is distantly removed. And in this body the pathologist has to study, not that which is fixed, orderly, and natural, but that which is in disorder and unsettled. May we not, therefore, hold that, among all the sciences of observation, human pathology has, in the very nature of its subject-matter, the greatest difficulties to contend with?

I have long and often felt that, in these difficulties, we might gain help from studying the consequences of injury and disease in the structures of plants. For although these, too, are complex, minute and hard to analyse, yet they are less so than are the structures of any but the very lowest animals; and, which is most important, the processes in them are not subject to the influence of a nervous system, or of a common nutritive fluid distributed from a central organ and quickly carrying to every part materials derived from all the rest. In the absence of a nervous system and of a quickly circulating nutritive fluid, we come nearer to the opportunity of studying a really elemental pathology, nearer to the changes wrought between formed and varying formless matter. I say, without a nervous system, and without a circulating fluid; for though some of the properties of vegetable structures, such as are shown in their subjection to the influence of anæsthetics, their movements in relation to light, and the various groupings of their colouring particles, indicate a likeness to the properties of simple nervous structures; and though, through communicating minutest channels, every portion of a plant may be regarded as in relation with all the rest; yet these small degrees of likeness can scarcely detract from the great contrast between plants and animals in the having, and the not having, nervous systems and circulating bloods.

It was in the hope of promoting a study of elemental pathology that I determined, when I had the honour of being asked to preside in this Section, to put together various facts in vegetable pathology which, in the idleness of vacations, I had learned. I thought that I might provoke some of my hearers to a study which I supposed that few had pursued. I was nearly turned from my purpose when I found the vast quantity of good scientific work that has been done in it; the many volumes of books and the hundreds of papers relating to the injuries and diseases of plants which have been written within the last twenty years by both botanists and cultivators, especially by those engaged in the schools of forestry and orchard-culture in Germany. I saw no hope of studying them worthily; but, in those that I have had time to read, I have seen enough to make me more than ever sure that human pathologists may find, in watching the consequences of injuries and diseases of plants, facts of the highest interest in their more proper study.

Let me point out some few of these; but, first, I must disclaim all pretence of an ability to treat the subject as a scientific botanist, or a practical gardener, or anything intermediate between these excellent extremes. I can only, as a human pathologist, see that knowledge of great value is within our reach: I may be able to point out to you where and how some of it may be found; and I can promise attractions of novelty in the study, and of renown to be gained from it; for, admirable as is the work already published, very little of it has been done by those who could fully estimate its value in human pathology.

In my selection of subjects, I will limit myself to those that are of interest in general pathology; and, first, to hypertrophies, or the simple overgrowths of natural, or nearly natural, structures. Of these, I do not know that there are in plants any well-marked instances corresponding with those which are the most frequent in animals, in which a part grows in direct proportion to the exercise of its function, and thus may grow to relative excess when its function is, through the will or for necessary adjustment, excessively discharged. But, in plants, there are abundant opportunities of studying those forms of hypertrophy which depend on an increased supply of nutritive material to any part. To mention but one: the arts of partial or complete "ringing" and of constricting or bending the branches of trees depend for success on their insuring an accumulation of nutritive sap in the part of the branch from which its movement is checked. The result is what we may call an hypertrophy of flowers or, in other instances, of fruit, or wood, or bark, proportionate to the increased supply of nutriment; just as, in ourselves, hairs and some other structures will grow excessively with an excessive afflux of blood; or, still more and in almost exact parallel, as limbs will grow with a retarded reflux of lymph.

Similarly, I believe that you may find in plants many instances of the kind of hypertrophy which, in ourselves, we call compensatory, in that, one part being repressed or removed, another enlarges with growth of natural structures, as if for compensation; for I think that some of the arts of gardening are based on observations that removal of certain parts of plants will induce an overgrowth of others. Perhaps, among these you may find facts which may help to explain those obscure cases in animals and ourselves in which parts or organs, which have no natural alliance in function, are yet commonly allied in disease, as if they were in some relation of complemental nutrition. Such are the excessive growths of connective tissue and fat which may follow the removal of the generative organs; events well known but, I believe, not well explained.

I will not cite more facts. Only consider how many of the luxuries from our orchards and gardens are really such growths as in our pathology we should call hypertrophies, and that to produce these is within the art of the gardener, and you may see how large a collection of facts which may be useful in our study are within our reach, constantly at hand for observation and, which is yet more important, within the range of experiment.

Let me speak next of some illustrations of the simple defects of nutrition which we class as atrophies or degenerations.

I am not sure whether there be among plants any atrophies by mere wasting of parts once completely formed, which may be compared with the emaciation of animal structures.* Shrivelling, drying, withering, and defective growth are only too frequent; but these are all different from that unmaking and removing of structures which we trace in both the healthy and the morbid processes of nutrition in animals.

The atrophies with degeneration are very numerous; but I will take for illustration only that group which we may see beginning all around us in the decay and fall of leaves. This decay is their senile degeneration. It is marked chiefly by their changes of colour—the changes to which we owe the characteristic beauties of our autumn scenery. These are accompanied by changes of texture, shown in the dryness and brittleness of the leaves, and by changes of chemical composition; but I will refer to only the changes of colour. And observe that these indicate decay, not death. They do not occur when fresh leaves are quickly killed, as in hot water, or when they are pressed and dried for a herbarium.

Among many things to be observed in the changes of colour, let me first ask you to note their usual symmetry. One of the characteristics of mere degenerations, as we see them in old age, is that they are symmetrical. I hardly need cite instances; many of us may study them in ourselves or one another. Symmetrically we become, equally on right and on left, bald, or grey, or wrinkled, or dusky with dark pigment in our epidermis, and harsh-skinned with thickening and hardening of its cells. And we know that, as a rule, arteries become symmetrically fatty and calcareous; and that very commonly joints are symmetrically affected with the arthritis of old age; and so on. Now, similarly, the rule in leaves is that, in so far as they are symmetrical in shape and structure, so are the changes of colour which mark their decay or degeneration.† You may find, indeed, very many exceptions to the rule; for it cannot be observed in leaves which have been unequally expanded, or whose several parts have not been equally exposed to heat and light, or in which parts have been killed or injured. Many

* I may have overlooked many instances of it; but some that may seem like mere wasting are rather diseases with associated degeneration. Such are the gum-disease (gummosis), the resin-flux (resinosis), and others of the same group, which I find classed as liquefactive diseases, and in which cell-walls, wood, and other structures dissolve in or into morbid products. See Sorauer, *Handb. der Pflanzenkrankheiten*, p. 184; and *Frank. Encykl. der Naturwissenschaften, Pflanzenkrankheiten*, p. 369. I venture to guess that these may give help in the study of our mucoid and other liquefactive degenerations.

† "In so far", for the symmetry of living things is not mathematical; it is artistic, n the divine perfection of art.

accidents may hinder the observance of a rule of symmetry; but the observance cannot be an accident; and, if you will pick up leaves enough, and look well at them, you will see that the general rule of symmetry in the changes of decay is as evident as is the similar rule in our own symmetrical diseases and degenerations.

The changes may best be seen in those leaves or leaflets of dicotyledons which have a simple bilateral symmetry, a median vein, or fibro-vascular bundle, passing through the length of each leaf and giving off side-branches; but it is often scarcely less plain in palmate and in pinnate leaves, both in their several divisions and in the comparison of each division with its opposite fellow. In such leaves you may trace, in each pair of similar parts, similar changes of tint spreading uniformly or gradually over them; usually, first, from a darker to a paler green, from brighter to less bright; then to pale yellow or brown, or to some tinge of red or scarlet or flame-colour or some other of the tints that make autumn scenery glorious.

Now let me point out some things in our pathology which these facts may illustrate. The changes of colour are not mere chemical changes ensuing in a dead part. Leaves do not usually die till after, sometimes long after, they have fallen. Their changes of colour and of texture, even to the last dull brown in which they crackle as we tread on them, are vital changes in the same sense as are those which we see in ourselves in the advance of old age. In this view, they may be taken in evidence on the question as to the nature and meaning of some symmetrical diseases.

There are at least two reasonable theories concerning these diseases. One is, that the symmetry is due to the relation between some morbid material in the blood and certain parts which are symmetrically placed and are exactly identical in composition; absolutely like to one another, and not absolutely like to any other part which is not similarly affected by the same material in the blood. This was the theory on which Dr. William Budd and myself wrote our essays on the symmetry of disease nearly forty years ago. The other, which at that time I only ventured to suggest, but which is now, I think, rather dominant, is that symmetry in disease is determined by the disturbed condition of symmetrically distributed nerves, the disturbance issuing from a single nervous centre. I cannot now discuss this question, or endeavour to show how probable it is that each theory is true and sufficient for certain cases, and that for some they must be combined; but the symmetry of decay in leaves may be taken as a strong fact in support of at least these two principles: 1. That symmetrical changes may occur in degeneration and disease, as certainly as in development, without any influence of a nervous system or of a circulating blood; and 2. That, among structures which, to all our tests, may appear identical, those alone may be absolutely alike which are symmetrically placed. Surely no two things can appear more alike than are two adjoining leaves of a tree, or two parts of the same leaf; and yet, if, under the same conditions, these do not decay in the same time and measure, it can only be because they are not absolutely alike. Thus the symmetry of decay in leaves may prove that none but symmetrically placed parts may be verily alike; and thus the possibility, to say the least, that in ourselves a diseased blood may similarly affect only such parts; and thus that, among symmetrical diseases, there may be some of which the essential and sole necessary condition is some morbid material in the blood.*

But let me now point out another of the lessons which may be read in the decaying leaves; for really the pathologist may find in them as many as the moralist and the poet have found.

The leaves, I have said, are decaying, not dead; and their fall is due to other degenerative yet truly vital changes. Dead leaves do not similarly fall. If a branch have been killed before autumn, you may often see its dead leaves hanging dry and withered all the winter through; and often, when leaves are yellow and withered in their last decay, they hang quivering and spinning, ready to fall, yet waiting. Each leaf is literally hanging on a thread; and at last, by a rougher wind, or a drop of rain, or some chance-violence, the thread is broken, and the leaf falls.

This breaking of the thread is preceded by degenerative changes in the structures of the leaf-stalk and of the stem adjacent to their juncture or articulation. These changes were first well described by the late Dr. Inman† of Liverpool; they have since been made more fully known by von Mohl* and others; and the rules observed in them hold, with certain variations, in the fall of petals, bracts, fruits, some twigs, and other deciduous organs.

In their beginning and maturity, the structures of the leaf-stalk and the stem or twig are continuous. There may be some external mark of distinction; but within there is exact continuity; the epidermis, parenchyma-cells, fibres and sap-vessels are alike continuous. But, in preparation for the fall, changes ensue in the adjacent parts of both leaf-stalk and stem. In both, alike and equally, the cells multiply by partition; and those most nearly adjacent change, by a process of degeneration, into cork-cells, dry, brown and air-holding. Then, as these degenerative changes advance from opposite directions towards the plane of junction between leaf and stem, they meet; and, at their place of meeting, an intermediate layer, or rather two layers, of cells die and become scale-like and part asunder; and now the leaf is ready to fall. It hangs only on the dried thread of fibres and vessels which pass into it from the stem; and the stem is protected by its layers of cork and withered cells from the invasion of parasites and insects.

It would be hard to find a more admirable instance of processes adjacent, coincident, concurrent to a common end, yet independent. We have many of the kind in our pathology, but none more evident, or more within reach of complete study, as of vital processes tending to one end, but not guided from one centre; concurrent, but not concatenate; as independent as are the works of the several bees that make one honeycomb. And thus we may learn from the falling leaves a lesson against thinking that, when we see concurrent morbid processes, we must always expect to find some centre from which all are guided. It is not to be doubted that in organisms such as ours, in which the work is more divided according to its kind and more distributed to appropriate organs, more is subjected to regulation by central organs, and the working of each part is more influenced by that of all the rest; yet it is not probable that, in any instance, the law is abrogated according to which each elemental structure lives its own life in a method determined by its own inherent properties. There is no law in pathology more important than this: let the falling leaves remind us of it.

And yet one lesson more. That thread on which for a time the falling leaf hangs quivering—that thin bundle of fibres and vessels connecting it with the stem—is regarded as a development from simpler cell-structures. Fibres and vessels are "higher" structures; so much higher, that the relation between the Vasculares and Cellulares in plants may match in importance with that between the vertebrata and the invertebrata in animals. But mark this instance of anomaly in our language. In the elevation from the lowly cellular state to the higher dignity of fibres and vessels, there is, indeed, an instance of that development which makes fit for membership in a higher economy; that is, an economy more nearly like our own. But in the attaining of this fitness there is loss of vital power. There is no such activity of organic life in the vessels and fibres of wood or bark as there is in the cells around them; they are comparatively unchanging; they cannot multiply; they cannot repair their own injuries; cannot protect themselves; cannot even degenerate as the fading leaf-substance around them does (for even to degenerate needs vital power); they can only die, and the dead thread on which the decaying leaf hangs cannot dispart itself; it must be broken by some alien force. In the taking of higher form, the cells seem to have spent their power of forming.

Now we have in ourselves similar instances of degenerations which we call developments. When cartilage becomes bone we usually say it is developed; but this is only because it becomes fitter for a share in a higher condition of our economy. The man is "higher" than the child, and therefore we are ready to speak of everything as ennobled if it contributes to his manliness. But, in respect of texture and self-activity in vital process, in the activity which can work with even a distant supply of blood, cartilage is better than bone; and the change into bone partakes of the nature of a calcareous degeneration; in general utility there is development, in self-activity there is degeneration.

The same may be said of many changes from cells to fibrous structures in ourselves. In teleology there is elevation; in vital histology, degradation. And this anomaly of words is found, not without some confusion of thought, in parts of our pathology. We speak of rickets as a hindered or arrested development, and so, in respect of purpose and utility, it is; but, in respect of elemental tissue-life it is rather an arrested degeneracy.

You may study such anomalies of terms in many instances in plants. Let me suggest a thesis for the D.Sc. There are such things as green roses: show the analogies between a green rose and a rickety child.†

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* In connection with this subject, it may be useful to study the variegations of leaves, in some of which, as in many varieties of Begonia, a perfect symmetry of colours is observed; in others, as in many laurels, complete asymmetry. Instances of completely unilateral decay may sometimes be found in cabbage-leaves and turnip-leaves near the roots; sometimes, also, in laurel-leaves. They may be suggestive in the study of unilateral organic diseases, some of which are not wholly due to disturbances of trophic nerve-force.

† Henfrey's *Botanical Gazette*, 1849, p. 59, from the Proceedings of the Literary and Philosophical Society of Liverpool, No. 4, p. 89.

* *Botanische Zeitung*, 1860, Jahr. 18.

† Help may be found in the study of Dr. Ord's thoughtful paper "On Brownian Movements" in the *Journ. Micros. Soc.*, June 1879.

But now let me end my notices of those changes in plants which you may study for illustration of atrophies and degenerations and retrogressive metamorphoses in ourselves. There are many more, such as the sweetening of fruits, in which, while becoming more useful to ourselves, they acquire chemical conditions less distant from inorganic matter; and the red and yellow tints of ripeness, which are colours indicative of imperfection, or the central softening and decay of fruits very like that of large morbid growths. In all these, as well as in decaying leaves, you may study general pathology when and where you will.

I will next speak of the repair of injuries. In studying the processes of repair in plants a first observation may be that, speaking generally, the repair of injuries and diseases is less complete in them than it is in animals, even than in ourselves and others of the highest groups. The processes of repair, so far as they extend, are similar in both, but in plants they rarely extend further than to be defensive or protective to the injured parts; they seldom reach to what may justly be called reparative or reformative, and much more rarely to anything that may be named reproduction or regeneration of lost parts. Indeed, the only instances of reproduction which I have found recorded, are those of the cells of Vaucheria,* and of parts of the minute leaflets of the small moss, *Bryum Billardierii*, and even in these the mid-rib was not reproduced.†

In most of the ordinary wounds and other injuries of leaves and stems, as well as of petals and fruits, we see only incomplete repair. Punctures and incisions and minute excisions, such as in ourselves would be quickly closed and healed, and in a few days be almost unobserved, are, in plants, not closed at all, unless with careful help and in some few species.‡ The gaps or spaces are not filled-in with new material, there is no tendency to contraction, the edges do not draw together. The healing which does take place in these cases may be compared most nearly with that which, in animals, we see in wounds left open and healing under a scab. The cells and the ends of the fibro-vascular bundles which are cut across empty themselves and die, and then, becoming dry, they slowly scale off and are detached: or, the contents of the cells may ooze out and yield a gummy deposit which may dry and glaze the surface of the wound. After a time this cracks and is detached, but while it lasts it serves, as do the dead and dry layers of divided cells, for some protection of the cut surfaces. They serve, alike, for timely protection against invasion by parasites, just as in an animal do the dried blood or the first exudation on a wound left open. Beneath this temporary protective layer the more permanently protective or reparative changes now ensue, and these are usually described as in two methods: the formation of cork and the formation of callus.

In the healing with cork, which is the more frequent in the more succulent parts of plants, the layers of cells next beneath the dead cells or the gummy covering multiply by frequent partition, forming rows of thin-walled flattened cells. Then of these the outermost, lying at and next to the surface of the wound, become cork-cells, their walls thickening and their contents being replaced by air. The more deeply seated remain active, still capable of multiplying and of replacing the cork-layer, which now serves as a dermal covering, and becomes continuous with the periderm at the borders of the wound, but does not acquire an epiderm.

In the healing with callus, examples of which may be studied in the closure of the wounded surfaces of slips and cuttings, the living cells next to the surface of the wound grow out into papillæ or short pouches, with or without cell-division. These may form a protective cork-layer, and if they approach from nearly adjacent surfaces they may intermingle and unite; or they may form other structures, replacing those injured, as epithelial cells, parenchyma-cells, or a new cambium layer, in which bark and wood and fibro-vascular bundles may form.

The best instances of healing after this manner are in the wounds or the splittings or strippings of bark which do not go through the outer layers of the cambium in vigorously growing stems or branches.§ In the actively living structures of the cambium, if it be very gently guarded, callus forms by outgrowth and division of cells, somewhat after the manner of granulations, and of these, not only bark but wood, vessels, bark and cork may form and become connected with the similar tissues at the borders of the wound.

These, I say, are examples of the best healing known in plant-structures, and they must be worth studying carefully, for they would illustrate many points in our own healings and are far more apt for minute examination than any injured structures in animals.* Yet even in these the defective reparative power in plants is shown. An animal, if skin be stripped from it, will, if possible, lick the raw part, and then let dust and hair and dirt collect and help to make a scab with blood and oozing fluid, and under the scab new skin will form, not indeed perfectly but well. But when bark is stripped only down to the living cambium the raw part must not be touched; mere wiping or touching with the finger, or too much drying, may kill the cambium-cells and prevent all healing; or parasites may attack it and make more mischief. And when we leave these best cases the repairs observed in plants are far less; even small branches or twigs when partially broken do not reunite, unless in a few instances in succulent plants in which the broken surfaces are carefully kept in contact, and even in them no new woody tissue may be formed. You know what is called in surgery a greenstick-fracture and its sure method of repair. In a real green stick no repair of the kind would happen; no ensheathing or intermediate callus would form; at the best the broken surfaces would be covered with a protective layer of cork without an epiderm. I cannot find an instance of repair in plants which even approaches in completeness to the ordinary repair of a broken bone or a divided nerve or tendon in ourselves or any other animal.

Perhaps the strongest contrasts may be seen in the wounds or strippings of trees that go down to the layers of wood; or, in what will follow the amputation of a branch from a tree and of a limb from a man. You may see in front of St. Catherine's College some elms from which branches were cut yesterday; and not far off, at Addenbrooke's Hospital, I dare say you may see patients from whom parts of limbs have been amputated; and, if the stumps have been treated after the manner advised by our distinguished President, they will have been left to be repaired by nature, as truly as are the stumps of the branches of the elms. The stumps in the hospital have been cut in better shape for healing; but those in the garden have the advantage of more perfect rest, and, in whatever shape they might have been cut, the result would have been the same. Now, it is most probable, nearly sure, that the human stumps will be healed in a few weeks, and that in two or three months all the wounded parts will be covered-in with skin and scar and cuticle firmly adhering and compact. But it will need a very long life to see the healing of any stump of the same size on the trees. The wood cut across will die, and its necrosis will never be repaired; rotting, like a caries, may extend from it into the trunk, but it will not be repaired. Year after year the annually formed rings of new wood and bark will overlap the borders of the wound; each year they will grow thicker and will converge, and at last after many years they may, perhaps, meet and coalesce and cover-in the wounded surface; but they will not unite with it, there will always be a cavity over the dead wood: a stump so ill-healed as would be a shame to any hospital. I must not imply that there are no better healings after amputations in trees than you may see in elms: some trees heal better, as do beeches and planes; but I think it may be said generally that the stump of any branch will need more years for its healing than the stump of a limb of the same size will need of weeks; and that, in the end, the work of the weeks will be far more reparative than that of the years. And in this reckoning I would include not only the limbs that have been surgically cared for, but those that have been violently crushed, mutilated, or torn off in animals left to themselves.

This slowness and defect of repair are observed in other things besides the healing of wounds. Dead portions of leaves, or of wood, or other structures, are not cast-off unless by external force.† We have borrowed the word "exfoliation" to tell of the separation of dead bone; but, as I have said, it is only living leaves that can exfoliate. Dead pieces of young wood remain where they were killed, as they often are, without external wounds, by hail stones‡ or any accidental blows. The structures adjoining them may become hard or corky, but they do not separate from them, there are none of the reparative changes which are seen in even a "quiet necrosis". Similarly you may often see dead tips of leaves, perfectly defined from the living parts by colour and by texture, yet without any groove or other sign of process of separation, the dead and the living epidermis remaining still continuous. And as to recovery from diseases I believe it may be summed up in saying that no vegetable structure altered by disease ever reverts to its original healthy state.§

* As quoted from Hanstein by Frank in the *Encykl. der Naturwissenschaften*, Abth. i, Lief 12, p. 380; and in *Botan. Zeitung*, 1873.

† Described by K. Müller in *Botan. Zeitung*, 1856, p. 200, and quoted by Frank, Waldenburg, Beijerinck and many more, who do not add any similar fact.

‡ See Frank, *l.c.*, p. 383-4.

§ It may be well studied in longitudinal wounds made through bark for the relief of tension (See H. de Vries in *Archives Néerlandaises*, t. xi; Haarlem, 1876).

* I have adopted, chiefly, the descriptions of healing given by Frank (*l.c.*). I hope that more minute descriptions and more mutual illustrations between animal and vegetable repairs will soon be published by Mr. Shattock, who has been studying the subject with great care and skill.

† A partial exception must be made for the tips of the fibres and vessels divided in some cuttings. See Arloing, *Sur le Bouturage des Cactées*, *Ann. des Sc. Naturelles; Botanique*, B. iv, p. 24, 1876.

‡ Goethe, *Ueber den Krebs der Apfelbäume*, 1877, p. 2.

§ "It is confessed that diseases in the vegetable kingdom, when once established, are, for the most part, uncontrollable." Berkeley, *Gardener's Chronicle*, January 21st, 1854, p. 37.

Now let me commend to you this subject of the repair of injuries in plants, not only for illustrations of our pathology, but as a part of the study of what may be called the philosophy of healing. They heal very slowly and imperfectly, they may need many years for the healing of small injuries, eight or nine years for a frost-crack in a young branch:* yet they do heal; the intention, as Hunter would have called it, is not given-up. Let me relate one case.† A fir tree, fifty years old, had a large piece of bark stripped from its trunk. The wound extended round nearly a fourth of the circumference of the trunk, and laid bare the wood. It was not dressed or guarded; the outer layer of the exposed wood died as usual, and then every year the successive annular growths of new wood and bark extended a little further over the bared place. In one hundred and fifty years these growths met and coalesced, and the wound was covered-in. When the tree was felled and cut through at the injured part, where there was still a deeply depressed scar, the concentric rings of wood proved the growth of fifty years before, and one hundred and fifty after, the injury, and even now the healing was not complete; there was still a cavity between the old wood and the new; the healing was not such as we should call good in any similar case in an animal. Still, there was healing; the "intention" was maintained for a century and a half.

Surely, in our familiarity with the processes of repair we overlook their wonder; the wonder that there should be in anything an inherent power of repairing the consequences of accident; that, for instance, in any one of us, after living for many years, with only those timely regular changes, the methods of which we have inherited from our ancestors, an accident, some quite unlikely event, such as may never have happened to an ancestor, such as no conceivable process of selection or of inheritance can have prepared us for, some mere chance as we must call it, should bring-out an increased power and a new method of organising structures exactly adapted to the repair of the consequences of that chance. And let me remind you that this power of repair is not a property of living things alone—it is evident in crystals.

It may seem unreasonable to say that we may study principles of elemental pathology in the apathetic inorganic world, or in things that we call dead. But certainly we may study them in crystals. The experiments of Jordan which I repeated many years ago, and related in lectures at the College of Surgeons,‡ have been extended by Pasteur,§ Karl von Hauer,‖ and others, and this chief fact has been abundantly proved—that if a portion of a crystal be broken off, or filed or dissolved away, and if then the mutilated crystal be replaced in a solution of the same salt or of an isomorphous one, the lost part will be replaced, the damaged form will be repaired. In this process of repair the whole crystal will be enlarged, new crystalline matter will be formed on every surface, but the quantity formed on the injured part will be greater than that formed on any other part, and repair will be more active than mere growth till the proper form of the crystal is regained. Then, when the repair is complete, growth alone will go on and each part of the crystal, if it remain in the same solution, will increase in due proportion with the rest.

It seems impossible, by any just definition, to separate this process from those which, as pathologists, we study in the repair of the accidental injuries of living bodies. In all alike, when a natural form has been lost or impaired by external force, the native formative power works at the injured part with an energy and a method modified appropriately to the recovery from the loss, and then, when the recovery is achieved, returns to its previous energy and method. Of all alike, it may be said that where we find evidence of a design to be fulfilled in the attainment or maintenance of a certain form, there, also, we may find evidence of some power to repair injuries which that form may sustain from accidental external forces.¶ However various in its degree and method the power of repair is in all.

I wish that some of you, with a good broad knowledge of pathology, would study this repair of crystals and the possibility of their recovery from other changes besides those of form. The study could hardly fail to yield facts that would be very useful in the proper business of our lives. Only let me warn you that, as I have learned from Mr. Maskelyne, injured crystals need great care; if they are to be well repaired they must have as gentle handling and as kindly nursing as the tenderest patients of our own race.*

* Goethe, *loc. cit.*, figs. 3 and 4.
† From Ratzeburg, *Die Waldverderbnis.*, vol. i, p. 98, pl. 21-22, and 31*a*-32.
‡ *Lectures on Surgical Pathology*, p. 118, ed. 3.
§ *Ann. de Chimie et de Physique*, t. xlix, 1857, p. 6.
‖ *Sitzungsbericht der K. Akad. der Wissenschaften*, B. xxxix; Wien, 1868, p. 611.
¶ In the repair of crystals, it is well seen that form, rather than size or other quality, is the highest object of the reparative process. Karl von Hauer has found that if a portion of a crystal be so removed that all the parts of the remaining mass are still within the law of its primary form, the repair is either very slow or is even not attempted.

Even if, in studying the repair of injured crystals, we should not learn things directly useful in our own pathology, yet the facts should keep us safe from the error of referring reparative processes to such supposed causes as are called increased action, or determination, or reflex trophic force, or the like; they must convince us that repair is the result of some elemental general law of formed matter prevailing beyond the whole range of life and living structure, even in all natural bodies having harmonious form and proportions.

But while, in the widest survey of repair that we can take, we may thus see an instance of so simple an expression of the Divine Will as we call a general law, yet, in the degrees of apparent observance of that law, we find differences very wide and, so far as I know, quite inexplicable. We do not find equality of reparative power in all formed bodies, nor any rule of proportion between that power and their less or more simplicity of structure. There are some rules of such proportion among animals, but they are very partial, and the rule fails completely when we compare the reparative processes in plants with those in animals.

Let me revert to this comparative defect of healing powers in plants, though it may be only to tell my ignorance of all relations between it and any other of their properties or the conditions of their life. It is not related to any immunity from injuries enjoyed by them, for they are far more exposed to injuries than are animals; nor to any absence of necessity for healing, for, after wounds, they suffer severely, and often fatally, from the attacks of parasites of all kinds. It is not because of any lack of productive power at the injured part, such as we might be disposed to refer to the want of circulating blood or of nerve-force; for from many wounds of plants, as the art of grafting and of multiplying by slips or cuttings may show, entire new plants may grow; and yet these are not reproductions; they may, in one sense, replace that from which the slip was cut away, but they do not reproduce it; they are not continuous with its remains, and they commonly become much more than that which was lost would have become. Again, the increased growths which injuries may produce in plants are not to their own advantage, though they may be so to that of a successor or a parasite; and on many wounds of wood hard and heaped-up masses of new wood may form, such as may be roughly compared with our cheloid scars and excesses of bone-callus. Neither can the defective repair be ascribed to any general tenacity in the regular methods of growth in plants, or to any general want of pliancy or of ability to adjust themselves to new conditions; for the art of horticulture abounds in instances of changes in methods of growth completely adjusted to changes of condition. There are in plants ample powers for enlarged growth and ample range of pliancy in method; but that special change in method of growth, which is familiar to us in ourselves and other animals, and which, as with design and on purpose, is adapted to the speedy healing of injuries, is in them comparatively defective. Which of you will work so as to find the explanation of what seems so strange an inconsistency?

(To be continued.)

* Yet their healing may be "left to nature". Mr. Maskelyne has often seen in native crystals marks of injuries repaired.

DROITWICH RURAL.—The statistics for this district show that during 1879 the birth-rate slightly decreased, whilst the death-rate increased. The infantile death-rate was higher than during the two former years, but the deaths over sixty showed a great increase; whilst the deaths from the ages of five to sixty were only 88, showing a death-rate of 5.04. Dr. Swete regards, therefore, the increased death-rate as clearly due to climateric influences on the very young and on the aged. The death of one female was registered at the age of 102 years. The zymotic death-rate was lower than it had been during the previous four years, scarlet fever having much decreased. No epidemic occurred throughout the district, the cases of zymotic disease being nearly all isolated, and some of them being imported cases. In one case of scarlatina, gloves were being made for the trade at Worcester. Dr. Swete communicated with the manager of the factory, and had the stock of gloves and material perfectly disinfected, and no more sent to the infected house. As he points out, gloving in a house infected with scarlet fever is a ready means of spreading the disease amongst families where no clue to the cause of infection is apparent; and it would seem necessary for great caution to be used in the giving out of work to houses where there is a suspicion of the presence of infectious disease. The birth-rate of the district was last year equal to 32.8 per 1,000 of the population, as against an average of 32.4; the death-rate 18.3 per 1,000, against an average of 16.56.