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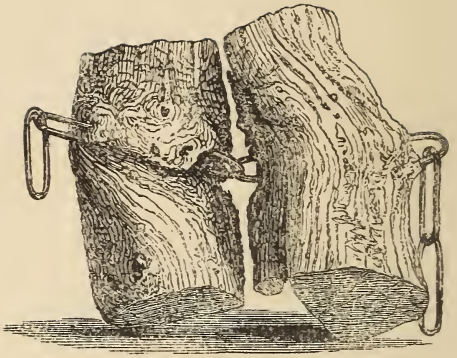
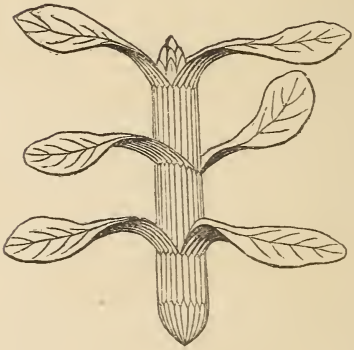
LETTERS ON TREES.





TREES AND THEIR NATURE;

OR,

THE BUD AND ITS ATTRIBUTES:

IN A SERIES OF

LETTERS TO HIS SONS,

BY

ALEXANDER HARVEY, A.M. M.D.

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TO

WILLIAM PULTENEY ALISON,

M.D., EDIN.; D.C.L., OXON.;

VICE-PRESIDENT OF THE ROYAL SOCIETY OF EDINBURGH;

FIRST PHYSICIAN TO HER MAJESTY IN SCOTLAND;

EMERITUS PROFESSOR OF THE PRACTICE OF MEDICINE IN THE UNIVERSITY OF EDINBURGH;

FELLOW AND LATE PRESIDENT OF

THE ROYAL COLLEGE OF PHYSICIANS, EDINBURGH;

ETC., ETC., ETC.

These Letters are Inscribed,

IN

TESTIMONY OF PROFOUND RESPECT FOR HIS PUBLIC AND PRIVATE WORTH, AND AS AN EXPRESSION OF PERSONAL REGARD,

BY

THE AUTHOR.

PREFACE.

THE view given in these Letters of the nature of Trees, although, in the main at least, the same as that first set forth by De la Hire, as long ago as 1708, and subsequeutly held by Darwin, Mirbel, Du Petit-Thouars, Gaudichaud, and others, differs widely from that commonly received among us. It neither represents the popular belief, nor does it accord with the recognised doctrines of the schools. To the popular mind, indeed, it may be said to be nearly unknown, while heretofore it has failed to secure the sanction of the greater number of our scientific botanists.

So little, indeed, has the theory been countenanced by botanists, that, to take Professor Balfour's excellent *Class-Book of Botany* (one of the fullest and most recent of our systematic treatises), as a fair exponent of the received doctrines in vegetable physiology, it may be questioned whether the notice there taken of the theory would lead any ordinary reader to do more than bestow upon it a passing regard, or would suggest to him the application here made of it (and obvious in itself) to two practical questions respecting trees—questions often put, and commonly felt to be exceedingly perplexing, viz., "To what age do they naturally live?" and, "To what size do they naturally attain?" Certain it is, that in considering these questions, Professor Balfour himself makes no allusion to the theory, and seeks for a solution of them in a direction altogether different from that in which it points.

It is precisely because our prevailing notions, both popular and scientific, differ so widely from what the author believes to be the truth on this subject, that he is induced to publish this volume. He is himself

so convinced of the soundness of the theory which he advocates, that he feels persuaded that all that is needed to secure for it a ready and general acceptance, is to lay both the theory itself and the evidence in support of it, fully and clearly before the mind. This, he ventures to submit, has not yet been done; and to this circumstance he would attribute the position which the theory at present holds. It appears to him, that, while, on the one hand, some supporters of the theory have advanced arguments in its behalf which are really untenable, so, on the other hand, some of its opponents have erroneously imagined that they had disproved the theory when they had merely shewn the fallacy of those arguments. It appears to him, likewise, that in respect both of the arguments in support of it and of the arguments in opposition to it, too much has been made of considerations connected with the *wood*, and too little of considerations connected with the *bud*. The former, indeed, seem to him extremely valuable, and he has taken full advantage of them in his argument. Yet it is rather on the latter that he would rest the theory. The in-

ferences to be drawn in support of it, from the nature and attributes of the bud, seem to him so unassailable and so convincing, that, although he does not imagine that, in the exposition here given of them, he shall succeed in carrying conviction to the mind of every one of his readers, he is not without a confident expectation, that among all classes of these, both the learned and the unlearned, the *contents* will greatly out-number the *non-contents*.

Although continually spoken of in these Letters as his own theory, the author begs to disclaim all pretensions on the score of originality. He has advanced nothing that was not known or held before. The only merit he is disposed to claim in connexion with it is, that of having unfolded it more systematically, and in greater detail, than any of his predecessors. At the same time, he thinks it due to himself to state, that it was worked out by him, substantially as it now appears, without any assistance from others; that it was embodied in the course of Lectures on Physiology, which he delivered in Marischal College during the winter session of 1844, without any recollection

at the time of the views of M. Du Petit-Thouars; and that it was subsequently more largely developed in a paper *On the Nature, Longevity, and Size of Trees*, which he published in the "Edinburgh New Philosophical Journal" for January 1847, long before he had any knowledge of the writings of De la Hire, Darwin, Mirbel, or Gaudichaud.

What led the author to direct his attention to this subject was, a difficulty he felt soon after he began his labours as a teacher of Physiology in 1840, in bringing trees within the pale of two laws universally regarded as applicable to *all* living beings—the law of a determinate duration of life, and the law of a determinate size of organism. His earlier inquiries disposed him to regard the difficulty as insuperable, and the laws as so far exceptional. After a time, however, two things drew him into the train of thought out of which the theory sprang. One was, reflection on the potato-plant as the produce of a *stem* furnished with *buds*, and capable of being reproduced from year to year *indefinitely* from buds alone, and the comparison of this with the results of

slipping and grafting in those trees that admit of being propagated in that way. The other was, reflection on the entire absence in all vegetables of anything corresponding to the *renewal of substance*, which is constantly going on in the living tissues of animals, and by which alone their *continued* vitality is maintained. Once in possession of these two keys, the whole theory, as here unfolded, gradually, and without any sensible effort, took shape in his mind. The difficulty referred to vanished, and the laws, imagined to be exceptional, stood out in their character of universality.

Trees being in themselves objects of universal interest—of interest even to the young, the author, while he has made it his first aim to treat his subject in a scientific spirit, has yet striven also to present it in a form, and in language adapted to the general and the juvenile reader. And, holding to the young persons to whom these Letters are more immediately addressed, the relation therein indicated, and writing under the promptings of that relation, he has not hesitated, as occasion offered, to introduce such ob-

servations as might lead them (and others of their tender years into whose hands this little book may come) to associate Nature with God, and Natural Truth with Revealed; and, in the words of the late venerable and revered author of the *Essays on the Nature and Principles of Taste*, "to look upon the universe which they inhabit, not as the abode only of human cares or human joys, but as the temple of the LIVING GOD, in which praise is due, and where service is to be performed."

SOUTHAMPTON, *December* 5, 1855.

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LETTERS ON TREES.

LETTER I.

"As the days of a Tree, *are* the days of my People."
"Les Jours de mon Peuple *égaleront* les Jours des Arbres."
ISAIAH lxv. 22.

March 10, 1854.

MY DEAR SONS,

1. The Winter is gone, and Spring is come again. The Sun, "like a giant refreshed with sleep," is again putting forth his strength; and under his influence, as the instrument of Him who made and still upholdeth all things, "the earth is again rising as from her grave into life and beauty." What season more fitting to take up our favourite subject—the Trees, and to pursue those speculations regarding their natural longevity and size, and likewise regarding their real nature, which have so often, in the fields and by the fireside, formed the subject of our casual conversation. The buds on many sorts of trees are already swelling. and the sap in the immediate vicinity of the buds is

already in motion,—to be followed, ere long and in quick succession, by the evolution of leaf, and flower, and fruit, and wood, and root, and by a perfect circulation of nutrient fluid in all the living and growing parts; and all this to be succeeded before the year has run its course, by the falling of the leaf, the dropping of the fruit, and the cessation of all vital action in what remains.

2. Taking up the subject now, ere yet the annual process of vegetation is well begun, and following this process through its several stages, we may have it in our power in the course of the season to make for ourselves observations enough, and experiments enough, to satisfy us whether our speculations be true to nature and to fact.

3. Of Trees in general, then, as of particular kinds of trees—for example, the Oak, the Elm, the Beech, the Fir, &c.—it may be asked, and often is asked, "How long do they naturally live?" And, "To what size do they naturally grow?"

4. Before proceeding to consider the answers to be given to these two questions, let us clearly understand on what footing the questions rest. To most, if not to all who entertain them, the questions proceed on the assumption that a tree is a *single* object, in a sense precisely analogous to that in which an ox or a horse is so regarded; they imply that every tree is as truly an *individual* being, corporeally regarded, as each of

us is; and has as real a *personality* as belongs to our mare *Fanny* or our dog *Cæsar*.

5. Nor is this all. They proceed also on the principle, that however the appointed term of life and size of organism may vary in the different sorts and species, *all* living beings without exception are subject to the law both of a determinate duration of life, and of a determinate size of organism.

6. And this principle is unquestionably a sound one. No law of nature is more absolute or universal than the law of mortality. Everything that lives, be it plant or animal, lives only for a given time, on the expiry of which it passes into the state or condition of death. Nor is this left to be brought about by accidental causes. To these, indeed, it is often owing, the greater number—probably of all sorts—of living beings thus prematurely perishing. But independently of such causes, the loss of its vital properties, and the cessation of its vital actions, is a fundamental law of the constitution of every living being. The conditions of its existence include within themselves provisions for its dissolution. The arrangements to which it owed its origin, and by which its vital actions have been since performed, are such as unfailingly ensure after a time the extinction of its vital powers,—

"Nascentes morimur, finisque ab origine pendet."

Such changes are gradually wrought in it by the

agency of its own vitality, as are ultimately incompatible with the longer continuance of life. Death then follows as a matter of course. And those changes are attended by a gradually increasing languor or sluggishness in the vital processes, and by a corresponding hardening and rigidity of the textures composing the organism,—changes that constitute and betoken the state to which the name of *old age* is given ; a state which obtains uniformly when life is not prematurely cut short, and is indicative of the approach of death.

7. Again, all organised bodies have an appointed size or bulk of organism. Of lifeless inorganic bodies, it cannot be affirmed that they possess any such property, being larger or smaller, to any conceivable extent, according as circumstances may determine. It is otherwise, however, with animal and vegetable organisms. These have naturally a fixed or standard size to which they grow, and from which they never greatly deviate.

8. I have perhaps needlessly gone into these details respecting this principle. But I have purposely done so, and for this reason, that, while the principle is confessedly one of the grounds on which the questions before us proceed, and one which I hold to be unassailable, no answer that may be given to the questions, that is not in conformity with it, can be regarded as satisfactory.

9. If, then, every tree be a single or an individual object, it is plain that, by the laws of its being, it must have a determinate period of life, and a determinate size of organism; and allowing that neither of these is *absolutely* fixed any more than in the case of the dog or the horse, but that each may vary within *certain limits*, there must nevertheless be an *average* in respect of both for each kind or species of tree—it being of course understood, that all the conditions requisite for its natural life and growth, obtain. And accordingly, the questions before us thus qualified are—"How long does this or that kind of tree naturally live?" And, "What is the size to which it naturally attains?"

10. These questions, you may imagine, must admit of a ready and a satisfactory answer. True, you may feel yourselves unable to answer them, and yet reasonably presume that our knowledge of all sorts of trees must be complete and accurate enough to make the answers easy to those possessed of that knowledge. They are not far to seek, speaking generally, as regards animals. Migratory as animals are, difficult of access or dangerous of approach as many of them are, these points in their history are accurately known, or may readily be ascertained in regard to a large proportion of them. How much more easily in regard to trees! Fixed to the soil as trees are, remaining always on the same spot of ground in which they were first planted,

or on which the seed dropt from which they sprang, continuing year after year, and from age to age, to be seen and read of all men living near them,—and many of them, in all parts of the world, allowed to live on and grow without let or hindrance, one would think that nothing were by this time better or more familiarly known than the natural age and size of trees.

11. It may very confidently be affirmed, however, that on the assumption stated as to the *nature* of trees, —to wit, that every individual tree is an individual plant, nothing definite or satisfactory has yet been ascertained respecting either the natural longevity or the natural size of any one species of tree—a circumstance which contrasts remarkably with the precision of our knowledge, as far as it goes, as to these particulars in the case of animals, and all the more from the facilities which thus obviously obtain for making observations upon trees. Nay, more, there are many known facts in regard to trees which, on that assumption, it is difficult or impossible to reconcile with the principle of their subjection to the laws of a limited duration of life, and of a limited size of organism.

12. But what if that assumption be a wrong one? What if trees be not what they seem to be, and what most persons take them to be? The common notion, as we have seen, is, that a tree is an individual in the same sense that a dog or a horse is, and it certainly appears to be such. It is assumed that the trunk, and

roots, and branches, the leaves, and flowers, and fruit, and buds, which form component parts of every tree, go to make up one and the self-same plant, in like manner as the bones and flesh, the nerves and blood-vessels, the heart and lungs, the head, and trunk, and limbs of a dog, do truly form the parts of one and the self same individual animal. Doubtless that is the common belief. A tree is regarded as having the same sort of individuality or personality that you or I have.

13. My notion, however, of the nature or constitution of a tree is widely different from this. In my view, it is not an individual in the proper or scientific sense of the term, but, on the contrary, *a body corporate;* and regarding it in this light, I hold that, but for purely *accidental* causes, any and every tree might live for ever, and go on growing and enlarging to any conceivable size. You have heard it said that the King of England never dies; and you will readily understand that what is not true of individual men may yet be true of individual families, or of the race in general. "*Hæc Naturæ lex, hoc consilium, ut singuli pereant homines, gens humana floreat,*"—individuals die, but the race lives on and multiplies. The Corporation of London has lasted, one may say has lived, some hundreds of years; and unless swept away by some such extraneous cause as an Act of the Legislature, may last till the end of time, although the individuals com-

posing it may none of them pass the allotted three-score years and ten.

14. Just so in respect of a tree. Take an Oak at mid-summer, in full leaf and in its full vigour. It is neither more nor less than a collection (an aggregate or corporation) of living and growing but separate and distinct oak plants, the production of the current year, and likewise of the *dead remains* of a still larger number of individual plants of the same kind or species, the production of a series of bygone years. And of these oak plants, each and every one lives only *one* year, and attains its *full* growth within the year—making provision in the form of buds for the evolution of similar plants the following year. Further, the plants of each year, shooting up in spring from the buds formed by the plants of the previous year, grow *parasitically* on the persistent dead remains of these. Acquiring their maturity in summer, and reaching to the height of a few inches only, they pass into the state of *old age* (the sere and yellow leaf) and eventually *die* in autumn, save only the buds they have formed, which survive the winter. And thus dying, the greater part of every one of them speedily undergoes decomposition, and disappears. The woody stems and roots alone remain. These, although dead, escape that process. Tipped with the living buds (as the ground may be said to be with the acorns that have dropped), they abide entire—as entire, yet as destitute of vitality

as the table I am writing at; and they abide to serve to these buds and to the young oak plants that are to come of them next year (as the earth does to the acorns and their produce), the purposes both of a *temporary soil* and of a permanent *mechanical support.*

15. Such is my apprehension of a tree. A tree is an aggregate of *annual* and comparatively *small-sized* and *slender* plants, the propagation of which from year to year is effectually provided for by buds; and the accumulation of which *en masse* by the living growing as *parasites* on the dead, necessarily keeps pace with the annual succession of plants. And if what I have stated be a true account of its nature, and of the manner of its production, it will of course follow (as was before observed) that a tree is an individual in precisely the same sense as a body corporate; and that, contrary indeed to the common opinion, but in perfect consistency with the principle that all living beings are subject to the law of mortality, and have a definite size or bulk of organism, there will be no limit, except from *extraneous* causes, to the size it may attain, or the number of years it may live.

16. What is called a *Genealogical* tree is constructed very exactly on the principle of this theory—or rather, as we must at present consider it, this hypothesis—and serves extremely well so far to make it intelligible. While the personality of each member of the tree is admitted, and his own individual *temporary* existence,

he is yet regarded as forming a scion or branch of one *common* stock, which may have had its origin in a remote age, and may endure as long as the world itself.

17. I dare say you have not been able fully to comprehend or to take in, in all its parts, what I have now propounded to you. I shall be content, however, if you have acquired a general idea of it. In future letters I will go into it more in detail, and endeavour to make it good.—I am, &c.

LETTER II.

"Réculer pour mieux sauter."—French Proverb.

March 14, 1854.

My Dear Sons,

1. In propounding a new theory, it will often go a long way towards securing for it a more patient hearing, and for the proofs offered in support of it a more candid consideration, and in the end for the theory itself a more cordial reception, if, in the first instance, the theory to which it stands opposed be shewn to be unsatisfactory. This course I purpose taking with what may at present seem to you my strange theory of trees. Before going further into this theory, without at present even seeking more fully to unfold it, and still less to prove it, I shall assume that the notion commonly held as to the nature of trees is the right one, and, on this footing, proceed to inquire what is known in regard to the natural longevity and the natural size of this class of objects. The general result of this inquiry you may already anticipate. From the remarks just now made, as well as from

what I stated in my former letter, you can scarcely fail to see what the general conclusion is to which I intend to lead you. Let us endeavour, however, to follow out this inquiry fairly and without prejudice, and (as I once did) without any such anticipation as to the issue.

2. Viewing, then, every individual tree as an individual plant, let us inquire what is known or believed in regard to those particulars in the history of trees which have been already specified. "How long does the Oak," for example, "naturally live?" "To what size does it naturally grow?"

3. The popular notion seems to be nearly limited to this, that, as compared with any known animals, the greater number at least of trees are very long-lived, and capable of attaining to a very great size. It is believed, indeed, that, in common with all other living beings, they are subject to the law of mortality, and grow only to a certain size, and perhaps that the appointed term of life and measure of growth vary in each species of tree; but beyond the general fact just stated little appears to be known; nay, there seems to be a general persuasion that nothing definite has yet been ascertained on the subject. If you ask, as I have often asked, an intelligent old forester, who has passed all his days among trees, what he knows of the matter, he will probably tell you that he knows nothing. He may remark of the Larch, for instance, that, growing

along with other larches in a plantation, it reaches its maturity, or becomes "ripe," in seventy or eighty years, and after that does no more good. But he will himself observe also, that the history of a larch so reared gives us no insight into its capacities for life and growth, and will point to numerous examples of larches growing singly and alone, which have already lived twice that period, are still growing, fresh and vigorous as ever, and are still enlarging in all directions.

4. Systematic treatises on Botany may reasonably be supposed to contain the wished-for information. It will be found, however, that but little information is to be had from them, and none that is satisfactory. For the most part, the subject is passed over in silence; or, if treated of, the observations made are of the most meagre description. One of the fullest, and best, and most recent—that by Professor Balfour of Edinburgh—makes no other than a cursory allusion to it, brought in, moreover, indirectly. "There is still wanting definite information as to the age which trees attain. The duration of their life has not been accurately determined. It exceeds so much the limit of man's life that it is not easy to collect data on the subject. Some exogenous trees attain a very great age. Trees, which, in individual cases, attain great ages, belong to the most different natural families. Among them may be mentioned the Boabab, the Dragon-tree, species of

Eucalyptus, Taxodium distichum, Pinus Lambertiana, Hymenæa Courbaril, species of Cæsalpinia and Bombax, the Mahogany-tree, the Banyan, the Tulip-tree, the Oriental Plane, Limes, Oaks, and Yews." * And again—" The age which trees attain has not been fully determined : some live for many centuries." †

5. As regards the size of trees, Professor Balfour observes—" Many coniferous trees, as the Larch, the Scotch Fir, the Norway Spruce, the Weymouth Pine, the Red Pine, Douglas' Pine, Lambert's Pine, the Norfolk Island Pine, and other Araucarias, have stems varying from 100 to 200 or more feet in height. Dicotyledonous forest trees in Britain, such as the Oak, sometimes attain the height of 120 feet. Forest trees, on the Continent and in America, are sometimes 150 feet high. Monocotyledonous stems, such as those of Palms, are usually unbranched, and their height is sometimes 150 or even 180 feet. Acotyledonous stems, as those of species of Alsophila, Dicksonia, and other Tree-ferns, attain a height of fifty or sixty feet." ‡ " Stems often attain a great thickness. The stem of the Dragon-tree of Orotava is seventy feet in circumference ; that of the Boabab has a circumference of ninety feet. Some Cedars of Lebanon at the present day have a girth of forty feet. Chestnut-trees have occasionally a circumference of sixty feet, and trees of

* Class-Book of Botany, p. 667. † Ibid, p. 669.
‡ Ibid, pp. 436–438.

the South American forests are mentioned by Martius with a girth of eighty-four feet at the base of the trunk." *

6. What do we learn from these statements? The height and thickness which individual trees of different sorts have been known to attain. But nothing approaching the expression of a law. And doubtless, of the trees specified, the measurements of many of them were taken at a time when they were still growing in height, and still increasing in thickness; or if dead, reduced to this condition by the axe of the forester, and felled while yet fresh and vigorous.

7. M. Richard, in his *Nouveaux Elémens de Botanique*, goes more expressly into the subject than Dr Balfour. He has sections designated respectively "*De la Durée des Arbres*," "*De la Hauteur des Arbres*," and "*De la Grosseur des Arbres*."† Let us see whether now we shall get the information we are in quest of. In the first section, M. Richard merely tells us that trees growing in a suitable soil may live for ages—the Olive for about 300 years, the Oak for about 600, the Boabab, according to the reckoning of M. Adanson, for about 6000 years; and further, that the Cedars of Lebanon appear to be in a manner indestructible. "Les cèdres du Liban paraissent en quelque sorte indestructibles." Mark this singular expression. In

* Class-Book of Botany, p. 438.

† 5ième Edition, pp. 130, 131, 132.

the second, he says, in general terms, that certain trees acquire, after many years, a considerable height and thickness, and in particular, that the greatest increase in height which the forest-trees of France arrive at is from 120 to 130 feet—those of America, however, often exceeding 150 feet. And in the third section, he observes that the trunks of individual Boababs have a girth of ninety feet; the trunk of a Dragon-tree in the Canaries, a girth of forty-five feet; that of a Sycamore in South Carolina, a circumference of sixty-two feet; and lastly, that in France certain trees which he specifies have trunks with a girth of from twenty-five to thirty feet.

8. We are still, I fear, as far off as ever from the discovery of the laws which we are seeking to ascertain. Let us turn next to M. De Candole, and inquire of him what he knows on the subject. This eminent botanist has written largely and very expressly on the longevity of trees. All that I happen, however, to know of his researches, is what is to be met with in our English works on botany, and these merely give us the result of his examination of certain trees, together with details as to the method he followed in his estimate of their age, and the data he supplied for computing the rate of growth, and consequently the age, of trees generally. His way of getting at their age was to count the number of annual layers or rings of wood—reckoning, of course, at that part of the

trunk on a level with the ground; or, having ascertained the average rate of growth, to deduce the age from the thickness of the trees. This method, it may be observed, is applicable only to exogenous trees, and even as regards these is beset with certain fallacies, although on the whole, and for general purposes, it is sufficiently accurate. Subjoined is a table, drawn up by himself and others, of the ages of certain trees :—

Elm,	355 years.
Cypress,	350 ...
Cheirostemon,	400 ...
Ivy,	450 ...
Larch,	576 ...
Chesnut,	600 ...
Orange,	630 ...
Olive,	700 ...
Oriental Plane,	720 ...
Cedar,	800 ...
Lime,	1076, 1147 ...
Oak,	810, 1080, 1500 ...
Yew,	1214, 1458, 2588, 2880 ...
Taxodium,	3000 or 4000 ...
Boabab,	5000 or 6000 ...
Dracæna,	6000 ...

9. Now, what is the real import of this table? What the precise value, in relation to our present inquiry, of the data supplied by De Candole for estimating the age of trees? What we want to know is, the *natural* longevity and the *natural* size of trees—their *average*

natural term of life, their *average* natural height and girth. On these points, I apprehend, we are left by De Candole as much in the dark as before. His table is simply a list of certain trees which, at the time they were examined, had, or were supposed to have, attained the ages specified. Many of them, doubtless, were then alive, and not a few of them probably still growing, if not in height, at least in thickness. Peradventure (the case is quite conceivable), according to the theory of trees at present assumed to be the right one, some of these trees had even exceeded the natural age and size of their kind—had as far surpassed it as Thomas Parr, who died at the age of 152, or Petratch Zortan, who lived to the age of 184, exceeded the natural age of the human species,—or as Charles O'Brien, who stood 8 feet 4 inches, and Daniel Lambert, of whose prodigious weight and bulk every one has heard, exceeded the natural weight and size and height of the race. In short, neither the table nor the data of De Candole take any account of, or have any bearing upon, the average natural duration or size of trees.

10. One other source of information yet remains—the books which treat expressly of trees. Of such there is a considerable number. It may suffice to instance one of the best and most widely known—Gilpin's *Forest Scenery*, and the late Sir Thomas Dick Lauder's edition of that work as being singularly

copious in supplementary details. In works of this kind especially, even more than in systematic treatises on Botany, one might expect to find the desired information. My own examination of them, however, has been to no purpose. They enter largely into the history of all or most of our British trees, and into that of many foreign trees; and they abound in details of exceeding interest regarding those that are most remarkable for their age or size, their historical associations, their beautiful forms or fantastic shapes, their modes of growth, &c. But they are absolutely barren of information bearing on the questions before us. They give us no insight into the allotted duration and size of trees. They do not even acquaint us what the extreme limit is to which their lives may be protracted, or the extreme height and thickness to which they may attain.

11. The fact indeed appears to be, and it is one which stands out in striking contrast with the particulars furnished by Balfour, Richard, De Candole, and others, as to the age and size of trees, that in many different parts of the earth there are individual instances of almost all kinds of trees, which have not merely already stood as many years and grown to as great a size as any of their species have ever been known to do, but (which is peculiarly remarkable, and indeed singularly striking), are still vigorous and growing, and as yet exhibit no signs of what can pro-

perly, that is, physiologically, be regarded as *old age.* Of many of these "oldest inhabitants" of the park, or the church-yard, or the forest, much of the trunk may be hollowed out; many of the larger branches may have been broken off or otherwise destroyed in the course of ages. The "sundry and manifold changes of the world" may have shorn them of their glory and left little of them remaining. Still that little evinces as *great activity in the vital processes as ever.* That is to say, it is the seat of as vigorous a circulation of sap as in its earliest years; it puts forth and matures leaves, and flowers, and fruit, which are as large and as perfect as in its best days; it is still forming fresh wood, and having every year additional bulk given to it.

12. Let one example suffice meanwhile. There is at Allonville, in France, an oak so decayed, that the only support it has is by the outer layers of wood and by the bark. It may be said to stand on stilts. Its trunk is a perfect hollow or cavern; and some idea, both of the size and age of the tree, and of the extent of its decay, may be formed from the fact, that in the year 1696 its hollow stem was converted into a little chapel of six or seven feet in diameter, wainscotted and paved, and in which Divine service is said to be still occasionally performed. It is computed that this tree, which is upwards of thirty-five feet in girth, must have seen at least from 800 to 900 summers.

Yet it is still vigorous. Every year "it is adorned with abundance of leaves, and laden with acorns."

13. The considerations now stated, and others to be adduced hereafter, when they will be better appreciated, can scarcely fail to suggest a doubt whether there may not be some peculiarity in trees as regards their longevity, beyond merely a very prolonged existence; nay, although according to the view commonly taken of their nature, it were absurd seriously to entertain the idea, whether there may not be in their case a virtual, if not an actual, exemption from the law of mortality. Some such idea may not unreasonably be supposed to have been present to the mind of M. Richard, when he remarked of the Cedars of Lebanon, that they appear to be indestructible—an expression which, if it have any meaning, is equivalent to saying that they appear to live for ever, and would imply that the law of mortality is not universally operative.

14. Such is the present unsatisfactory state of our knowledge respecting the natural longevity and the natural size of trees—regard being had to the popular belief as to their real nature. In the case of each species of animal, the natural term of life, and the appointed size of organism, are either known to us, or may, with comparative ease, be ascertained by us. But with respect to trees, these particulars in their history may fairly be said to be absolutely unknown

to us,—and that, too, as I before observed, notwithstanding the facilities within our reach for making observations in regard to them. Each one of every species is looked upon as a single individual in the same sense that each one of every kind of animal is so regarded; and while it is believed to be subject to the law of mortality and to the law of a determinate stature, it is believed to be also, as compared with any known animal, very long-lived, and capable of attaining to a gigantic size. No more precise idea, however, as to either its longevity or its size is entertained or seems possible; and even this conception of both is beset with considerations of perplexity.

15. It is no doubt true, as Professor Balfour observes, that the duration of the life of trees "exceeds so much the limit of man's life, that it is not easy to collect data on the subject." It is true, also, that even were "tradition" more to be relied on than it is, most trees are already old before they come to be objects of historical interest. But their past history is not therefore buried in oblivion. And it is a sufficient answer to both the difficulties now started, to say, that every tree carries within itself the record of its birth and of its career through life. Each year that has passed over it has left its impress upon it. We have only to count the cylinders of wood it has gathered round it, to know how old it is—to examine the thickness of the several cylinders, to determine what the

character of the seasons, and the circumstances under which the tree has grown, have been. The real difficulty lies in this—that we nowhere see or can discover trees presenting indications of their having passed the limits of their natural growth, or lapsed into the state of *natural old age.* Examine the oldest known tree of any species: take, for example, the tree at Pear-tree Green, in this neighbourhood, the trunk of which is now reduced to a mere band or strip of wood and bark, and which can stand only (or rather, as it does in fact, recline) by the help of a crutch. You will find that so much of it as yet remains is still extending its roots and lengthening its branches—is still forming new wood and bark; while, further, the leaves which it sends forth year by year are as large, and the circulation of sap through it as vigorous, as in the days of its youth.

16. But if my theory of trees shall prove a sound one, this and every other difficulty will be obviated. And it will then appear that a book which I have not yet named, the oldest known book extant—the Bible—gives a far more satisfactory answer to our questions than is to be met with in our scientific treatises. "As the days of a tree are the days of my people."* That is to say, the days of a tree are naturally indeterminate —without set limit—in the ordering of Nature *everlasting.* In this lay the significancy and the value

* Isaiah lxv. 22.

of the declaration. Possibly, however, it may have been of wider import, and have embraced a larger view of the nature of the tree. The tree, rather than the "everlasting hills," may have been made the basis of the declaration, as being possessed of only a *contingent* perpetuity, — in its own nature most truly perennial, yet subject to decay and ruin. And so the declaration may have carried with it an admonition and a warning, as well as a gracious assurance; and have been so intended and understood. Looking at it, at least, from our present stand-point in time and in the light of history, it is scarcely possible to read it otherwise. "The days of my people shall endure as the days of trees." Yet the Cedars, the "indestructible" Cedars, which once covered and were the glory of Mount Lebanon, have all, save a very small remnant, disappeared; while the "People" that once "filled the land," and, like those "goodly cedars" to which they were compared, "sent out their boughs unto the sea and their branches unto the river," have been driven out and dispersed into all lands,— "scattered and peeled."*—I am, &c.

* Isaiah xviii. 2 and 7.

LETTER III.

"It has often happened to me to have been occupied by a particular subject of inquiry; to have accumulated a store of facts connected with it; but to have been able to proceed no further. Then, after an interval of time, without any addition to my stock of knowledge, I have found the obscurity and confusion, in which the subject was originally enveloped, to have cleared away; the facts have seemed all to have settled themselves in their right places, and their mutual relations to have become apparent, although I have not been sensible of having made any distinct effort for that purpose."

SIR B. C. BRODIE, Bart.

April 18, 1854.

MY DEAR SONS,

1. In my last letter I hope I did not altogether fail of my purpose, which was to shew you, that as trees are commonly regarded, it is impossible to arrive at any satisfactory knowledge either as to their natural size or their natural longevity. And I would fain persuade myself that you are now prepared cordially to go along with me to the examination of my theory.

2. Of this theory, I doubt not you still retain a general notion. But before entering on the evidence to be adduced in support of it, or meeting the objections that may be urged against it, it will be desirable

to make the theory itself clear and intelligible in all its parts.

3. Agreeably to this theory, as you may remember, a tree is not what it is commonly believed, and what it certainly appears to be, a single or an individual plant. On the contrary, it is a collection—congeries, or congregation of individual plants of the same species, and is the production of a series of successive years. It consists, when fully equipped at midsummer, partly of living and growing plants, the growth of the current year, and partly of the persistent dead remains of the plants of former years. And of the individual plants composing it, each lives only one year, reaches its full size within the year, and, on dying at the close of it, mostly disappears and passes away. Certain parts, however, remain. These are the buds which survive the winter, and the dead stems and roots which are to serve the purposes as well of a soil as of framework to the plants of the next and succeeding years. And, accordingly, the production of the aggregate, which makes up and constitutes the tree, is referable to the living plants of each year growing parasitically at the end of, and likewise either around or within, the dead stems and roots of the plants of the previous year.

4. All this I stated in my first letter. I now advance a step further and say, that the theory in question forms but a part of a proposition in vegetable physi-

ology of a still more general character, and may be more clearly apprehended if this proposition be laid alongside of it. The proposition is this: That all plants without exception, even those called *perennial*, are strictly *annual* plants, live therefore only one year, and reach their full size within the year; that is to say, that all plants spring up year by year either from seeds or buds, and attain their maturity within the year, forming, in the course of it, either seeds or buds, or both seeds and buds, for the production of similar plants the following year; that, as the season advances, their vital actions languish, and their organism becomes drier and more rigid—changes these which constitute their old age; that at the close of the season they die; and that on this happening, the materials composing them speedily undergo either an entire or a partial disintegration,—in the one case *wholly* disappearing,—in the other, some portion remaining to serve ulterior purposes in the vegetable economy of nature, but still remaining only as *dead* vegetable matter.

5. And in connection with this general proposition, and as forming part of it, it may be further stated, that the only difference between the plants called annual and those called perennial is, that the former produce seeds only for the propagation of their species, and are reared annually from seeds alone; while the latter produce both seeds and buds, and, *as* perennial, spring up each year from buds; and, therefore, that

seeds and buds are in their own essential nature *identical*, the only difference between them—and that not a uniform one—being, that seeds are free, detached, isolated, and intended for dispersion—buds fixed and adherent to the stem on which they grew.

6. If now, in regard to any given tree, or kind of tree, it be asked, "How long does it naturally live?" the proper answer will be (contrary, however, to the common belief), that there is no set limit to the age it may attain, or the number of years it may live, and no actual limit other than that resulting from purely *accidental* or *extraneous* causes; because, according to the theory now advanced as to the nature of trees, there is no *natural* limit to the annual propagation from buds of the individual plants composing the tree. According to this view, the observation of Richard (formerly quoted)—to wit, that the Cedars of Lebanon appear to be "indestructible"—is perfectly intelligible, involves no violation of the principle that all living beings are subject to the law and the dominion of death, and is applicable, besides, to all trees.

7. And if it be asked, in respect of any given tree, "What is the size to which it naturally grows?" the proper answer will be (contrary, again, to the popular belief), that there is no determinate limit thereto, and no actual limit, except from such extrinsic causes as may prevent the formation of buds, or the evolution from them of new plants.

8. If, however, the like questions be asked, not in respect of individual trees, but of individual tree-plants (as these may well be called)—of the Oak, the Elm, the Fir, viewed simply as plants, and independently of their parasitic relations to others of their particular species and community, very different answers must be returned. The answer to the *first* question will be, that they live, one and all of them, only a single year; and that, as regards their longevity, they stand on precisely the same footing with confessedly annual plants. And in answer to the *second* question, it may always suffice to observe, that as they all attain their maturity within the year, so the natural size of any of them may be accurately determined by observation of the seedling plants of its kind in the forester's nursery, or of the yearly shoots issuing from the buds on any healthy tree of its kind; and, in general terms, that while subject to some variety, it does not in any species exceed a few inches, or at the utmost a very few feet, in length.

9. There are still sundry particulars in this theory that require to be more fully unfolded; but it will be convenient to take them up separately.—I am, &c.

LETTER IV.

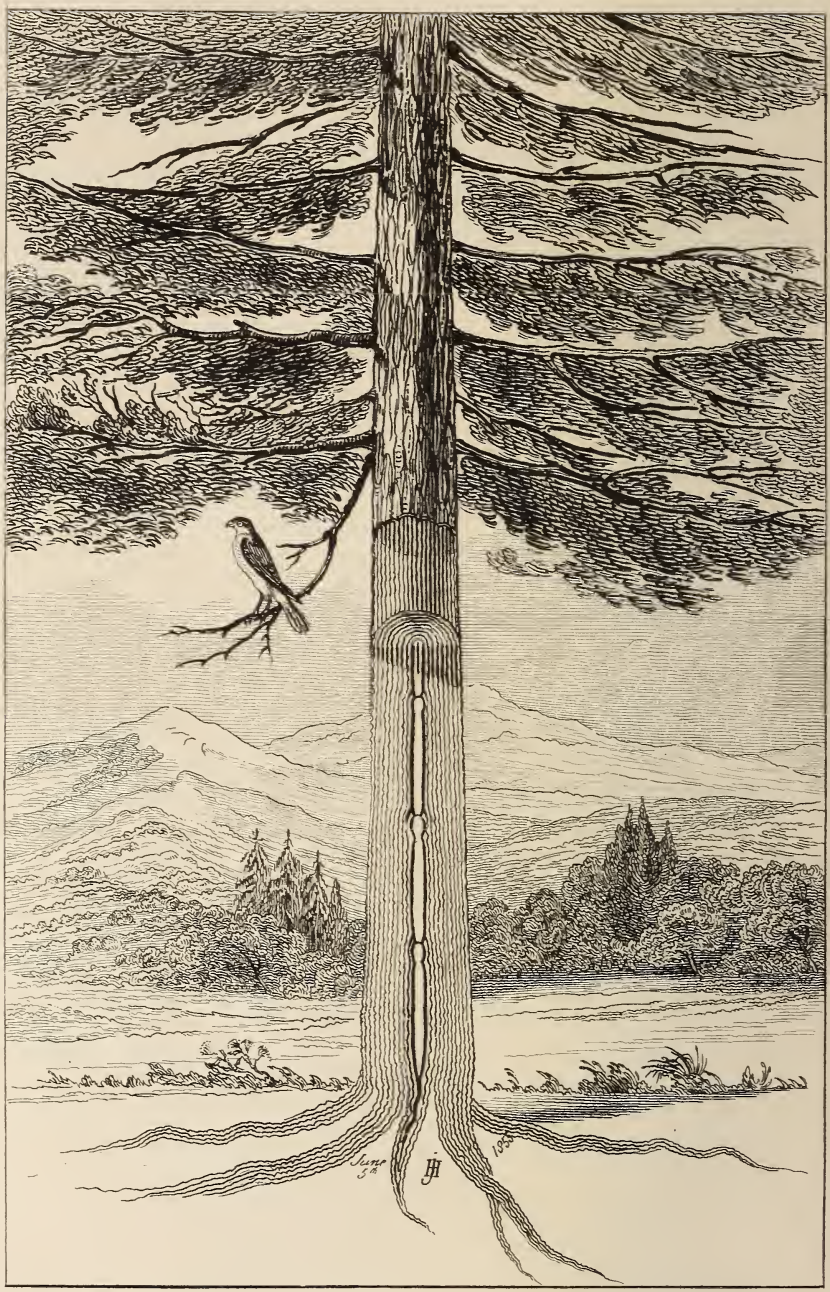
"The growth of one year is only subservient to the circulation of the next, and is ever afterwards of use merely in giving strength and stability to the trunk, in order to support the increasing size and weight of the branches and leaves."—Dr John Ware.

June 30, 1854.

My Dear Sons,

1. To proceed with the exposition of my theory. I have said that the dead stems and roots of the plants of this year serve to the plants of next year both the purpose of a *soil* and the purpose of a *support*, or of a framework, or scaffolding; that the former is for a time only, the latter for all time—the one purpose being *temporary*, the other *permanent* as the tree itself; and likewise, that the living plants of this year grow *parasitically* at the extremities of, and also either around or within, the dead stems and roots of the plants of last year. Possibly you may have difficulty in comprehending what all this means. I will endeavour to make my meaning plain.

2. Trees, you know, are divided by botanists into two great classes, the Exogens and the Endogens.



PLAN OF FIR TREE

They speak of trees as being either exogenous or endogenous, according to the manner of their growth and the disposition of their parts. In the first of these, as the Greek word from which the name is derived signifies, the woody matter yearly added to the trunk (or the annual woody layer) grows and is deposited *outside* that of the previous year; in the latter, as the Greek derivation of the name implies, the woody matter of the one year is deposited *inside* that of the previous year. The Fir is an example of the first, the Palm of the second sort of tree.

3. Let us first of all see how the matter stands in respect of the exogen; and for illustration sake, let us take a Fir-tree—the Larch, for example. The engraving on the opposite side, entitled "Plan of Fir-tree," is an ideal representation of such a tree,—stript of its bark, as high nearly as where the branches are seen to come off, next sawn crosswise to the centre of the trunk, and then cut vertically downwards, right through the middle plane of the trunk and roots. It exhibits the relations which the several parts composing the trunk and roots bear to one another. In other words, it is a representation of the relations that subsist between the *organic remains—i. e.*, the dead stems and roots—of the annual fir-plants that have grown successively one above another. To avoid complexity in the details both here and in the "plan,"

the vertical plants alone are figured—the side plants, composing the branches, being supposed not to have grown during the first few years.*

4. In the centre of the trunk, just above the surface of the ground, as figured on the plan, is an oblong narrow clear space, bounded on every side by a dark line of corresponding form, and terminating above in a sort of head or tubercle. Directly above this is another similar space, bounded by a similar line, and furnished with a head or tubercle. And above this again is another space exactly resembling the other two, and enclosed after the like fashion. These lines, spaces, and tubercles, represent respectively a section of the woody stems, the medullary (pith) cavities, and the buds of the first three in the series of fir-plants. From the bottom of the first and undermost, is seen passing down into the soil a single dark line: this is the root of the first year's plant. From the bottom of the second are seen two narrow lines, one on either side, also passing downwards,—first along the stem, and then along the root of the former,—at the extreme point of which (below) they meet, and beyond which, after meeting, they extend a short way as a single line: These denote the root of the second year's plant. And so of the third,—the roots of the third year's plant passing down alongside first the stem and then the root of the second year's plant, meeting at the tip

* Compare this "plan" with figure 1 (A and B).

of this root, and thence extending singly still farther into the ground.

5. Ideal as this plan is, the representation given tallies very exactly with the appearances presented by a young fir-tree cut lengthwise through the middle; and may at any time be verified, as regards the trunk, by examining a railway sleeper—at least one that has chanced to be suitably sawn. No continuous, uninterrupted, medullary cavity (as many fancy there is), reaching from the top to the bottom of the tree, and filled with pith, or the remains of pith, will there be seen. What we actually find is a set of narrow spaces or cavities, rising one above another, in number corresponding to that of the annual shoots (which in fact they indicate), each circumscribed and shut off from those directly above and below it by a thin layer of woody tissue, and each containing a dry cellular substance, the remains of the succulent pith with which it once was stored, and each varying in length from ten inches or less to a foot and a half or more, according as the year's growth has been. On either side of these medullary cavities may be seen a series of woody layers passing downwards in the direction of the ground; their number progressively increasing in that direction, and each pair coming off from the lower end of each one of those medullary cavities,—each one of these, therefore, in succession downwards, having a pair more investing it than the one directly above it.

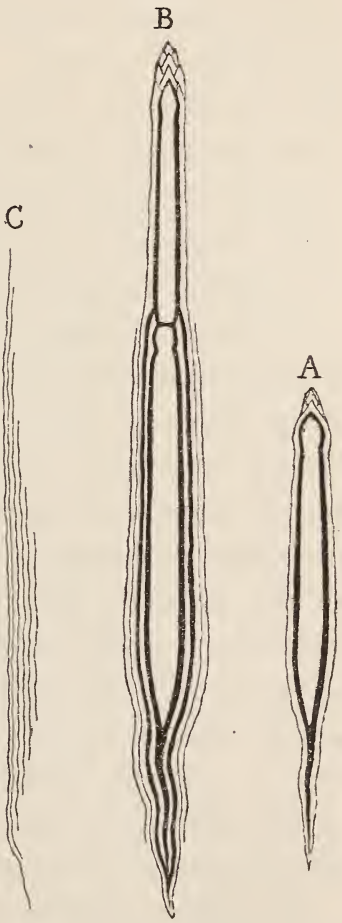
And on the summit of the terminal shoot of the tree will be found a bud in immediate connection with the pith of that shoot, and this pith (if the tree have recently been felled) plump and succulent.

6. The longitudinal woody layers then of the trunk, though *above ground*, I have described as being (equally with the continuations of them under ground) the roots of the several plants that have grown successively one above another. They are not, indeed, commonly regarded as roots, but simply as the wood and conjointly as forming the trunk of the tree,—the term *root* being restricted to all that part of the tree which lies buried in the soil. Believing them, however, to be really of the nature of roots, I call them such, and their being so regarded forms an integral part of my theory.

7. The persistent stems and roots, then, of the several fir-plants are successively set one above another, and alongside of one another,—the stems of the plants of one year resting on the stems of the plants of the previous year, and their roots creeping down outside both the stems and the roots of the latter, and even extending beyond. Thus are the parts below a mechanical support (a framework or scaffolding) to the parts above; while these in their turn become conservative, by cutting off from the parts below atmospheric and other influences, which would otherwise speedily entail their decay. Thus, too, are successive additions made to

the height and thickness of the aggregate remains of the plants; and thus also, while the roots of the plants of each succeeding year, extending beyond those of the preceding, strike into new and fresh soil, is the basis of sustentation under ground proportionally widened and strengthened.

Fig. 1.



8. As yet I have said nothing as to the *bark* and its disposition. A fresh layer of this is formed annually in connection with the plants of each year; and if our theory be correct, the successive annual layers will be disposed in accordance with its requirements. And such is actually the case. The woody stem and root of each seedling tree-plant is everywhere invested on its exterior with a coating of bark, as in figure 1, A. But how do the bark and root of the next year's plant comport themselves in relation to the wood and bark of this seedling, on the summit of which it grows? By the theory they ought to press down wedgewise

between them, parting them asunder. And this they do, as represented in figure B. And these latter, again, in direct relation to one another for one season, are themselves in their turn parted after the like fashion by the root and bark of the third year's plant. And so on. Thus, the most external of the annual layers of bark corresponds to the most internal of the annual layers of wood. And were the several layers of bark distinguishable, or rather could they be separated from one another, each would be found to correspond in length with the plant in connection with which it grew, and the whole to become individually longer from without inwards, as shewn in figure C.

9. From this disposition and wedgelike action of the wood and bark, it comes to pass that year by year the older layers of wood are pressed inwards, and more closely compacted; while the older layers of bark are pushed outwards, and become in process of time so distended or stretched, that, unable to yield otherwise to the pressure from within, they rend. And this occurs in a great variety of ways—by exfoliation in some (as in the Sycamore or Plane, and in the Birch), and by fissure in most (as in the Fir, the Oak, and very remarkably in the Acacia)—each particular kind of tree having its own, and, it may be added, its distinctive manner of rending.

10. Again: The bud at the top of the terminal shoot, the embryo of the plant of next year, is to

derive the first materials for its development in spring from the succulent pith of that shoot. This pith is simply a store of nourishment laid up in the cells, which fill the medullary cavity of the shoot; and it is placed in closest proximity to the bud for the supply of its earliest and more immediate wants. Thus the shoot or stem yielding nourishment to the bud (besides being to it, as we have seen, a stand or support on which and around which to grow), may fairly be said to serve to the young plant, which is to emanate from the bud, the purpose of a temporary soil. This purpose answered, and the supply of nourishment there exhausted, the growing plant issuing from the bud will send down a root; and this root, passing alongside the stem and the root of the plant of the bygone year, will ultimately reach the ground. In its course downwards, encased in its own layer of bark, it will pass between and part asunder the bark and the woody tissue of the stem and root of that plant, traversing in its passage the cellular tissue which connected these, and which, stored with nutritious juices as the pith was, will supply all its intermediate wants. On reaching the ground—its permanent soil—it will thence derive what further supplies it needs.

11. I have repeatedly spoken of the roots as *creeping* down, and as *passing* from the lower end of the stems of the plants above downwards, into the soil. I use this expression meanwhile analogically and pro-

visionally. The fibres composing the roots do creep down virtually, although not actually,—potentially and in effect, but not really. And I shall continue to make use of these expressions till such time as I explain how the roots are in fact evolved. I am, &c.

LETTER V.

"Look here, upon this picture."—Hamlet.

August 18, 1854.

My Dear Sons,

1. Hitherto we have examined the Exogen in its longitudinal or vertical aspect only. Let us now view it in its transverse or horizontal, and in connection with a tissue which is equally *annual* in its formation as the wood or bark, but widely different from the former, at least in the manner of its disposition and growth. I mean the *cellular tissue.* This tissue may be said to be the basis or matrix within which, or rather through the midst of which the bundles of woody tissue pass, and by means of which they are bound and knit together. The *medullary rays*, as they are called, seen in the cross-cutting of a tree, have their seat in this cellular tissue, and are in fact nothing save a peculiar appearance given to it by the mode in which the bundles traverse it.

2. Viewed in this aspect, the additional facts furnished by the Exogen will, if I mistake not, come out very favourably for our theory.

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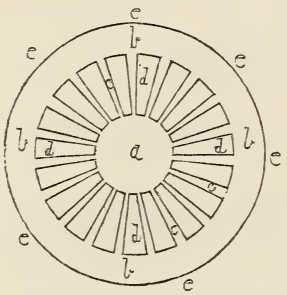
3. The accompanying figures are plans of horizontal sections of the stems of Exogens, and shew the wood, the bark, and the cellular tissue, together with the central medullary (or pith) cavity and the medullary rays. Figure 2 is the scheme of a shoot one year old. In the centre (*a*) is the medullary or pith cavity; around this are blocks or bundles of woody fibres (*d d d*), having the appearance of truncated wedges, and forming the woody stem of the shoot. Proceeding from the medullary cavity, and passing between the bundles (which they separate and isolate), are the medullary rays (*c c c*); encircling both these and the bundles is a ring of cellular tissue (*b b b*), which may be termed the medullary ring; and encircling the whole is the bark (*e e e e*). The medullary cavity, the medullary rays, and the medullary ring, are everywhere continuous, form but one and the self-same tissue—the cellular, and have their distinctive appearances given them simply by the woody bundles passing down through the common mass of tissue. Take away these bundles, and nothing will appear save an unbroken mass of cellular tissue, enclosed within a ring of bark.

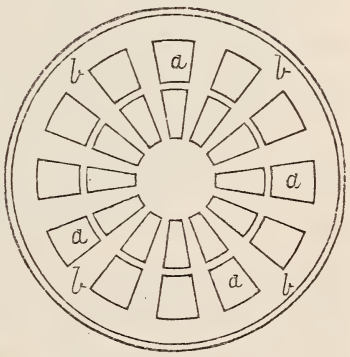
Fig. 2.



4. This cellular tissue, which, as I before remarked, appears to be the basis or matrix of the whole stem or

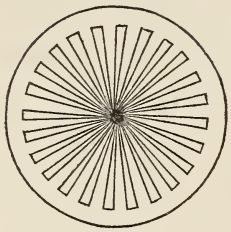
shoot, grows and extends itself horizontally. In the course of each season provision is made for that which is to be developed the next, just as provision is made for the evolution of every part of the new plants. That is to say, equally with a set of buds, a layer of embryo cellular tissue is each year produced for the purposes of the next. This layer has received the name of *Cambium*, and is found on the side of the medullary ring next the bark. On the return of spring it begins to grow, and rapidly extends itself by the development of new cells. These in due time are traversed by a new set of woody bundles (*a a a*) as represented in figure 3. These bundles are the roots of the new plants emanating from the buds, and they pass down in such manner as that the new medullary rays are on a line with those of last year's. The whole is bounded by a new layer of bark (*b b b*), lying inside that of the previous year's plant. And it may be remarked in passing, that, while the cellular tissue serves permanently to bind those woody bundles or roots together, it serves to them also, in their passage to the soil, the like office which the pith in the medullary cavity does to the bud—that of supplying their present needs in respect of nourishment.

Fig. 3.



5. The only difference between that part of the stem which is above ground and that which is below, consists in the absence from the latter (as shewn in fig. 4), of the central medullary cavity. The woody bundles here have still the common cellular tissue for their basis, and the medullary ring and medullary rays exist as in that portion of it which is above-ground; but the bundles meet at a point in the centre. There being no buds on this central portion of the root, to be nourished by it (although, as we shall hereafter see, there often is on its exterior, lying underneath the bark, and in connection with the medullary ring), the pith and its containing cavity are wanting.

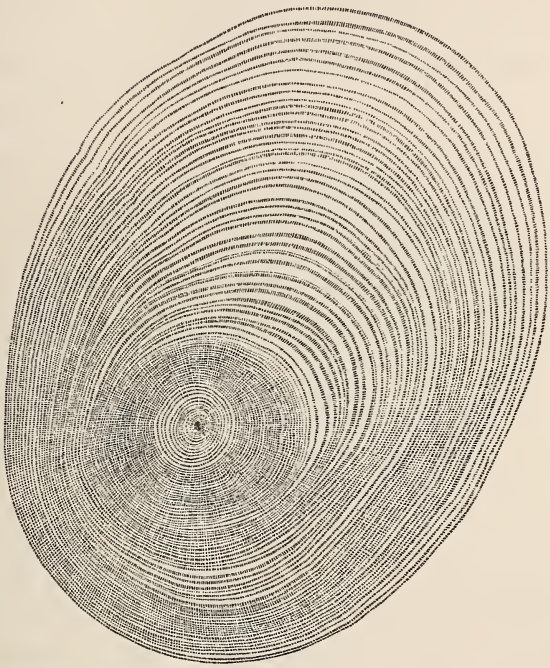
Fig. 4.



6. The disposition of the woody bundles in concentric zones or circles, is by no means always so regular as is represented in the foregoing figures. In the Fir, indeed, as associated with other firs in a close plantation, and growing chiefly in the vertical direction (the lateral branches or side plants being, from the circumstance of their position, arrested in their growth), the disposition is, on the whole, singularly uniform. In most trees, however, and, in fact, in all that have full freedom of growth allowed them, not only do the zones of different years vary greatly in thickness, but different parts of the zone of the same year are very unequal in this respect, as shewn in

figure 5. Hence the central point of the trunk is by no means always the medullary cavity, which is consequently more or less *eccentric*. How is this? These zones are sections of the *roots* of the plants above, and their thickness indicates the quantity of roots sent down, which will of course be in proportion to the number of the plants, and the vigour of their growth. In these respects there are great differences in different years and on different sides of the tree, corresponding to variations in the temperature and character of different seasons, and likewise to variations in respect of exposure to light, to prevailing winds, and other causes. That is the explanation.†

Fig. 5.*

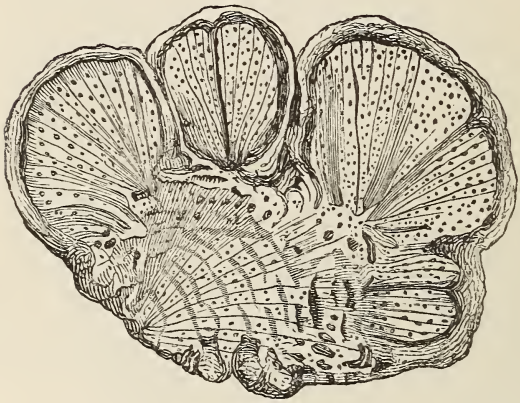


* Fig. 5. Concentric woody circles of the Box-tree,—from the drawing made by Nature on the block from which it is printed.

† "In a crowded plantation there is a marked difference between the trees on the outside and those in the centre; the former, having

7. An extreme degree of this—natural, seemingly, to several sorts of trees, particularly the Beech, the Yew, the Thorn, and the Normandy Poplar—consists in sets of woody bundles (such as those connected with particular branches) grouping themselves together year after year, to the exclusion of other bundles, and passing down in masses more or less distinct (Fig. 6). The trunk has thus given to it a columnar or buttressed aspect; and a section of it, while exhibiting often great confusion in the mutual relations of the zones and the cellular tissue, shows, even more clearly than can be made out from an inspection of the exterior of the trunk, both the extent and the reality of the grouping. This arrangement, you cannot fail to perceive, is in prin-

Fig. 6.*



their branches and leaves fully exposed on one side, grow with comparative vigour, and form excellent timber on that side of the stem where light and air are admitted ; while the latter, hemmed in on all sides, are drawn up like bare poles, producing a small amount of ill-conditioned wood."—Balfour's *Class-Book of Botany*, p. 428.

* Fig. 6, Section of stem of a tropical Climbing-tree, copied from the *English Encyclopædia*, art. *Exogens*.

ciple—nay, is in fact, that which obtains in a still greater degree in all trees as soon as the woody bundles reach the soil. At this point the bundles not only group themselves into sets, but part company altogether, spreading themselves in all directions in the ground. Need I say how strikingly this process of grouping identifies the bundles above ground with those under ground, and imparts to both one common character.*

8. One other feature the bundles often present, allied to that just mentioned, and not less remarkable in the

* The following passages from Wallace's *Travels on the Amazon* (p. 23) furnish an admirable illustration of the statements in the text :—"Among the trees, the various kinds that have buttresses projecting around their base are the most striking and peculiar. Some of these buttresses are much longer than they are high, springing from a distance of eight or ten feet from the base, and reaching only four or five feet high on the trunk; while others rise to the height of twenty or thirty feet, and can even be distinguished as ribs on the stem to forty or fifty. They are complete wooden walls, from six inches to a foot thick, sometimes branching into two or three, and extending straight out to such a distance as to afford room for a comfortable hut in the angle between them.

"Other trees, again, appear as if they were formed by a number of slender stems growing together. They are deeply furrowed and ribbed for their whole height, and in places these furrows reach quite through them, like windows in a narrow tower; yet they run up as high as the loftiest trees of the forest, with a straight stem of uniform diameter. Another most curious form is presented by those which have many of their roots high above the surface of the ground, appearing to stand on many legs, and often forming archways large enough for a man to walk beneath."

like point of view. It is this: very often, instead of passing down in straight lines, they wind about the trunk, turning and twisting themselves, in their course downwards, in an endless variety of ways. Particular fibres or bundles, or sets of these, which, eight or ten feet up the trunk, may be distinctly seen on one side of it, perhaps forming part of a branch on this side, may be traced gradually making their way round to the opposite side, and in the end joining one of the roots under-ground, which spreads itself in this other direction. Even where their course is, on the whole, in a tolerably perpendicular direction, their meanderings are frequently singular enough—the fibres occasionally reversing their course, and after a little space, turning sharply round again, going out of their proper direction (as if actuated by a sort of instinct) to avoid obstacles, and then holding on their way. The old Yew in Pear-tree Green Churchyard, and the magnificent Chesnut in North Stoneham Park, afford excellent illustrations of these particulars. But an inspection, in any timber-merchant's wood-yard, of the pieces of hard-wood that have been stript of their bark—and particularly of those parts of them where the chief branches join the trunk—will illustrate them sufficiently well.

9. One other observation, and I will bring this letter to a close. There may be said to be a certain antagonism between the woody and the cellular tissue.

Elm at North Stoneham, Hants. with Roots filling up the Decayed Bole.

One main use of the cellular tissue is to bind together the woody fibres, as well as all the other parts of the plant. Its tendency, accordingly, is of a cohesive nature. The tendency of the woody fibres, on the other hand, at least as they exist in the "roots," is to separate from one another, to strike off sideways, and spread themselves horizontally in all directions. And this tendency is exhibited in not a few trees (as we have just seen), even in the fibres composing the trunk. To what cause this tendency is more immediately owing, we need not now inquire; but in as far as it is not actively exerted, in so far do the fibres glide passively down, as in a mould, between the last year's layers of wood and bark, and yield themselves to the agency of the cellular tissue. Thus is their real character as roots overlaid and obscured in the trunk. Break down that mould, however; take away the cellular tissue, and the fibres will stand out even in the trunk as genuine roots. Do you ask for a proof of this assertion? You have it in the Elm at North Stoneham in this vicinity, of which I give you a representation on the opposite page. It had been dismembered, many years ago, of one of its chief limbs, which had at the same time, in parting, riven and splintered a large portion of the bole, destroying also the cellular tissue there. Since then the woody fibres have continued year by year to pass down from the living and growing parts above.

Reaching the injured part of the trunk, they have then found themselves naked and exposed, unsupported, and unfettered also, by the cellular tissue; and thus circumstanced they have gathered round them, each fibre for itself, or each little bundle for itself, a thin coating of bark, and still pushing on, some in mid-air, and some on broken pieces of the trunk, have become and do now display themselves as genuine and unmistakeable roots. Nor is it uninteresting to remark that the splintered wood, exposed for many years to the full action of the weather, has rotted; and that (soft, spongy, and friable) it has in the course of time come to be mixed up with earth, wafted to it as dust from the adjoining fields and road, and so has formed a veritable soil everywhere pervaded by those roots. I am, &c.

LETTER VI.

" It is pleasant to note all plants, from the rush to the spreading cedar,
From the giant king of palms, to the lichen that staineth its stem."
MARTIN FARQUHAR TUPPER.

September 20, 1854.

MY DEAR SONS,

1. We have yet to examine the Endogenous tree, of which the Palm is an example, and see whether the disposition of its living parts and of its organic remains accords with our theory. I have no misgivings as to the issue, and am persuaded you will agree with me in thinking that the whole economy of this division of the Tree-tribe is in perfect harmony with the theory.

Fig. 7.

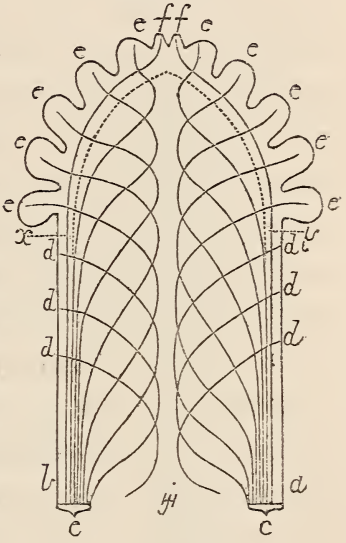
2. The Palm is, in fact, strictly an *annual*, and its evolution year by year takes place on this wise: In the centre of a whorl

of dead leaves is a bud—a truncate flesh-like substance, resembling the root-plate of a bulb, but of nearly the full size of the after-diameter of the tree on the summit of which it rests. This bud, formed by the plant of the previous year, and consisting mostly of a mass of cellular tissue, first sends out from its exterior a tuft of fresh leaves, and then extends itself a short way horizontally. Next, it rises slowly upwards, leaving the tuft of leaves at its base, but giving off others in succession from its sides and summit. The leaves in their turn send down bundles of woody tissue, which traverse the cellular tissue, and, proceeding some distance down the tree, finally curve outwards, and lose themselves in the cortical integument of its trunk, immediately within which (contrary to what obtains in the Exogen) the most compact wood is always found. These bundles are the *roots* of the plants; and these, together with the cellular tissue and the persistent remains of the first set of leaves (which decay and drop off in the course of the season), are all that can be regarded as the *stem* of the plant, —for, in reality, according to Botanists, it has no proper stem. And this stem, such as it is, together with those of the plants of former years, constitute the *trunk* of the Palm-tree. In figure 8 is represented a transverse section of this

Fig. 8.

trunk. It will be seen that there is an entire absence of the concentric circles both of wood and bark so characteristic of the Exogenous stem, and that instead of this there is a mass of cellular tissue inclosed within a single cortical ring of somewhat irregular outline, and pierced here and there throughout, but most abundantly towards the circumference, by bundles of woody fibre. Fig. 9 is a mere plan of the upper part of the palm-trunk, showing the manner in which the woody fibres pass downwards from the leaves in curves or arches towards the circumference of the stem, in the cortical integument of which they lose themselves.

Fig. 9.*



3. The trunk of the Palm-tree, it may be observed, does not increase in diameter by age, as does that of the Exogen. It increases only in height, and that by

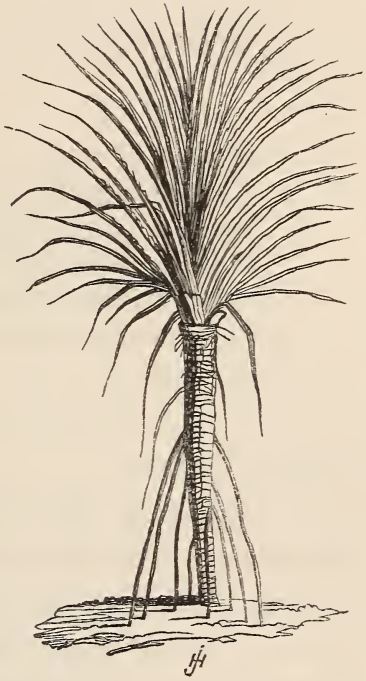
* Fig. 9.—*a b*, The lower, fully developed, part of the stem; *c c*, External firmer portion of the stem, formed by the closer course of the woody fibres; *d d d*, Woody fibres running as far as the cicatrices of leaves that have died off; *e e e e e*, Leaves in the bud, in the order in which they are developed, with the woody fibres belonging to them; *f f*, The latest-formed leaves. All that is cut off by the dotted line *x y*, above the stem, has originated at the same time with the lowest pair of leaves (*e e*).—See Schleiden's *Principles of Scientific Botany*, p. 246.

reason of the successive production of distinct palm plants growing year after year one above another. In most species of Palm there are no branches. In most the trunk towers upwards singly and alone,—sometimes to an elevation of 150 or 180 feet, and is naked throughout, save only at the summit, where it is surmounted with large and numerous leaves, with flowers and fruit; and likewise, in the very centre, and forming its highest point, with a fleshy bulb or bud for the evolution of next year's palm plant. This trunk, in fact, may not inaptly be likened to a stately monumental column, on the top of which an embryo palm plant is every year placed by the hand of Nature,—the column itself, however, serving to this plant simply the purpose of a stand-point, and having as little to do with its germination and growth as it manifestly would have nothing, were it the "Monument" in Fish Street. Its offices are purely mechanical, not vital. It gives support to the young plants; and by the porosity of its substance, it gives scope for the roots to strike a short way down into it, while it also allows fluids to pass upwards from the earth beneath for the growth and nourishment of the plant.

4. The trunk of the Palm-tree is fixed to the soil by means of a strictly *fibrous* root resembling that of the grasses; and this root appears to be derived from the woody bundles of the earliest set of plants,—those of the plants subsequently formed never reaching the

ground. It is singular enough, however, although quite in keeping with the account now given of the Endogen, that in some sorts of Palms, as in the *Pandanus*, or Screw Pine (Figure 10), those bundles pierce through the trunk, and become in the first instance *aerial* roots; and that gradually pushing down into the ground, apart and at some little distance from the trunk, they form props or buttresses for its support.

Fig. 10.



5. The fibres constituting the roots of the individual palm-plants undergo, I believe, no increase in length or thickness after the year they are formed; and as those which pass into the ground proceed from a few only of the earliest in the series, the hold which the trunk of the Palm-tree has of the soil, when compared with the height of the column, comes after a time to be comparatively slight. I am, &c.

LETTER VII.

"He was not of an age, but for all time."

BEN JONSON.

"To Time
The task was left to whittle thee away
With his sly scythe, whose ever-nibbling edge,
Noiseless, an atom and an atom more
Disjoining from the rest, has, unobserved,
Achieved a labour, which had far and wide,
By man performed, made all the forest ring."

WILLIAM COWPER.

October 21, 1854.

MY DEAR SONS,

1. In a former letter (Letter II.) I told you that in different parts of the world there are trees of almost all sorts which have already stood for ages, and have grown to a vast size; that many of these trees are still vigorous and growing; and, what is particularly remarkable, that they exhibit as yet no signs of what can properly be regarded as *old age*. Much of their trunk, as I then remarked, may have been hollowed out from the decay of the heart-wood, and many of their larger branches may have been broken off in the lapse of time. But so much of them as yet remains

evinces as great activity in the vital processes as ever —that is to say, is every year the seat of as energetic a circulation of sap; puts forth every year, and matures, leaves and buds, and flowers and fruit, as large and perfect as in its earliest years; and every year, notwithstanding the dropping off and destruction of its dead parts, is having *additional* bulk given to it. And I instanced, in illustration of all this, the Oak of Allonville, the hollow trunk of which has been a little paved chapel these hundred and fifty years or more, and which, although now from 800 to 900 years old, is still vigorous, and still bears abundance of acorns.

2. This general fact I then adduced as an argument against the old theory of trees. I now adduce it as an argument in favour of mine. Before proceeding, however, to the proof and vindication of this theory, I purpose dwelling for a little on the history of some of those reliques of bygone ages, and submitting to you some further observations on trees, with a view to the introduction of certain details still needed to make the *exposition* of the theory complete.

3. Of old trees still extant in this country, and still living and growing, we need not look beyond the Yew tribe. There are indeed Oaks, Limes, Sycamores, Chesnuts, Ashes, and others, of great antiquity and vast size, some of them coeval with the Conquest, some of them probably much older still; but they all sink into insignificance before the Yews. Of these, there

are some at Fountain's Abbey, near Ripon, in Yorkshire, which are believed to be more than 1200 years old; there are two in the Churchyard of Crowhurst, in Surrey, 1450; and one at Fortingall, in Perthshire, from 2500 to 2600 years old. One in Brabourn Churchyard, in Kent, is said to have attained the age of 3000 years; and another at Hedsor, in Bucks, which is still in full vigour, and measures above 27 feet in diameter, is reckoned to be above 3200 years old. These estimates, indeed, founded on data supplied by De Candole, are probably too high—the Yews in this country being, it is now suspected, less slow in their growth than those on the Continent, at least than those examined by that distinguished physiologist. Making due allowance for this, however, there can be no question that the Yews just referred to have attained to an age that is altogether wonderful.

4. For details regarding these and other remarkable trees in this country—remarkable, I mean, in respect of their age and size—I must content myself with referring you to the writings of Gilpin, Evelyn, Jesse, and others. The subject is too extensive for my limits, and would, if entered on at any length, keep us too long away from the proper subject of these letters. I shall therefore confine myself to a brief notice of three or four trees only, the produce of other countries, and either not generally known, or peculiarly well fitted to serve the purpose I have in view.

5. In the Brazils, in one of the primæval forests, there are some trees supposed to be *Courbarils*, which, in respect of size, are truly collossal, and, in respect of age, have been variously computed at from 2000 to 4000 years. "Never before (says Martius) had I beheld such enormous trunks. They looked more like living rocks than trees; for it was only on the pinnacle of their bare and naked bark that foliage could be discovered, and that at such a distance from the eye that the form of the leaves could not be made out." Fifteen Indians, with outstretched arms, could only just embrace one of them. At the bottom they were eighty-four feet in circumference, and sixty feet where the boles became cylindrical.*

6. Another tree which has recently been described in certain of the American journals is too remarkable to be passed over. It is a *Cedar*, growing in one of the valleys in the county of Calaveras, in California. "Level with the ground, its circumference is ninety-two feet; at a height of four feet, it is eighty-eight feet; at fourteen feet, it is sixty-four feet, and so it gradually diminishes. Its height is 285 feet. There is nothing misshapen about it. On the contrary, from top to bottom, it is a model of symmetry, elegance and grace appearing to be conditions of its greatness, and its collossal proportions only awakening in the spectator ideas of the sublime and the majestic. The age of this

* *The Gardener's Chronicle* for January 25, 1845.

giant, calculated by its rings, is 2520 years. This king of the forest is to be girdled, and the operation has already commenced. The bark — which at the foot is nearly fourteen inches thick — is to be taken off in fragments up to the height of fifty feet, and sent to the Universal Exhibition in New York." *

7. Then there is the famous *Boabab* (the *Adansonia digitata*) growing in Senegal, and supposed to be the oldest kind of tree in any part of the world. The trunk of this extraordinary tree does not attain a height much exceeding fifteen feet, but in some instances it is from eighty to ninety feet in girth. And, according to the estimate of Adanson, founded on a comparison of Thevet's account of one seen by the latter in the year 1555, with his own measurement of the same tree two hundred years later, the trees that are twenty-seven feet in diameter have an age of 4280 years. Some of them have a diameter of thirty feet, and these are supposed to have attained an age little short of 6000 years.

8. Coeval probably with the Boabab is the Gum-Dragon Tree (*Dracœna Draco*), which furnishes the astringent resin called dragon's blood, once used in medicine, but now chiefly by painters as a red varnish. Of this tree there are two specimens in the Palm-

* Communicated to the "*Heraldo*" of Sonora, by a correspondent "who lately went to see this prodigy of the vegetable kingdom."— *Aberdeen Herald* newspaper, 1853-4.

house of the Kew Gardens. "Lofty as these specimens are (says Sir William Hooker), they are pigmies compared with the stature the tree attains in its native island, Teneriffe." One growing there is described by Humboldt as the "gigantic tree of Orotava"—centuries ago an object of veneration to the Guanchos (the aborigines of Teneriffe). A little above ground it measures forty-five* feet in circumference, a girth indeed which, vast as it is, comes far short of that of the Boabab. The tree, however, seems to be of exceedingly slow growth; so much so, that according to the traditions of it which have been handed down, it was as large and hollow 450 years ago as it is now. Sir William Hooker observes regarding it, that it is of "incalculable" age. "Doubtless it and the Boabab (he adds) are among the oldest vegetable inhabitants of our planet."†

9. The *Taxodium Distichum* (or deciduous Cypress) seems to be the most gigantic of any on record, and to be second to none in age. Two existing specimens may be referred to — one in the church-yard of Santa Maria de Telsa, near Oaxaca, in Mexico, which has a trunk ninety-three feet in girth; the other, that of Chapultepec, which is said to have a circumference of 117 feet 10 inches! Regarded as of "wondrous" magnitude by the Spanish conquerors, this tree of

* Professor Balfour says seventy feet (Letter ii. 5.)

† *Popular Guide to the Kew Gardens.*

Chapultepec "certainly" reaches back (according to De Candole) "to the origin of the present state of the world"—"an epoch of which (in his view) it is the most indisputable monument." Professor Henslow, it may be observed, estimates the longevity of the Taxodium at above 4000 years.*

10. The Banyan of the East, the *Ficus Indica*, is also remarkable for its size and longevity. It has besides certain peculiarities in its manner of growth and extension which demand for it a special notice. Every branch, issuing from the main or primary trunk, throws out *aerial* roots, in the form of small tender fibres, which gradually elongate and become thicker, and at length, reaching the surface of the ground, strike into the soil. They gradually increase in girth till they form large and distinct trunks. These secondary trunks in their turn send out branches from the top, which in time give off aerial roots that grow downwards into the ground, and become trunks also. The tree thus continues to progress, and indefinitely to extend itself. One such tree, now growing on an island in the river Nerbudda, is believed to be identical with one that existed there in the time of Alexander the Great, and which, according to Nearchus, was, even in those days, capable of overshadowing 10,000 men. It is not now, indeed, so large as formerly, portions of it having been carried away by

* Sheppard *on Trees*, their Uses and Biography, p. 89.

floods. What remains, however, affords ample room for 7000 persons to repose under its shade, and has a circumference of 2000 feet—measuring, that is to say, round the principal trunks. The overhanging branches cover a much larger space. The chief trunks of this *single* tree, it may be added, greatly exceed in thickness our English Oaks and Elms, and are above 350 in number, while the smaller trunks number more than 3000 ;—and every stem is still becoming thicker, and still sending out new branches and hanging roots,

11. As directly akin to the subject before us, I cannot forbear directing your attention to an enormous *plank*, which was some little time ago to be seen at the Bridgewater Canal Yard, Chester Road, Manchester; and which had been brought there from Liverpool by the Canal. "Its dimensions were—length, 144 feet; breadth, twenty inches; and thickness, six inches throughout. It was of a species of wood known as gum-wood, or African Oak, and was imported from Africa into Liverpool during last summer (1851). The tree from which this plank had been sawn must have been of a gigantic height, probably not much less than 300 feet.* Its age must have been proportionately great.

12. Let these examples suffice.† Enough appears

* *The Gardener's Chronicle* for July 17, 1852.

† One other may be referred to here. At the floral exhibition held in the *Crystal Palace*, on Saturday, June 2, 1855, there was to

from them to shew that trees may attain to an age altogether wonderful, and to a size that is quite prodigious, *and still continue to live and grow.*

13. But you may very naturally remark, that, after all, as common observation demonstrates, the individual instances of trees of such extraordinary growth and longevity are comparatively—indeed, actually—very few; and that, if the representation I have given of the nature and constitution of trees were well-founded, they should be very numerous. Nay, you may ask how it comes, that we nowhere find what we might expect to see everywhere, Oaks, Elms, Firs, and others of our familiar forest-trees, evincing by their size and by their appearance generally, that they are coeval with the creation of man—coeval at least with the Deluge, or the age immediately succeeding that catastrophe?

14. Allowing freely that none such exist anywhere on the earth's surface, unless, indeed, we may except the *Boabab*, the *Dracœna*, and the *Taxodium*, said to be severally from 4000 to 6000 years old,—and readily admitting that trees of *any* kind much exceeding even a *few* centuries are extremely rare, the answer to these questions is not far to seek. All

be seen, among the curiosities of the show, in a moderate-sized flower-pot, a specimen of the *Wellingtonia gigantia*—"the parent tree of which, we are told, was 300 feet high, thirty feet in diameter, and supposed to be 3000 years old."—*The Times* Newspaper, June 4, 1855.

trees, and some kinds more than others, are subject to certain influences from without, and to certain changes from within, which unfailingly entail, not the *natural decline and death*, but the *accidental destruction* of the far greater number of them,—and that before the lapse of any very lengthened period. In Endogenous trees, for example, the trunk, incapable of yielding sideways, has, after a time, its interior so thoroughly filled up below with the roots of the plants above, that the sap can no longer ascend; whereupon either the last-growing plant dies, or the bud of the next in succession is not developed. A change somewhat similar, and attended with the like result, appears to occur in old trees of the Exogenous kind. The internal and more recently formed layers of bark are prevented from yielding by the drying and hardening of the older layers of bark without; while the inner and older wood loses its porosity, partly by the pressure of the younger wood without, and partly from deposits (*crystalline?*) of organic matter in its substance. And thus it happens that neither can the roots of the growing plants readily find room to grow, nor can the sap rise freely upwards. Again, in Endogens, the trunk becomes at length so disproportionate in height to the naturally narrow basis of sustentation under ground, as to be easily blown down. And even in Exogens, proportionally broad as this basis is, the vast height and breadth of surface which they at

length acquire, causes the wind to act on them to their destruction, the older they become, at an advantage infinitely greater than in their earlier years.

15. Further, all dead organic matter sooner or later undergoes certain purely *chemical* changes, which lead to its decay or decomposition, and end in its disappearance; and this process once begun goes on all the more rapidly that the conditions favourable to it obtain. I need scarcely remind you that, according to the theory, the greater part of all trees consists of vegetable tissue that has lost its *vitality;* and it must be obvious to you, that exposed as they are to the full action of the weather, trees are naturally placed in circumstances highly conducive to the decay of this tissue. Endogens, indeed, are for the most part swept away or otherwise destroyed before there is time for the occurrence of such decay. But in Exogens, the process is matter of daily observation, while its results are familiar to every one. From this cause, the heart-wood of all of them after a time disappears, leaving the trunk hollow within, often reducing it to a mere shell, and thus necessarily weakening the mechanical support given by it to the growing parts above, as well as its power of resistance. And it is obvious to remark, that the older an Exogen becomes, its liability to be uprooted or dismembered by any passing storm of wind, increases in a double ratio, and from two distinct but concurring causes,—on the one hand (in sum-

mer especially, when in full leaf), from its greater size and breadth, enhancing the power of the wind,—and, on the other, from the more extensive decay of the heart-wood, making it less able to withstand the agency of the wind.

16. Moreover, the nourishment existing in the soil comes often to be exhausted, and even that supplied by the atmosphere to be rendered unavailable. Of this, plantations furnish us with continual examples. The forester or the wood-merchant may tell us that certain sorts of trees become "*ripe*" after seventy, eighty, or ninety years, and after that do no more good. They thus speak of trees growing together in a wood—of Firs, for example. So far, or in a certain sense, they speak truly. And the explanation of the thing is, that the trees so circumstanced have by that time extracted from the soil all the nutriment it can yield them, and particularly the saline matters (*ashes*) that are essential to their growth. And you must yourselves have often noticed (in plantations especially that are densely crowded, and have not been duly thinned), that such trees are wholly, or at least almost quite destitute of branches,—the side plants, that is to say, having either been stunted in their growth, or having altogether died out. And this happens, because, although the air (from the carbonic acid of which they derive a large part of their nourishment), can gain access to them, the light and the heat of the sun, with-

out which it is impossible for them to appropriate it, cannot reach them. And yet the same sort of trees, growing singly or at suitable distances, freely exposed on all sides to light, heat, and air,—and having, besides, an unlimited command of fertile soil, may flourish for centuries, spreading abroad numerous and massive branches. In proof and illustration of this, let me refer you to the condition of any ordinary plantation of Larches seventy years old, as compared with that of the two Larches in the Park at Dunkeld, in Perthshire—the first of the kind introduced into this country, and planted by the Duke of Athole in 1737. The former are tall, straight, branchless poles, growing only at the top, their growth even there failing, and likely soon to cease entirely: the latter tall also, but thick in proportion, and amply furnished with large and spreading branches, growing in all directions, and altogether presenting such an aspect as bespeaks for them a much more prolonged existence, and a much greater height, and breadth, and girth, than they have yet attained.*

* Suppose yourselves on a hill-side, on a summer day, looking down on such a plantation of Larches. The whole upper part of it will appear as one continuous sheet of green. Next make the circuit of the plantation: it may still be green on every side, enclosed as by a wall of foilage. Then enter the plantation, and walk through it in its length and breadth. It will feel everywhere cold and cheerless. Scarce any traces of vegetation will be visible. Little else will anywhere meet the eye save the bare trunks and withered

17. Add to the agency of the causes already specified, that of a thousand other destructive influences, which come of "the sundry and manifold changes of the world"—frost, fire, hurricanes, lightning—the necessities and caprices of man himself; and a calculation of chances will put it beyond all doubt, that the far greater number of all sorts of trees, perennial as "the everlasting hills," as I maintain they naturally are, must *perish* at no very remote period from their origin; and that ultimately, though at no definite time, even the oldest and the greatest of them must disappear from off the face of the earth.—I am, &c.

branches of the trees. The whole plantation will contrast remarkably with the Dunkeld Larches,—the reason of which, as of the entire aspect of both, you have in the text. Such a plantation may be compared to a vast marquée, the framework and supports consisting of long wooden poles, the covering of green baze.

LETTER VIII.

"Wherever a bud is, it contains within itself the germ of an entire plant." T. Appleby.

"Les bourgeons donnent naissance à des *scions* ou jeunes branches chargées de feuilles, et le plus souvent de fleurs. Chaque bourgeon a une existence en quelque sorte indépendante de celle des autres. M. Du Petit-Thouars les regarde comme analogues, dans leur développement et leur structure, aux embryons renfermés dans l'intérieur des graines, qui, par l'acte de la germination, développent une jeune tige que l'on peut comparer, avec juste raison, au scion produit par l'évolution d'un bourgeon. Aussi donne-t-il à ces derniers le nom d'*embryons fixes* ou *adhérens*, par opposition à celui d'*embryons libres*, conservé pour ceux renfermés dans l'intérieur de la graine." Richard.

November 11, 1854.

My Dear Sons,

1. I have now completed the expository part of my subject. It remains for me to substantiate the allegations made, and, if possible, to raise to the level of a sound theory what as yet can only be regarded as a pure hypothesis. To this task I shall address myself in this and subsequent letters.

2. It will I think at once be obvious to you, that all I have to do is to make good the allegations I have made as to the *nature* of trees. If this can be done,—

if I can prove that what I have affirmed concerning this is true, the other allegations as to the natural longevity and the natural size of trees, will necessarily be true also.

3. Now the evidence to be adduced will consist in shewing, *first*, That the annual growths emanating from the buds constitute, severally, perfect and independent plants; and that a succession of such plants may be kept up from year to year, and for an indefinite period, from buds alone;—and, *secondly*, That the same year they are produced, the plants or growths in question (save only the newly-formed buds) die, and never live again; or, in other words, cease to be, and never afterwards become the seat of any vital action.

4. All this it will be incumbent on me to make good. Beyond this, however, I do not see that anything will remain to be done, unless it be to add strength to my argument by adducing the concurring testimony of others in favour of it, and to meet objections that may be advanced against it. And with regard to that testimony I may in anticipation observe here, that singularly strong and varied as it will be found to be, its great value will lie in its being thoroughly independent and undesigned.

5. My first endeavour, then, will be to shew that the annual growths which issue from the buds constitute, severally, perfect and independent plants; and likewise, that a succession of such plants may be kept up from year to year for ever, from buds alone.

6. On each returning Spring, we see the buds on the stems of the previous year first swelling and afterwards sending out new stems, which in themselves and in their appurtenances are precisely similar to those which the seeds send up. Like them, they are furnished with leaves and roots, they form buds, and they put forth flowers and bear seed. Now, in this annual formation we have, as the produce of the buds, all the parts that are essential to the constitution of perfect plants; and, while the plants which thus issue from the buds produce buds in their turn for the evolution next year on the same tree of other like plants, they produce seeds also for the evolution elsewhere of precisely similar plants.

7. The fact that the buds in question evolve the *seed*, —that, while they give rise to other structures in every respect identical with those which come of the seed, they are themselves adequate to the production of the seed, —this, to my mind, is proof sufficient that the buds are physiologically co-ordinate with the seed, and that their produce is equally with that of the seed entitled to be regarded as distinct plants. In order, however, the more fully to demonstrate the accuracy of this assumption,—in order the better to satisfy you as to the proper individuality of each and all of the growths thus formed by the buds of trees, and their claim rightfully to be regarded as perfect plants,—and likewise as to the capacity of each of them to reproduce

its kind annually in endless perpetuity from buds, I will adduce further proof. And, in the first instance, I shall refer you to the potato-plant,—a plant which, though it never grows up into a tree, contains all the elements of a tree, and is equally perennial in its duration as any tree.

8. The tuber familiarly known as the potato bears a very close resemblance to the yearling shoot or stem of a tree. It is confessedly of the same nature with such a shoot. It is, in fact, an *underground stem*, and consists of a layer of bark and a layer of woody tissue enclosing a mass of pith, and furnished with buds. This underground stem, when planted in Spring, sends out from each of its buds a growth, which has a stem (underground) and roots and leaves and flowers, and which forms buds and seeds—structures that are the exact counterparts of those composing the growths that proceed from the buds of trees. Does any one ever doubt that the annual potato-growths which he sees in the fields are perfect and independent plants? Does any one doubt that from the buds alone, without ever having recourse to seed, a succession of such potato-plants may be kept up from year to year for ever? I apprehend not.

9. The tree-plant and the potato-plant, each growing from buds after its kind, are in fact identical in constitution and structure. The only difference between them lies in the situation of their respective stems,—in

the changes which these and their roots respectively undergo,—and in the habitudes of their respective offspring. Thus the stem of the tree-plant grows above ground, that of the potato-plant under ground; the dead stem and roots of the tree-plant continue undecomposed and entire for years and ages, those of the potato-plant decay early the following year—its roots perishing, in fact, the same year with the leaves; the offspring of the tree-plant grow together, and as parasites on the persistent dead remains of their parent, which serve as a common axis on and around which they grow — those of the potato-plant strike down singly and separately into the soil, and have no connection with any portion of their parent, the remains of which have in fact ere this stage of their growth wholly disappeared,—and nothing left around which, as a common centre and a mechanical support, they could grow as parasites. Had it suited the purposes, immediate and remote, which the Author of Nature had in view in giving them existence, we might have had the respective peculiarities of these two kinds of plants completely reversed. The potato-plant and its progeny might have grown together parasitically, and by their aggregation have formed a true potato-tree. Fantastic, doubtless, would have been the aspect of such a tree; but it would have possessed, as a whole, the same individuality which common opinion ascribes to an ordinary tree, and the several plants composing

it would have been regarded and spoken of as mere annual *growths*. The tree-plant, on the contrary, and its progeny, might have grown and extended themselves year by year as distinct and separate plants, and the so-called annual growths or shoots been looked upon as perfect and independent plants. They could not, in this case, have been called tree-plants; yet such might have been the constitution and habitudes of the oak-plant, of the beech-plant, and others.

10. But we need not have recourse to a speculation of this kind. We cannot, it is true, cause the potato-plant to grow after the manner of the tree; but we can cause the individual plants composing the tree to grow after the manner of the potato, and may see their shoots striking down separately into the soil, and growing up independently one of another, the stems themselves (the counterpart of the tubers), to which were attached the buds from which the shoots sprang, speedily rotting and passing away. We can plant the willow as we do the potato, and with like results. Were it to serve any good end, we should have our willow-fields as we have our potato-fields. In precisely the same way as year by year we raise a crop of potatoes, and with as much ease, we might raise annually a crop of willows. Cutting off the last year's shoots from a willow-tree, and planting them in a moist soil, we may obtain as many young willow-plants and

embryo willow-trees as we have planted shoots, all of them as independent of the parent tree as they are independent one of another, and each one of them as truly an individual as is the produce of the potato-bud.

11. The common Strawberry affords a somewhat different, but in principle the like illustration as the potato. The stem of the Strawberry is *above-ground*, but possesses such length and tenuity as makes it lie sessile or recumbent on the soil. The young plants that come from its buds, finding themselves thus in contact with the ground, straightway strike down into it, and the stem decaying and disappearing, the connection between them and the stem is thus severed, and they grow up as separate and distinct plants. But for this *accidental* tenuity of its texture (so to speak) the Strawberry stem might grow erect, the roots of the several plants might creep down alongside of it, and so a Strawberry-tree, or at least a shrub like the rasp or the currant, be produced. Analogous to what I have just mentioned as the natural habit of the Strawberry, is an occurrence observed a few years ago by a friend of mine in a Fir-tree. This tree had chanced to be broken across near the butt, and had fallen to the ground,—without, however, being completely severed from the short stump left standing. A small strip of wood and bark still connected them. As the tree thus lay, one of its branches being in direct

contact with the ground, threw out fibres, which took root separately. And at the time it was examined by my friend, some years after the accident, this branch, which had assumed a tolerably erect attitude, was in the course of establishing for itself an independent footing, and of growing up into a tree, amid the decay and ruin of its prostrate and dead parent.

12. It is only necessary further to advert to the processes of grafting, budding, and layering. These processes seem to me to furnish unequivocal evidence that the allegations made as to the annual growths on trees are well-founded, and indeed to be themselves explicable only on the principle of my theory. From the yearling bud taken from one kind of tree and duly grafted on another of the same natural family, though of a different species, we get the first year a growth, and in the course of years a tree, exactly similar to the tree and to the other growths of the tree whence it was taken. And the tree thus derived, though growing on another, preserves nevertheless its own distinctive character, has its own peculiar leaves and blossom, produces its own peculiar fruit, and is in every respect as perfect a tree as if it had been raised from a seed, and had grown up independently from the soil.

13. Nor is it unimportant to observe, as exemplified in our various fruit-trees, that any particular variety may be in this way not only multiplied indefinitely,

but preserved in *perpetuity*,—although (from *accidental* causes, however, as explained in the preceding letter), the original tree will not and cannot continue to last for ever. The late Mr Knight, indeed, as is well known, maintained the contrary. Participating in the popular belief that there is a fixed period of life for every tree, and one common period of death for all its parts, he held that a young shoot taken from an old tree could live only as long as the tree, and would die with it, *i. e.* supposing that it died from natural causes. In this way he accounted for the disappearance, or at least the scarcity of several once well-known fruit-trees, such as the *Red-streak* and the *Golden-pippen*. His views, however, have not been confirmed by the observations and the experience of others. The fact which he thus endeavoured to explain has been shewn to be exceptional, and referable when it does obtain to an entirely different principle.*

14. Similar remarks to those now made in regard to grafting apply to the analogous processes of propagation by slips or layers, and to the indefinite multiplication and endless perpetuation of such trees (the Willow, for example) as admit of being reproduced in that way. It is observed by Professor Henslow, that all the Weeping-willows in Europe are said to have been derived from cuttings taken from a single tree,

* Balfour, *Class-Book of Botany*, pp. 665–8. See also Letter xvii. section 8.

and this, probably, still growing in Africa.* Now, were Mr Knight's views correct, or were the prevailing theory as to the nature of trees a sound one, these Willows, though themselves to all appearance trees, would in reality be nothing more than "the developed state" of the original and proper tree. There could not with propriety be said to exist in Europe a genuine Willow-tree of this kind. It might be feared, at least, if not confidently anticipated, that over every part of Europe they would all die about the same time, and simultaneously with the death of their African progenitor!†

15. Such is my argument. It goes to place the bud on a level with the seed, and the growth that comes from the bud on a footing with the seedling plant. It goes also to invest the annual cylinder of woody tissue, formed in connection with the several growths of the year, with the character of roots. To my own mind, the proofs now advanced in support of the *former* of these positions are clear, unequivocal, and decisive. The evidence in favour of the latter, in as far as not included, directly or by implication, in the former, or not already adduced in Letter V., I reserve for the present. There are those, however, who would regard them as insufficient. Dr Carpenter, for instance, would take exception to the main assumption. He would

* *The Principles of Descriptive and Physiological Botany*, p. 242.

† Henslow, *Ibid*, p. 242.

refuse to co-ordinate the bud with the seed; and would maintain that the produce of the bud is none other than the result of a process of "continuous growth," a mere extension of the parent tree, and that this tree, sprung originally from a seed, constitutes but a single or an individual plant. The adherents of Mirbel, on the other hand, holding that the woody cylinder is altogether a *special* structure, and formed *in situ*, would deny to it the character of *roots*. And taking up this position, they might retort upon me these two questions—*first*, Where are the roots of your alleged annual tree-plants? and, *secondly*, What is there in confessedly annual and true plants analogous to the woody cylinder of the tree?

17. The objections which may be thus or otherwise urged I will not now stop to consider. They will engage our attention in future letters, in which also, from the considerations to be therein adduced in answer to those objections, I hope that both the theory itself and the evidence in support of it will come out still more clearly and decisively. And asking of you meanwhile, and till those objections are disposed of, only a provisional assent to this branch of the theory, I will, in my next letter, endeavour to prove that the young plants which in spring issue from the buds are strictly *annuals*—that is to say, that they die the same year, and never afterwards live.—I am, &c.

LETTER IX.

"Nature, indeed, yearly perishes."

Rev. Archibald Alison.

"Our very life is nothing else but a succession of dying; every day and hour wears away part of it; and so far as it is already spent, so far we are already dead and buried."

Jeremy Taylor.

"All vital affinities are of transient duration only."

William Pulteney Alison.

December 23, 1854.

My Dear Sons,

1. But for the demurrer entered at the close of my last letter, I should now unhesitatingly speak of the produce of the buds as real plants, each perfect and complete after its kind. I will henceforth call them such notwithstanding,—under reservation, however, of the objections to my argument hereafter to be considered. And I now proceed, as proposed, to make good my other allegation respecting the plants,—to wit, that they are *mere* annuals, living only *one* year, losing their vitality the *same* year that they spring up, and never afterwards becoming the seat of any vital action, or the subject of any vital change; and

further, that they are essentially independent, that is, physiologically, or in respect of their vital relations, of the stock on which they grow.

2. That at the close of the year the young plants die, and never afterwards live, is sufficiently obvious as regards the leaves and flowers, which wither, fall off, and completely disappear. How large a part these form of the whole annual vegetation of a tree, it is unnecessary to insist upon. The only question, therefore, is as to what remains of the other parts of the plants—viz. the roots and stems.

3. Now on what grounds are we entitled to affirm that these stems and roots then die and never live again?

4. To pave the way for the evidence to be adduced, let us dwell for a little on some considerations connected with general physiology, comparing and contrasting, as we proceed, animals with vegetables, and the everlasting trees producing *timber* for the use of man, with the annual corn-plants which supply him with his daily bread.

5. Consider, then, first of all, what is true of the whole organised creation, of vegetables equally with animals, of animals in common with vegetables, that *all vital action is of exceedingly short duration in any organised structure.* The *chemical* affinities by which the various organic compounds are formed, and the *plastic* affinities by which these compounds are subse-

quently transformed into the various organised structures—and these again knit together and built up into the several plants and animals which we see around us,—and which affinities are the most general and fundamental of all vital actions,—are exceedingly transient in their agency. Their office may be said to cease in each structure on the completion of the structure; and if this structure have no special purpose to serve in Nature other than that connected with its formation as an organised tissue,—if the object of its existence end with its formation, its vitality may be said to cease with the play of the chemical and plastic affinities by which it was formed; and losing its vitality, it tends (as is the tendency of all dead organic matter) to revert back to the condition of inorganic. Add to this, that the more active and energetic the agency of these affinities, *i. e.* the more rapid the formation of the structure, the shorter is the duration of its vitality.

6. If, on the other hand, the structure have some specific end to serve; and if, in order thereto, its maintenance for a time in a *living* state be required, this can be accomplished only by a *continual change and renewal of substance.* For the general law of transient vitality still attaches to its several molecules; and these, as they die, must be removed and replaced by new—a process involving the continued agency of the affinities by which the structure was at the first formed, exerted on foreign matters taken in from without—

involving also the agency of oxygen to effect the disintegration and removal of the old. To this process physiologists give the name of *interstitial* or *molecular nutrition.*

7. If the special end which the structure has to serve be merely *mechanical,* as is the case, for example, with bone and cartilage, the general observation now made embraces all that need be said as to its vital relations. But if its end be *higher* than this, as is the case with the secreting cells and glands (both vegetable and animal), with the muscles also, and with the brain and nerves of animals, it will have, *superadded,* a suitable *specific* vitality; and then, there is this further law, that every exercise of its proper function is more or less exhaustive, as well of the general as of the specific vitality of the structure; and that just in proportion to the amount and frequency of the exercise. Every muscular effort we make, every exercise of thought and will, exhausts the vitality of so much brain and nerve and muscle—involving thereby the diminution or loss of the specific power—entailing also the death and removal of so many of their moelcules —necessitating likewise their replacement by new ones; and that in the exact measure and proportion of the acts of thought and volition and of muscular exertion. But observe, further, as the subsequent result of that exercise, that, under favourable circumstances, the restorative process outruns, within certain

limits, the destructive; and that the structure acquires ultimately an increase of bulk and power.

8. All vital action, then, is exceedingly transient in any structure. The greater the rapidity of its formation and growth, the more frequent the exercise of its own peculiar function (if it have any), and the greater the energy of this exercise, the shorter time does the structure retain its vitality; while its *continued* maintenance as a *living* structure can be accomplished only by an incessant change and renewal of its constituent molecules. So true is it that we begin to die as soon as we begin to live (*nascentes morimur*); that our very life is nothing else but a succession of dying; that every day and hour wears away part of it; and that, so far as it is already spent, so far we are already dead and buried—a truth, however, which has only been recognised in all its fulness by physiologists within these few years, and which was perhaps first brought thus prominently into view as a principle in physiology by Dr Carpenter.

9. If these views as to the general nature of vitality be correct, it will be a fair inference that the *absence* of any such process of interstitial or molecular nutrition in a tissue or organ, *after its full development*, is equivalent to that tissue or organ being destitute of vitality—to its being no longer the seat of any vital change or action. It will be a proof that, however it may retain its characteristic appear-

ance, and its ordinary physical qualities, it is really *dead*.

10. Now, how stands the case with Vegetables? It is on all hands admitted, that such a process has no place in their economy. No removal of their substance and replacement of this by new tissue ever takes place. The tissues composing them undergo no change of that kind. Once formed, they are never afterwards the seat of any change corresponding to the renewal of substance which is continually going on in the living tissues of animals.*

11. And this is true of *all* vegetables without exception—of the *perennial* tree equally with the *annual* plant. They stand in this respect on precisely the same footing. Are we not warranted then in saying, that the absence of all change of that kind in the stems and roots that remain after the fall of the leaves, and

* "The economy of vegetables is fitted for their office of constantly converting inorganic into organised matter, by this peculiarity, that their nutrition is maintained without any such function as the interstitial absorption of animals; and necessarily involves, during the whole time that any vital actions are going on, continual additions to their substance."—Alison, *Outlines of Physiology*, 3d Ed. p. 12.

"In vegetables there is none of that absorption of the different parts which takes place in animals. The matter of which they are composed, being once deposited, is never taken up again; whilst in animals there is a constant process going on, by which the old matter is taken away and the new deposited, and the organs thus renewed."—Dr Ware of Philadelphia, in his Edition of Smellie's *Phil. of Nat. Hist.*, Introduction, chap. ii.

flowers, and fruit, goes far to make good our assertion, that the parts in question then die, and never live again ?

12. If we pursue this matter a little further, we shall not only see still more clearly, I think, the *reason* of this difference in the constitution of plants and animals, but be able to trace a closer affinity between the tree and the annual in relation to the duration of their vitality—nay, an actual identity between them in this respect.

13. The *objects* for which animals exist, and for which they have been created, may, in a general way, be said to have reference to the *mental* powers bestowed upon them. Those objects require the maintenance of the animal structures, in a state of vitality and efficiency, for a certain time, which is very various in different structures and in different kinds of animals. Agreeably to the laws of vitality, this can be accomplished only by an incessant change and renewal of substance; and accordingly this change forms a distinguishing characteristic of the vital actions of animals. To this it may be added, that their several structures are designed either to serve as the seat or the instruments of the mental principle within them, or to provide for the continued maintenance of the entire organism.

14. On the other hand, the *objects* for which vegetables exist have reference to animals. Vegetables

exist only in subordination to animals; and the objects of their existence are as various as their kinds or species. One is, the *formation* of *organic* matter for the use and sustentation of animals. That, indeed, is the first and chief end of their existence, and the only one that need engage our attention here.

15. Observe: All organic matter comes from the inorganic world—from its water, its air, and its soil; and sooner or later all organic matter is resolved back again into air, earth, and water. "Dust thou art, and unto dust shalt thou return." That is the beginning and the end, the source and destiny of the material part of every living thing. It is true of animals as it is of vegetables. They are linked corporeally to the dead earth as closely as vegetables are. Equally with vegetables, they are beholden to it for their very fabric, for the materials out of which this is built up and fashioned, and by which it is continually renewed and upheld during its allotted time.

16. But observe further: Animals require for their sustentation that this inorganic matter shall first have been transformed into organic. They cannot themselves subsist on inorganic matter as such. Neither have they the power of effecting that transformation for themselves.

17. Vegetables, however, can do both. Their proper food is carbonic acid, water, and a few simple salts; and they can so act upon these, and upon ammonia, as

to form cellulose, starch, sugar, oil, gluten—nay, albumen and fibrine, and the several structures and juices of which they consist. In forming these, they fulfil the end of their being; and having no object to serve beyond this or not *arising* out of this,* and having made provision concurrently with it in the form of buds, or seeds, or both, for another race of the like kind with themselves, they die. And accordingly, they neither need nor do they exercise any such function as the molecular nutrition of animals.

18. Let me take you one step farther. Dependent as the whole animal creation thus is on the vegetable, man is in an especial degree, and in an infinite variety of ways, beholden to it. Gifted with reason, which has been denied to the brute animals, his merely natural wants are far greater than theirs; while the reason which has been given him, and, as arising out of this, the objects of his existence and the manifold relations in which he is placed—all these *multiply* his wants to a degree which it is scarcely possible for us to conceive.

* "Or not arising out of this." One exceedingly important object of their existence is that of maintaining the atmosphere in a state of purity for the respiration of animals. This they accomplish by the power they possess of decomposing carbonic acid—retaining and fixing the carbon within themselves, and setting free the oxygen. But the carbonic acid existing in the atmosphere forms one main source of their food, and the accomplishment of the object here referred to may be said to spring from that mentioned in the text.

19. Now, his various wants are *mainly* such as vegetables only can meet. We have already seen how dependent he is, in common with all animals, on vegetables for *food;* and we may just add, with reference to this, that besides the enormous quantities of corn and other kinds of vegetables grown annually, to be directly consumed by him, a large part of every year's vegetation is raised for the support of animals which he lives upon, and rears exclusively for their use as food. The grass of the field is thus indirectly but as truly his stay and support as the corn. But, passing from this class of vegetable productions, and from that more immediate and pressing want which they supply, let us ask what kind of vegetables come next in importance to man—what sort of vegetable produce is he most dependent on? Were we to say trees and timber, and trees as producing timber, should we be far from the truth? Doubtless not. Wanting timber, what could man have done? What would have been —what would now be his condition? He could have done very little towards subduing the earth, or replenishing it; he could have made little or no progress in arts, or commerce, or civilisation. It may be questioned whether he could have continued on the earth at all, so intimately are the properties and uses of timber bound up with the very conditions of his existence.

20. We are now arrived at the point to which I

wished to bring you. We have seen what are the more special objects of the existence of vegetables, and what the character and duration of their vitality. We have seen also the importance of timber to man, and may infer from this the main object of the existence of trees and tree-plants. And we may now, I think, see a reason why the stems and roots which remain after the fall of the leaves need not, nay, why they should not, any longer retain their vitality. For the chief object of the existence of trees and tree-plants is plainly the production of timber; and, its production going on by the formation year by year of distinct layers of woody matter, there is a strong presumption, from the considerations now adduced, that on the accomplishment of this object each year, both the timber produced, as well as the plants producing it, will no longer be either the seat or the subject of vitality. We may thus perceive why the production of our "*timber-stuffs*" need not differ in principle from the production of our "*bread-stuffs.*" I say in principle, for there is a difference. It is one, however, in mode only; a difference in the accidents, not in the essentials of its production, the reason for which also we may readily perceive. For, although for some purposes the wood of the seedling or sapplings is useful, yet for most purposes the *aggregate collection* of the wood of several years successive tree-plants is necessary. Indeed, it is only such an aggregate that

we regard and speak of as *timber;* and while for many purposes immense aggregations of this kind are needed, they could have been produced only, consistently with a strict adherence to the general analogy of vegetable life, by such peculiarities in the modes and habitudes of growth of the various tree-plants as it has been my object in these Letters to point out as belonging to them.

21. In truth, then, as I believe, just as we have annually a crop of corn, so have we annually a crop of timber; and just as we stack the one or put it into barns of our own building, so does nature stack the other for us, laying it up and preserving it in a way we cannot, leaving it to ourselves to draw from her store, and turn it to our purposes as we need, or as we please, after the stack has stood ten, or fifty, or a hundred, or a thousand years. A tree is but a timber-stack of nature's building.

22. But however this may be, the fact is, as we have seen, that after its formation the woody matter of a tree undergoes no such molecular change of substance as we have reason to believe *essential* to the *continuance* of vitality in any organised structure. And to this it may be added, that after the year of their formation, the several layers of wood and root undergo no farther extension by *growth.* So unchanged do they remain, that from an examination of the woody cylinders of an old tree, we may readily gather, nay

with the utmost precision determine, what were the characters of the seasons 500 or 1500 years ago.

23. But, allowing that no such molecular change takes place in the woody matter, nor any farther increase of growth, the *sap* continues year by year to move through it; and this movement is a vital action, and due to vital agency: True. And is not this a proof that the old wood still continues to be possessed of vitality? In my next letter we shall consider whether it be or no.—Meanwhile, believe me, &c.

LETTER X.

"Ubi stimulus, ibi fluxus."

"It is evident that the force, whatever be its nature, by which the continued movement is kept up, must be developed by the processes to which that movement is subservient; in other words, that the changes involved in the acts of nutrition and secretion are the real source of the motive power." DR CARPENTER.

"If a piece of bladder be tied over the surface of a vine-stump, when the sap is rising rapidly, it soon becomes tightly distended, and will ultimately burst." PROFESSOR HENSLOW.

January 7, 1855.

MY DEAR SONS,

1. I concluded my last letter by observing, that although (as we there saw) the old stems and roots undergo no organic change of any kind after the year they are formed,—neither an increase in length or thickness, nor a renewal of substance,—the sap, nevertheless, moves through them during the next and several subsequent years. And I remarked, that this might be regarded as a proof that they retain their vitality for a much longer period than I allow they do.

2. It does not therefore follow, however, that the parts in question are alive. To warrant such an infer-

ence, it must be shewn that they contribute actually and actively towards the movement; and that, too, in a way not referable to their porosity merely, or to any other simply physical property they may possess. There is a familiar experiment which you have yourselves often made for your amusement—that of strewing cress or mustard seeds on a bottle or other vessel covered with flannel and placed in a shallow dish, which you fill up, and from time to time replenish with water; the result being, as you know, that in due time the seeds germinate and cover the vessel with living plants. Here, in this simple experiment, the flannel by reason of its porosity conveys, or rather allows the passage of the water from the dish to the living seeds and plants. No one, however, would for a moment imagine that the flannel is alive. No more are we entitled to infer that the old stems and roots of a tree are alive because of the sap moving through them to the living and growing parts above. They may be merely the medium or channel of its transmission, and may contribute towards this in the same way that the flannel does, and in no other. Their vitality, therefore, if they be really possessed of any, must be established on other grounds than this.

3. Unquestionably, the circulation of the sap is a vital action, and due to vital agency. This agency, however, has its seat or centre in the living buds, and in the living structures proceeding from them, and actually

growing. It is directly connected with the vital processes going on there during the spring and summer —nay, it is exclusively dependent on these processes. The first or earliest movement of the sap in spring is in the immediate vicinity of the buds. The fluid there, previously at rest, is the first to be set in motion, and its movement is determined by the act of vegetation beginning in the buds under the quickening influence of the sun. The subsequent and very rapid increase in the activity of that process necessitating additional and proportionably larger supplies of sap, an agency is exerted which operates *downwards* in the direction of the soil, and causes the nourishing fluid to *ascend*. And it is further of consequence to remark, that the whole season through, the amount of sap drawn from the soil, and the rapidity of its ascent through the trunk to the parts above where vital actions are undoubtedly going on, are entirely regulated by the activity of these actions. The supplies furnished, and the times and rates of their delivery to the living and growing parts above, are in the exact measure and proportion of the demands they make. They are large or small, slow or rapid, just as the vegetation is scant or luxuriant, languid or energetic.

4. Of all this we have several decisive proofs. If any single branch of a tree, standing in the open air, be carried through and led into a hot-house hard by, at a time when no vegetation is going on in any part of

the tree, and the sap is everywhere quiescent, the buds of that branch will vegetate, and the sap circulate through it, while as yet nothing of the sort is in progress in any of the other branches of the tree.* It cannot surely be that the roots and stems should exert an agency so exclusive, or have any share in the production of a change so strictly local. Conversely, if the buds be cut off from a branch prior to the commencement of the annual process of vegetation, no sap will pass into that branch during the entire spring and summer, although the other branches not thus mutilated will be full of it. Again, if at a later period in the season the leaves be stripped from off a branch, the flow of sap through it will speedily if not at once be effectually and permanently arrested.

5. What may be the nature of the agency thus exerted in the living buds and leaves, or of the force emanating from them, which thus causes the sap to circulate, and which regulates the quantity of it passing through the old stems and roots,—and what the mode or manner of its action, it is not easy to say. It is clearly a force acting *a fronte*, or *in advance*, and *attracting* the sap,—in contradistinction to a force acting *a tergo*, or *from behind*, and *propelling* the

* "The excitement of vital action in a branch of a tree *exclusively* exposed to the sun, is the cause, not the effect, of an *exclusively* increased flow of the sap into it."— Alison, *Outlines of Physiology*, 3d ed. p. 70.

fluid.* But be its nature what it may, the old roots and stems may be no farther concerned in it, than as being the channels through which the nourishing fluid passes upwards from the soil. No facts yet known to physiologists demonstrate that they are any otherwise concerned in it, while those just adduced sufficiently account for it independently of them.

6. But in the course of the season, there is a *descending* as well as an upward or ascending movement of the sap. And this other must equally be regarded as a vital movement, and equally due to vital agency. May not that movement, at least, argue vitality and vital power in the old stems and roots? I apprehend not; and for this reason,—that while the ascending current is plainly referable to the processes going on in the buds and leaves, to the evolution of which as well as its own elaboration it is subservient, the descending current now in question is connected with the formation of the woody layer all over the exterior of the tree, and as plainly referable to the processes by which that structure is evolved. This layer is distinct from the layers of previous years; it is a new formation, of the same year's growth with the young

* To Dr Alison, unquestionably, the merit is due of being the first, in this country at least, clearly to establish both the reality and the importance of this general principle in physiology; and likewise to shew how large a part it plays in the morbid as well as in the healthy processes of the living body—in the acts of nutrition and secretion, as well as in the movements of fluids.

plants above, and growing concurrently with them. And it requires for its evolution equally as these do for theirs, a supply of prepared or elaborated sap. But the sap is elaborated only in the leaves; and as the woody layer extends from the base of these downwards to the tips of and even beyond the roots of the previous year, so the sap can be supplied only from *above*, and must *descend* in order to reach every part of the layer in question,—its descent, however, in common with its ascent, being immediately due to the *attractive* force exerted by living and growing tissue.

7. But the agency now dwelt upon as seated in the growing parts, and thence exerting an attractive influence over the sap, is not the only one concerned in the movement of this fluid. The well known experiments of Hales, and those subsequently instituted by Dr Daubeny and others, leave no room to doubt, that at the extreme points of the roots (designated the *spongioles* of the roots) there resides another and a very efficient moving power.* Let us consider

* "Hales cut off the stem of a vine in the spring, when the sap rises with the greatest velocity, and luted a tube to the top of the stump, bent in the manner we have described in the construction of the Endosmometer. As the sap rose into the tube, mercury was introduced at the open end; and a measure of the force of the rising sap was thus obtained, and found to equal the pressure of an atmosphere and a half."—Henslow, *Descriptive and Physiological Botany*, p. 181.

it for a little, and see where it exactly lies, and how it acts. The old rootlets and their spongioles have, I apprehend, no real concern in it, but only the new—those that have grown during the year, which stand related to the new plants, and to the corresponding layer of woody tissue, and which, as we shall yet see, actually begin to grow contemporaneously with these.* It may be supposed, however, to be of the nature of an *a tergo* force—that is, of a moving power acting from *behind* and in the way of *propulsion*—differing, therefore, in its mode of action, if not in its essential nature, from that already considered. It is clearly, as the facts connected with it show, *elective* in the first instance—allowing certain fluid matters existing in the soil to gain entrance within the tree, and rejecting others.† But in the next place, with regard to the fluid thus admitted, it is as clearly *attractive* as is the agency of the buds and of the living structures which spring from them. So soon, indeed, as it is drawn

* See Letter XII., Sections 7–13.

† "If a grain of wheat and a pea be grown in the same soil, the former will obtain for itself all the *silex*, or flinty matter, which the water can dissolve; and it is the deposition of this in the stem which gives to all the grasses so much firmness. On the other hand, the pea will reject this, and will take up whatever *calcareous* substances (or those formed of lime and its compounds) the water of the soil contains, these being rejected by the wheat."—Dr Carpenter. This selecting power, however, is limited, as in the case of the animal body—substances being readily absorbed which prove hurtful to the system, or even fatal.

within the tree by the young spongioles, the fluid has no help but to move on and pass upwards. Even were there no force in advance, as we have seen there is, sucking it upwards, the fluid must needs pass in this direction, because *driven* on by the portions subsequently absorbed. Physiologically considered, then, the force acting at the spongioles is, I am inclined to think, attractive *only*, and only *indirectly* and *mechanically* propulsive.* It is one, too, I apprehend further, which is strictly *subordinate* to that seated in the living and growing parts above,†—the two acting in harmony together, in ways provided for by the Creator, but which we can as little fathom as we can the essential nature of the powers themselves. In anywise, the facts known to us regarding

* Professor Henslow, indeed, regards it as a *vis a tergo* and *propulsive* in its mode of action,—while Dutrochet, regarding it as simply physical, resolves it into a principle, of a twofold nature, designated by him the principle of *Endosmose* and *Exosmose*. I agree with Professor Henslow that there is a difficulty in resolving the one into the other, and feel inclined to reject Dutrochet's theory altogether as inadequate to the explanation of the phenomena included under it,—but I differ from Professor Henslow in the view taken of it by him. To my mind, a *vis a tergo* must lie without and beyond the roots, *i. e.*, in the soil itself, or the matters contained in it.

† Energetic as his experiment with the vine shewed this power to be, Dr Hales found that, cut off from the force acting above, "it soon diminished, and after a time ceased altogether."—Dr Carpenter, *Principles of Physiology, Gen. and Comp.*, p. 655.

the agency of the spongioles, furnish no grounds for ascribing vitality to the old roots.*

8. Hitherto, then, we have seen nothing in the old stems and roots to lead us to believe that they are possessed of vitality. And I would fain persuade myself that in the facts which have passed under our view, in this and the preceding letter, we have seen enough to satisfy us that they are really dead. And to the considerations already adduced in behalf of this conclusion, I would just add this other. We know that after a time,—altogether indefinite, often not for many centuries, sometimes within a few years,—the earliest formed wood, the *heart-wood*, as it is called, decays and disappears; and that this change may proceed to such an extent as to destroy a large part of the entire trunk, without in the least degree impairing the vegetation going on at the extremities, and on the exterior of the tree. This it is easy to understand on the view we have all along taken of the nature of trees, but very difficult on the supposition that a tree constitutes but a single or an

* "The *spongiole* is sometimes spoken of as a distinct organ; but it is nothing more than the *growing* point of the root, which, with a few exceptions, lengthens only by additions to its extremity. The soft, lax texture of the *newly-formed* part causes it to possess, in an eminent degree, the power of absorption: but as the fibre continues to grow, and additional tissue is formed at its extremity, that which was formerly the spongiole becomes consolidated into the general structure of the root, *and loses almost entirely its peculiar properties*."—Dr Carpenter, *ibid*, p. 652.

individual plant, and is endowed with vitality in its every part. On this supposition, such a change occurring in the heart-wood should spread, or might reasonably be expected to extend to the adjoining living parts, and, sooner or later, but before very long, to kill the whole tree. This, however, does not happen; nor is the complete and premature decay of an entire tree ever due to the agency of such a cause.

9. It has thus, I hope, in this and the two preceding Letters, been satisfactorily made out — *first*, That the growths emanating from the *buds* of trees constitute severally perfect and independent plants; and, *secondly*, That what remains of them, after the fall of the leaves, and flowers, and fruit, with the single exception of the buds, ceases to live, and never afterwards becomes the seat of any vital action.

10. And if this be conceded, it will probably be allowed also, that the view here presented of the nature and of the natural longevity and size of trees is well-founded; — that is to say, that a tree is simply a "*corporation sole*" — a collection, aggregate, or congregation of annual plants of the same species, the production of a series of successive years, the individual plants of each year shooting up in spring from buds adherent to the persistent dead remains of the plants of the previous year, growing as parasites on these remains, putting on the character of old age in

autumn, and speedily thereafter dying — provision, however, having been made by them in summer, in and by the formation of buds, for the reproduction of similar plants the following year: And that being thus evolved, and thus growing from year to year, and having no actual limits to their reproduction in this way, there is in point of fact no actual limit to the age or to the size to which the tree collectively resulting from them, or produced by them, may attain.—I am, &c.

LETTER XI.

"Take an octagon building; paint each side of a different colour. Fix eight men fronting severally each side. Call them away, and ask them the colour of the *building;* and each will give a different account. Now, where does the falsehood lie? Do the same external colours produce different impressions on different eyes? Is the evidence of the senses uncertain? Are there no fixed principles of sensation? No: the mistake lies in a false *inference.* Each man, instead of confining his statement simply to the *part* which he saw, declares that the *whole building,* which he did *not* see, is of the same colour with the part that faced him. His senses are correct: his belief would be correct, if he would not *fancy* more than he really *perceived.* Shift the parties, and try if, when placed before the same side, they all agree in seeing black, or blue, or red, or yellow, where the colour really exists."—SEWELL.

January 25, 1855.

MY DEAR SONS,

1. Professor Sewell, in his "*Christian Morals,*" says truly that "all our knowledge is in fact a perception of relations." And, after remarking that our ideas of the relations that subsist among the many and very various objects of our knowledge, necessarily and intuitively spring up in the mind on the very perception of the relations, he observes that when those

ideas seem to vary, "the variation arises, not from a different idea following the perception of the same relations, but from the perception of seemingly the same thing in different relations." Among other illustrations of this observation, he gives that placed at the head of this letter,—alleging also that what holds true of the perceptions that come to us through the *senses*, is true also of the perceptions derived through the *reason*.

2. Comparing, then, our subject—the Tree—to this octagonal building, and the details regarding it which have engaged our attention, to the several sides of this building, let us consider, before we finally take leave of it, whether we have examined it in all its relations, —whether we have indeed gone completely round it, and looked at its every side.

3. And that we may be well assured that we have done so, let us inquire what account other observers have given of it. We may not find, perhaps, that any one has examined it exactly as we have done,—or rather with the view of discovering whether these particular relations obtain among its several parts which we have seen or fancied to hold. But I have no doubt we shall find that every face and side of the building has been seen by some one or more observers; and our business will be to see whether or how far the descriptions given of it by others agree with or differ from ours. If they agree, well and good. The coincidence

will give us all the more confidence in the accuracy of our own survey. If they differ, it will be necessary to consider wherein the discrepancy lies. The result may be a virtual agreement,—or, perchance, a demonstration that all the while I have been fancying in my favourites—the Trees—much more than I really saw,—seeing in them relations that existed only in my own imagination. Be it so. I hope that love of truth is stronger with me than fondness for a long-cherished theory, and that once convinced that this theory is not what I have hitherto deemed it—an expression of the truth—I shall no longer have any regard or consideration for it. When one has discovered that a coin which he valued is counterfeit, the best use he can make of it is, to bury it out of sight.

4. To proceed: At the head of every one of this series of Letters, I have placed one or more short extracts from the writings of various authors, as more or less illustrative of the views unfolded in the letters, and to serve as a sort of text. I shall now request you to give your best attention to such of these extracts as bear on our present subject, and also to some others which, from their great length, I could not make that use of, but which I will now embody here, along with such observations of my own in the way of criticism or application as may seem naturally to arise out of them.

5. Turn then to *Letter* VIII., and read again what I have there quoted from M. Richard as to the views of M. Du Petit-Thouars regarding the nature and capacities of the *bud*. Literally rendered into English, the passage is as follows:—

"The buds give origin to *shoots* or young branches furnished with leaves and most commonly with flowers. Each bud has in a manner an existence independent of that of the others. M. Du Petit-Thouars considers them as analogous in their development and their structure to the embryos enclosed in the interior of the seed, which, by the act of germination, develope a young twig, which may justly be compared to the shoot produced by the evolution of a bud. Accordingly, to these last he gives the name of *fixed* or *adherent embryos*, in opposition to that of *free embryos*—reserved for those embedded within the seed"*

M. Du Petit-Thouars, you will perceive, maintains, in the first place, that of the several buds on a tree, each one is virtually independent of every other bud—each having an independent existence of its own; in the second place, that in its development and structure, the bud is analogous to the embryo contained in the seed; and, in the third place, that the young plant which issues from the embryo within the seed is analogous to the young shoot which proceeds from the bud. The analogy, in respect both of the seeds and buds themselves, and of their respective produce, is, in his view, as perfect as it is possible to be—amounting

* Richard, *Op. Cit.* p. 103.

as it does to an identity in nature and character, — in structure and function. For he puts the bud on a level with the seed, calling them both "*embryos*,"— and he indicates the differences that obtain between them by calling the one a *fixed* embryo, the other a *free* embryo;—differences, these, which attach, not to the *essence* of the two objects, but to the *ends* to be accomplished by them in the economy of nature,— and which, therefore, important as they are in that respect, may, in a physiological point of view, truly be regarded as *incidental*.

6. It is unnecessary to dwell longer on these views of M. Du Petit-Thouars. But familiar as I have been these many years with the whole passage in Richard which we have just been considering, there is an expression in it which has only now for the first time occurred to me as peculiar. The seed is spoken of as *containing* an embryo; and the bud is said to be analogous — not to the entire seed, but only to the embryo within it. There is a real propriety in this distinction. Besides the embryo, there is enclosed within the seed a quantity of starch for the earliest growth of the embryo. The bud contains none. But observe, the *pith* in the shoot to which the bud is attached consists of starch, and holds precisely the same relation to the bud, as an embryo, that the starch of the seed does to its proper embryo. The analogy, instead of being weakened by this distinction,

comes out all the stronger. It is the whole shoot, with its "adherent" bud, that is the counterpart of the entire seed. It is the whole tuber, and not the "eyes" only, that is the co-relative of the *plum* of the potato-plant.

7. Consider next what Mr Appleby — speaking of "The *Hollyhock* and its propagation by cuttings"*— says of the bud (Letter VIII.)—

"Each joint had a dormant bud, which, when isolated and placed in shallow pots, in a gentle stimulative, started into growth, and soon shewed a shoot projecting above the soil: This in time, as the leaves unfolded, pushed forth roots and formed a plant. This shews that wherever a bud is, it contains within itself the *germ* of an *entire plant*, which, when correctly managed, can be formed into a plant *equal* in *vigour*, and in *every way* as *perfect* an *individual*, as the plant from which it was cut or taken."

In writing thus, nothing seems farther from Mr Appleby's mind than any theory or argument as to the nature of the bud. And yet his language respecting it is strikingly in accordance with that of M. Du Petit-Thouars, and with the views which have been laid before you in these Letters.

8. I now request your attention to what Dr Ware says on the subject (Letter IV.):—

"The principal seat of the growth and nutrition of plants is in the bark and alburnum, and all the new matter yearly added is deposited on the outside of the latter and the inside of the

* *The Cottage Gardener*, vol. viii. p. 339.

former. The growth of one year is only subservient to the circulation of the next, and is ever afterwards of use merely in giving strength and stability to the trunk, in order to support the increasing size and weight of the branches and leaves. The wisdom and beauty of this provision, by which that portion of the plant *which has become useless for every other purpose*, is thus made to answer a very important end, are sufficiently obvious; and it is rendered necessary by the circumstance that plants do not like animals arrive at a definite size and there cease, but go on growing to an *indefinite* extent, and consequently require corresponding increase and strength in those parts which are to support them."

And again :—

"Those parts of plants which perform the functions necessary to their nutrition and growth, are *strictly annual*. So that all plants are either annual, that is, wholly renewed every year, — or at least have the circulating vessels and all the organs taking an active part in their economy annually renewed." *

9. In these two extracts, there are several statements which tally very exactly with mine. Observe, first of all, what Dr Ware says as to the indefinite growth of trees :—"They do not, like animals, arrive at a definite size and there cease, but go on growing to an indefinite extent," — an observation, I need scarcely remark, which is precisely in accordance with what I maintain. Again, Dr Ware virtually says, in perfect keeping with my argument, that, in respect

* John Ware, M.D.—Introduction to his Edition of Smellie's Philosophy of Natural History.

of the processes of "nutrition and growth," which, in truth, is in respect of the *whole* of their vital actions, trees are made up of *annuals*,—growing upon the *remains* of annuals. And the uses of these remains, in relation to the living annuals, he mentions in terms almost identical with my own:—"The growth of one year (or rather what remains of that growth), is *only subservient* to the circulation of the next,"—not being itself (beyond the year of its formation) the seat or subject of any further growth, or indeed of any vital action, but simply serving as the channel by which the sap passes upwards to the living and growing parts above it, "and it is ever afterwards of use merely in *giving strength and stability* to the trunk *in order* to *support* the increasing size and weight of the branches and leaves,"—that is, it serves as a framework or scaffolding to the living annuals growing as parasites upon it (Letter IV. 7). And important as this purely mechanical use which it serves is, "it has become useless for every other purpose." Though clothed and decked in a living mantle of green, it is itself really *dead*. And this beautiful arrangement is an express adaptation to the whole nature and economy of trees. They "go on growing to an indefinite extent," because in the annual formation of "fixed embryos" provision is made for such indefinite growth: Yet this requires a "*corresponding* increase and strength in those parts which are to support

them." The remains of the seedling oak-plant would be inadequate to support the whole growth of the oak-tree's twenty-first year. But it is quite equal to that of the second year, as the remains of the twentieth are to the twenty-first,—the growth of each year being exactly proportioned to that of the years immediately preceding and following it,—to the support it has to rest upon, and to the burden which in its turn it has to bear.

10. I will now introduce you to M. Mirbel, a botanist deservedly of great celebrity, with whose views on the subject before us I only became acquainted (and that by the merest chance) several years after my own had been made public. They are contained, in as far as known to me, in a paper in the fourth volume of the *Quarterly Journal of Science*, entitled "Of the Death of Plants: From the French of M. C. F. Brisseau Mirbel." In reading what I shall here quote from that paper, you will not fail, I think, to be struck with the very close resemblance which his views generally and many of his expressions bear to mine. Nor can I forbear expressing my surprise that views so detailed, and so clearly and forcibly set forth by M. Mirbel, should not have found their way into our systematic works on vegetable physiology.

11. M. Mirbel begins by observing, that

"Plants, like animals, unless destroyed by disease or casualties, are *doomed to die of old age*."

He starts, you will observe, from the same point, making the same assumption that I do (Letter I. 6). And after stating how this law applies to several sorts of plants, he goes on to say of trees—

"In the dicotyledonous class there are enormous trees, whose existence seems to date *from before the records of history*, and which, in *spite of* their *antiquity*, are *loaded*, in each returning year, with *blossom* and *seed*.

"If we were to view the perennial and woody plants as *simple individuals*, as such we should be naturally induced to conclude, that unless destroyed by disease or casualties, they were free from the liability to death from old age; but a due consideration leads us to distinguish in every perennial and woody plant, the *new* part which *actually lives and grows*, from the *old*, which has *ceased* to *grow*, and is *dead*.

"I will state this in a broader way. Plants of this nature have *two* modes of propagating their races: one, by *seeds*—the other, by a *continuous evolution of like parts*. In the first case, the seed presents us with an embryo plant, a new and different individual, independent, and unconnected with that from which it derived its existence; in the second, we are presented with a *series* of *individuals*, which issue from the surface the one of the other in an uninterrupted sequence, and in some instances continue permanently united. But whether individuals of this description are produced by seed or by continuous evolution, it is certain that they escape, in neither case, the influence of time; while, on the other hand, the *succession* of individuals, or what we may call *the race*, produced in *either* of the ways, is as clearly *beyond the reach of age*, and *will endure until destroyed* by some *extraneous* cause.

"We will endeavour to show how these general laws apply:—All the parts of the young herbaceous annual are susceptible of enlargement; the cells of the tubes, at first very small, are,

soon after extended in every way; in process of time their membranous walls, fortified by the absorption of nutrient juices, grow thicker, and lose by degrees their original pliancy. The membranes once hardened, excitement ceases to be produced, and the vital functions are at an end; nourishment is no longer drawn, growth is at a stand, and the plant, unable to resist the ceaseless attacks of the external agents employed by nature for its destruction, decays in a short time." "By renewals of the same nature, the life of shrubs and trees proceeds. In them, the liber or inner bark represents the herbaceous plant, and has, *like that, only a short period of vegetative existence.* For when vegetation revives in the woody plant on the return of spring, it is *because* a *new* liber, *endowed* with *all the properties* of a *young herbaceous plant* (annual), has replaced, under the cortex or rind, the liber of the preceding year, which has hardened and become wood."

12. M. Mirbel next refers to certain trees notable for their great antiquity,* and then proceeds as follows:—

"All of them, *giants* as they are, vegetate, *as does* the

* "The yews of Surrey, which are supposed to have stood from the time of *Julius Cæsar*, and are now two yards in diameter; the cedars on Mount Lebanon, nine yards in girth, from the measurement of the learned Labillardière; the fig-tree of Malabar, according to Rumphius, usually from sixteen to seventeen yards round; the stupendous chesnuts on Mount Ætna, one of which, Howell tells us, measured seventeen yards in circumference; the ceibas of the eastern coast of Africa, of such bulk and height that a single stick is capable of being transformed into a *pirogua*, or sailing vessel, of eighteen or twenty yards from stem to stern, and of three or four in the waist; the boabab of Senegal of ten or twelve yards in girth, and, according to the computation of Adanson, 5000 or 6000 years old."—(Mirbel, *Loc. Cit.*)

smallest bush, *solely* by their herbaceous layer of the liber, *annually* produced at the inner surface of their bark. The concentric layers of preceding libers constitute the mass of the wood, a *lifeless skeleton*, serving *solely* to *support* the new-formed parts, and to conduct to them the juices by which they are fed; nor is it even necessary for these functions that this should be in an entire state. Willows and chesnuts, when quite hollow at the heart, still continue to grow with vigour; but in their soundest state strip them of their bark, and they quickly perish.

"Thus reflection teaches us that the *long life* of the greater part of trees, and the *immortality* which at first sight appears to have been imparted to others, ... form in reality no exception to the general law which destines every organised *individual* to perish in determined course; since we see . . . . that the concentric layers which constitute the wood or heart of the trunks of trees, are no other than the *accumulated remains* of *by-gone generations*, in which *vegetation* and *life* are *entirely extinct.*

"This appears to us the true view of the nature of the life and death of such beings as are constantly regenerated by the successive evolution of continuous parts.

"And we may observe, that the liber which is formed on the stem of a tree *centuries* old, if the treee have met with no accidental injury to affect its health, enjoys the vegetative power *in as full force* as the liber which is formed on that of the *sapling;* and that a sound, well-grown scion from the *aged* but healthy tree, affords as *good* a cutting for *propagation* as that taken from the *young* one, so that the *race* might be *perpetuated* by *cuttings alone*, *without* the assistance of *seeds.* From this we are entitled to conclude, that according to the course of nature, the progress of regeneration by continuous evolution would *never* be *arrested*, if the *over-grown size* of the branches and stem, the *hardening* of the wood, and the

obstruction of the channels which permeate it, did not *impede* the *circulation* of the *sap*, and consequently its *access* to the liber.

"In fine, what we call death by *old age* in a tree, to speak correctly, is the *extinction* of that *portion* of a *race* which has been carried on by continuous evolution; the inevitable result of an *incidental* death in the liber, occasioned by the privation of nourishment.

"In proportion as a tree increases in size, the vessels of its ligneous layers become obstructed, and the sap circulates with less freedom. Hence absorption and secretion decrease after youth, in proportion as the bulk of the tree is enlarged. The liber is less vigorous; the buds and roots become fewer and feebler; the branches wither; the stem decays at the head; water settles in the injured parts; the wood moulders away. Ere long, the new liber, the *annual* herbaceous part of woody vegetables, loses the power of completing its regeneration, new parts are no longer evolved, and the tree perishes."

13. But though the tree finally perishes, it is not from *old age*. It is from purely *accidental* causes. M. Mirbel has already told us that the tree is in its own nature as imperishable as a *race*, or as that *portion* of a race which constitutes a *family*, or a *house*, a *lineage* or a *clan*. But it is needless to dwell on the details comprised in M. Mirbel's paper. I have underlined those expressions in it which bear more directly on the views unfolded in these letters. Further comment than this seems to me superfluous. You can yourselves make the application of them to my views.

I shall only observe that, while, in M. Mirbel's mind,

the *liber** occupies the chief place, as representing the *annual* in the yearly succession of individuals, the *buds* are the parts which in that respect have the chief regard in mine—following herein as I do the teaching of M. Du Petit-Thouars. In every other respect, M. Mirbel's views and mine completely coincide. Nay, in as far as we differ, or rather as he and M. Du Petit-Thouars differ, it will not, I think, be difficult to shew, as I shall endeavour to do in my next letter, that there is an intermediate view, which will include and harmonise the views of both these eminent physiologists, and more truly than either of them express mine.

14. There is yet another author whose views I wish to place before you—I mean M. Gaudichaud.† I extract the account given of them by Professor Balfour of Edinburgh, in his *Class-Book of Botany* (pp. 442–444) :—

"A Monocotyledon (Endogen), in its simplest form (Fig. 11), may be said to consist of an axis producing a leaf (*c d*), and a bud (*e*) at its upper part, and a root (*a*) below. It may be represented as a phyton, or single plant or bud, having an axis or axial merithal, with a leaf or foliar merithal (*c d*), divided into a laminar (*d*) and petiolary portion (*c*), the latter usually sheathing the axis, and a radicular merithal (*a*),

* M. Mirbel subsequently saw reason to substitute the *Cambium* for the liber.

† Recherches sur l'Organographie la Physiologie et l'Organogenie des Végétaux, 1841.

whence roots are produced. This phyton is capable of producing others having a similar constitution; and thus a more complicated Monocotyledonous plant consists of a *series* of *phytons* placed one above another, the parts being alternate (as seen in the adjoining figure, Fig. 12). Each phyton has a distinct leaf, producing a bud in its axil, or at the part where it is united to the axis; it has also an ascending or foliar, and a descending or radicular system. In the case of the first phyton, the latter descends at once into the soil; but in the case of the others, it passes downwards *through the first axis*, before it reaches the ground, or in some instances it appears externally at the base of the phyton, and thus becomes for a time aerial (r, r'). A Monocotyledonous plant may thus be said to consist of a *series* of phytons, arranged one within [and above] the other, with shortened axes.

Fig. 11.

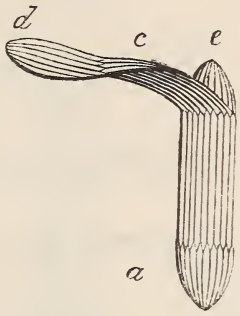
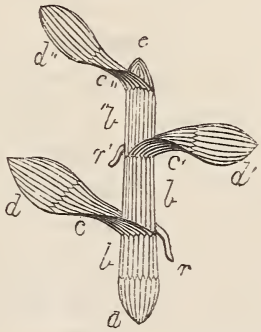
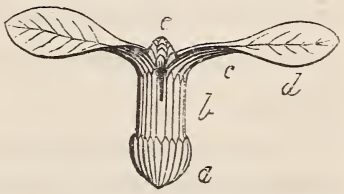


Fig. 12.



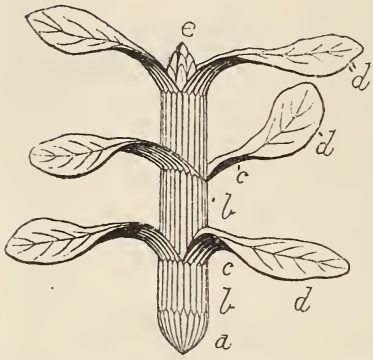
"A Dicotyledon (or Exogen), on the other hand, in its simplest state, may be said to consist of an axis producing two leaves at its summit and roots below (Fig. 13). It may be represented as two phytons united, the foliar merithals (c d) being placed opposite to each other. In the Monocotyledon, each node produces one leaf and is unifoliar; in the Dicotyledon, two, and is bifoliar. This tendency to produce two leaves at a node does not, however, remain permanently in all Dicotyledons; for,

Fig. 13.



by the extension of internodes, the foliar merithals frequently become alternate. A Dicotyledonous plant may be considered as consisting of a *series* of *phytons* (Fig. 14), which produce an ascending foliar system, and a descending radicular one," — [the series being arranged one above and *outside* the other.]

Fig. 14.



" In the phytons or foliar types of these two great classes of plants, cells and vessels of different kinds are united; and the phytons may be considered, in reference to the entire plant, precisely in the same way as the simple cell is regarded when compared with the various tissues forming the compound individual. A phyton may be thus regarded as an organ furnishing a *type* of all the parts which enter into the composition of the nutritive and reproductive compound organs. While the *embryo* of phanerogamous (or flowering) plants may be considered as a *phyton* produced by the process of *reproduction*, the *bud* may be reckoned a *phyton* produced by the *vegetative* process. A bud has a certain degree of vitality *inherent in itself;* and it may be called a *fixed embryo*, or one attached to the plant, and depending for its vigour upon it, but frequently capable of growing when separated from it."

15. Now observe what Professor Balfour says further:

" A tree is composed of a series of buds, each having *independent* vitality, and yet all united on a common axis, *on the life of which* they depend for their continued growth and vigour. Buds may be taken from one tree and grafted upon another, and, in some instances, buds, or bodies equivalent to

them, separate spontaneously from plants, and form independent individnals. This latter phenomenon occurs in *Bryophyllum*, *Pinguicula*, *Malaxis*, viviparous plants, and in the bulbils of *Lilium bulbiferum*, and *Dentaria bulbifera*. In all this there is a remarkable analogy with what occurs in Compound Polyps. In Sertularian Polyps, there are numerous separate individuals united on a common stock, each having a *certain* inherent vitality, and yet *all depending* on the *general life* of the compound zoophyte."

16. All this, you will perceive, is, with one single exception, in perfect harmony with what I have myself urged as the right view to be taken of the nature of trees. The exception is this: Professor Balfour, or perhaps I should say M. Gaudichaud (for Dr B. does not seem to identify himself with the views of the latter), says of the *buds* of trees, that while each has an "independent vitality," they are *all*, as *united* on the "common axis," which constitutes the tree, "*dependent* on the *life* of this axis for their *continued growth* and *vigour*." And he makes a like observation regarding the individuals composing the compound animal zoophyte. How the fact may be as regards the zoophyte, I am not prepared to say. But I demur to his statement as regards the tree. I have throughout alleged, not merely that each bud, and each plant issuing from this bud, is independent of every other of its fellows; but that the "axis" on which they vegetate and grow—and that parasitically—is made up of the *dead* organic remains of the plants of former

years,—in short, that the axis is destitute of vitality; and that in as far as it contributes to the "growth and vigour" of the buds and plants, it does so precisely in the same way that the soil does to the vigour and growth of the seedling plant. And I would fain hope that the evidence already adduced in support of that allegation is sufficient and conclusive.

17. In his work *On Parthenogenesis*, published some years ago (in 1849), Professor Owen has enunciated a theory as to the constitution of certain of the lowest tribes of *animals*, which accords in many, if not in most, of its essential features with that here unfolded as to the constitution of trees. And in vindication of his views, he has adduced like facts to those on which mine as to trees are based,—referring, moreover, to the vegetable kingdom generally, and to trees in particular, as being fashioned on the principle of his theory.

18. To quote at large from this distinguished author, as I have done from Mirbel and Gaudichaud, would occupy too great a space, and be besides to travel over again, unnecessarily, much the same ground we have already trodden. In another Letter I shall have occasion to refer to his views. Meanwhile, I may observe, that reading his work on "Parthenogenesis" shortly after its publication, and being struck with the similarity of many of his views to mine, I sent Professor Owen a copy of the essay on "The Nature, Longevity, and Size of Trees," which I had published two years

before, in *The Edinburgh New Philosophical Journal*, and received from him a communication in reply, in which he expressed not merely his concurrence in my views, but his regret that he should previously have been unacquainted with them,—adding (and this I think will form a fitting conclusion to this long letter, and be in character with its beginning), that "the fact of like views of the same truths springing up in different independently thinking minds, is one of the good grounds of conviction in the reality of such views." I am, &c.

LETTER XII.

"Audi alteram partem."

February 17, 1855.

My Dear Sons,

1. You may remember that at the close of my eighth letter, I made allusion to certain exceptions that might be taken to my theory, and that I there promised to consider these exceptions in future letters. I purpose now to redeem that promise.

2. One exception which I mentioned bears on a much agitated question in vegetable physiology—the nature and mode of formation of the woody layers annually formed in exogenous trees. M. Du Petit-Thouars holds, as you are aware, that the layer in question is none other than the roots of the buds, and grows if not actually yet virtually downwards from these to the soil. This view, I need scarcely say, accords entirely with the argument pursued in that letter—viz. that the shoots emanating from the buds constitute severally perfect and independent plants, and as such are furnished with roots.

3. M. Mirbel, however, and otners, maintain that

the woody layer is formed *in situ*, and is altogether a *special* formation. And denying to it the character of roots, they might ask, and so as to cast discredit on my theory—"Where are the *roots* of those annual growths and alleged perfect plants in trees?" And, again, "What is there in annual and avowedly perfect plants, at all analogous to the woody layer in exogens?"

4. Before discussing these questions in detail, I have some remarks to offer which will in fact reduce them to a single question—protesting, at the same time, that Nature is not to be tied and bound after a fashion of this sort. Suppose the growths emanating from the buds on trees to be actually destitute of roots, this would by no means take from them the character of perfect and entire plants, if it could be shewn that the office of roots is otherwise adequately provided for. "*Natura ne fit per plura quod potest fieri per pauciora.*" On the other hand, the fact of a structure entering into the constitution of those growths not to be found in confessedly perfect annuals,—allowing this to be true of the woody layers of trees, would not at all affect their claim to be equally so regarded, if it could be shewn to be required either to meet some condition of their existence peculiar to themselves, or to serve some ulterior purpose in the economy of Nature designed to be accomplished through them. The mollusk is not less truly a perfect animal because of its wanting a bony skeleton than the mammal which

has one; nor, conversely, is the mammal more or other than a perfect animal because of its possessing such a skeleton.

5. Now, the annual woody layer clearly subserves, *physiologically*, the purpose of a *prop* to the young plants developed from the buds—and, *economically*, that of providing *timber* for the supply of man's needs. Again, whatever may be its real nature, or however it may grow, it does in point of fact serve also the office of *roots* to those plants, being the channel whereby the nutritive matters in the soil are conveyed upwards to the growing stems, and leaves, and flowers. And since it thus serves these several purposes, the questions before us are, I think, fairly met and satisfactorily disposed of. The only question will be, whether the woody layer is primarily of the nature of roots, and only secondarily intended as well for a support to the young plants as for the production of timber for man; or whether it is truly a special formation for the accomplishment of these latter objects, and only virtually, and by adaptation of the nature of roots.

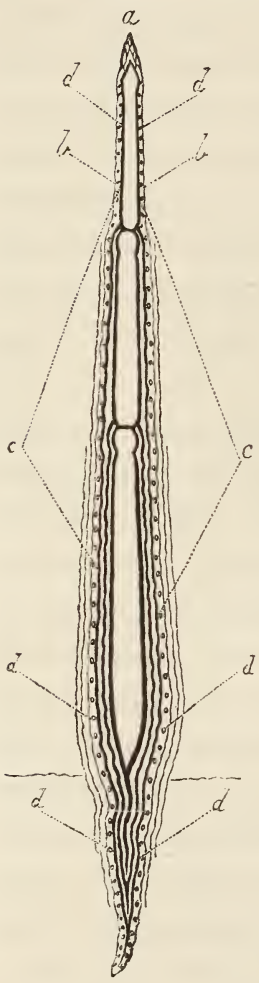
6. Reduced to this their proper issue, the questions before us have in reality no importance, either speculative or practical, in relation to our theory. The woody layer may constitute true roots, or it may be a special formation altogether. Be it which it may, the theory will be noways affected by it. Further,

add this other consideration, that the layer in question is strictly an *annual* formation, of the same year's growth with the plants proceeding from the buds, and equally short-lived. And with reference to this point, it is not a little singular that, however they may differ in their views as to the nature of this layer, both M. Du Petit-Thouars and M. Mirbel (as we have already seen in Letter XI.) agree in regarding every tree as being in its nature *composite*, and, as such, without natural limit to its duration and growth. They both arrive at the same conclusion as to this, which is the main point of my theory, although they reach it in different ways.

7. That the woody layer is both structurally and physiologically the roots of the young plants, that issue from the buds, I maintain. Nor will it, I think, be difficult to demonstrate that they are. That in the manner of its formation and growth there is a peculiarity, I readily allow. That is to say, I allow that with the exception of a small portion, the fibres composing it do not actually *creep* and grow *downwards* from the base of the buds and young plants above to the soil below. The portion which I except is that part of the root beginning at the *tip* of the last year's root, and thence extending a short way beyond it into the soil. This portion does in fact grow and creep downwards, just as does the root of the seedling. Excepting this part, however, I admit that there is

the peculiarity mentioned attaching to all the rest of it. And for that peculiarity I not only see a *reason*, but in it I see also a singularly ingenious *contrivance* to obviate a difficulty which the circumstances of trees create, and to meet which a strict adherence to the rule of ordinary annuals would have been a clumsy expedient.

Fig. 15.



8. For observe: great as is the known power of roots in making their way through obstacles to the soil, and far as they will often travel to reach it, it seems scarcely conceivable that in a tree—say—150 feet high, and with roots stretching perhaps fifty feet under ground, the roots of the young *terminal* plants could, in the course of a few weeks in summer, creep down and traverse the distance of 200 feet. That they do not, I admit:—nay it is certain that they do not. For if they did, it would be easy by a few simple experiments to ascertain the fact, and to measure also the rate of their descent.

9. Let us now consider wherein the peculiarity of their formation lies, and how their growth is effected.

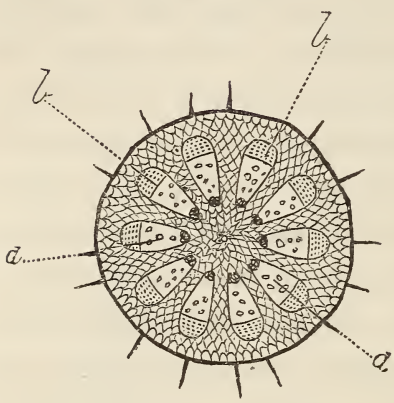
The accompanying figure (Fig. 15) will aid us in the understanding of this. It is the vertical section of a tree three years old, as it exists in autumn after the fall of the leaves and flowers and fruit. At the summit of the terminal shoot, there is a bud (*a*), and proceeding from the base of this downwards, and lying between the bark (*b b*) and the stem and root (*c c*) of that shoot, is a layer (*d d, d d, d d*) of cells, constituting the *cambium layer*. This layer may in a certain sense, and that a very correct one—if not, indeed, as I believe, truly and physiologically,—be regarded as an EXTENSION of the BUD, and a *constituent* part of it. Formed concurrently with the bud, and in common with it, out of the general cellular basis, it may likewise be regarded as an *adaptation* of the bud to the special *circumstances* of tree-plants as *parasitic* plants, and to the special *objects* of their existence as *timber-producing* plants.

10. Until a comparatively recent period, the minute structure of this layer was but imperfectly known, and its real nature so far misunderstood.* It is not what it seems to be — a glutinous or mucilaginous fluid, —

* "Pour nous, le Cambium est toujours le *fluide* nutritif, produit de la sève élaborée, qui s'epanche au printemps et en automne entre le bois et l'ecorce." "Le Cambium est de *fluide* essentiellement nourricier du vegetal, comme le sang pour les animaux." "Il ne devient pas tissu cellulaire, ni tissu vasculaire; mais ces tissus déjà existans y puisent les principes au moyen desquels ils se multiplient." —Richard, *Nouveaux Elemens de Botanique*, 5iesm. Ed. (1833), p. 111.

or semi-fluid matter. It really consists of cells of a very delicate texture. In figure 16, a transverse section of it is given, in connection with a plant of one year's growth. Immediately beyond the woody bundles already formed (*a a*), there lies a mass of cells of a semi-lunar form (*b b*), cut off, so to speak, by a bounding line from those bundles on the one hand, and from the general cellular basis on the other. These cells are that part of the Cambium-layer out of which the woody bundles of next year will be evolved. Lying directly beyond and around these semi-lunar masses of cells, is the remainder of the Cambium-layer, consisting likewise of cells.

Fig. 16.



11. Such is the condition of the tree in Autumn, and such the provision made for the growth of next year's tree-plants. In spring, the bud, growing in the first instance at the expense of the pith, sends out a shoot, which *rises upwards* and puts forth leaves; sap ascends from the soil and passes to the leaves. Being there elaborated, a portion of this sap again descends, in order to the development of the Cambium-layer. From all that portion of this layer that as yet exists

(and which extends from the summit of the last year's shoot to the extreme point of last year's root), there is ultimately evolved three distinct tissues — woody tissue, cellular tissue, and bark tissue,—the bark lying outside and enclosing the other two, the cellular connecting the wood and the bark. Grant that all these are formed as they lie (*in situ.*) It is not, however, the whole account of the matter. For, from the lower end of the Cambium-layer,—at the point where it is in contact with the *tip* of last year's root, a new root comes off which does in fact *creep downwards*,—which *descends* into the soil, just as from the bud at the other end of the Cambium-layer the shoot *ascends* into the air.

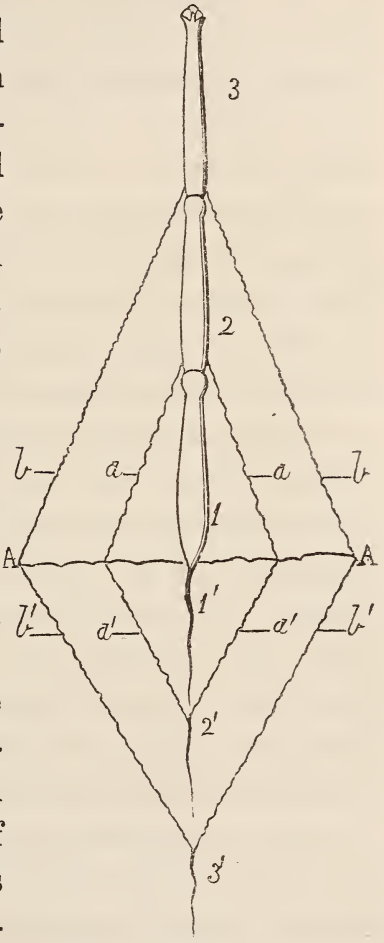
12. We shall presently consider in what way the transformation into woody tissue of the intermediate (and far greater) portion of the Cambium-layer is effected. Meanwhile, let us compare what has just been described as occurring in the tree with what occurs in the seedling plant. We shall see that the analogy between them is as complete as possible. From the embryo contained in the seed, there passes upwards the shoot, and downwards the root—the shoot and the root being united at a point called the *neck*. In like manner, from the summit of a tree fifty years old there rises upwards a new shoot, and from its opposite extremity in the soil there passes downwards a fresh root—separated, however, the one

from the other by the persistent stems and roots of the intervening fifty years' plants. Now, in order to connect them, or rather in order to bring the base of the root into direct relation with the base of the shoot, the expedient of a Cambium-layer is resorted to; and in striking accordance with the general analogy of the seedling, the tissues into which that layer is transformed are identically of the same nature with the root. Thus is the root lifted up, as it were, to the base of the shoot or stem.

13. It will perhaps enable you the better to understand what I have now said, if I observe that there is no natural line of demarcation, and, in point of fact, no structural difference between the woody tissue above-ground, forming what is called the *trunk*, or wood proper, and the woody tissue under-ground, forming what is called the *root;* and that if we are to adhere strictly to the proper meaning of the terms *stem* and *root*, we must restrict the one to those parts of the mass above-ground which have, year by year, actually grown and *risen upwards*, and the other to those parts of the mass under-ground which have actually grown and *crept downwards.* We should thus have nothing more than the bare skeleton represented in the vertical line of Figure 17,—the parts marked 1, 2, 3, being the stems, and those marked $1'$, $2'$, $3'$, being the roots,—while the side parts, marked *a*, *b b*, and $a'\,a'$, $b'\,b'$, which represent the woody

tissue of the far greater part of the Cambium-layers (and which give strength and stability to the stems and roots, and preserve them from decay), would be entirely *accessory*, and would require some proper name *common* to the portions both above and below ground. At all events, as regards this whole mass of ligneous tissue, whatever name we may give it, it is one and the self-same structure throughout, and identical in its character with true and genuine roots.

Fig. 17.



14. With regard to the transformation of the Cambium-layer, it is effected after this manner: Such of the cells composing it as are destined to become cellular tissue merely, undergo no particular change beyond a full development, and that in the *transverse* direction of the axis of the tree. Those of them, on the other hand, that are to form woody tissue, undergo

an elongation in the *vertical* direction (on one side or on two opposite sides), and thus elongating become fusiform or spindle-shaped fibres. These cells have likewise a peculiar tendency to the production within their substance, or on their inner surface, of a consolidating deposit, to which they owe the tenacity and toughness which gives to wood its value. Their elongation, according to Dr Carpenter, does not seem to be the result of pressure, but of the unequal nutrition of different parts of the cell-wall.* Whether each individual cell is drawn out to any considerable extent, or whether a number of them coalesce to form a single fusiform fibre, does not yet appear. Neither is it known whether the individual fibres join end to end together, and so form continuous threads of great length. But we shall see by and by that some such union and coalescing of cells and fibres must needs take place. And we shall see also that there is a good deal more in this part of the process of transformation than has yet been unfolded even in our more recent treatises on vegetable physiology. Certain it is that the whole account of the matter is not ended by saying that the tissue in question is formed *in situ* and by an *elongation* of the cells.

15. That this tissue is really of the nature of roots,

* *Principles of Physiology, General and Comparative,* 3d ed., p. 99.

by which expression I mean *identical* in every respect, structurally and physiologically, with roots, is to my mind as plain as anything can well be. In my next Letter, I shall endeavour to make it as plain to yours. —I am, &c.

LETTER XIII.

"Truth proposed is much more easily perceived, than without such proposal it is discovered." ARCHBISHOP SECKER.

March 29, 1855.

MY DEAR SONS,

1. I proceed, as proposed in my last letter, to consider the evidence in favour of the assumption that the woody tissue evolved from the Cambium-layer is of the nature of roots.

2. And the first consideration which I shall urge is this,—that, whenever the circumstances of the Cambium are such as to admit of it, the tissue developed from this layer palpably assumes the character, puts on the aspect, and grows after the manner of roots. Take, for example, the process of "slipping." You cut off the upper part of the young shoot of a willow, to which is attached a bud, and you plant it in the ground. In due time the bud sprouts, and from all that part of the Cambium which is in immediate contact with the soil, genuine roots are given off, such as will be given off from the Cambium in the parent tree, at the *tips* of the last year's roots, and *nowhere*

else—the corresponding portions of that layer in the shoots that remain in connection with the tree being all converted into "wood." The like occurrence takes place in the process of propagation by "layers." A branch of a tree is turned down, and part of it placed under ground. From the whole of that portion of the Cambium of the branch which is thus brought into relation with the soil, and which, under ordinary circumstances, would have been transformed into "wood," true roots come off.

3. Again, consider what is presented to our view in the Elm at North Stoneham, to which I formerly referred. Read again what I said in my *fifth* letter (section 9) respecting it; and consider this further, that from all that portion of it which was cut or torn and brought into contact with the air—and which was left unsupported and unfettered by the cellular tissue—the Cambium-layer sent down fibres and bundles of fibres, the radicular character of which is beyond all question. In a little volume, entitled *The Book of Trees*,* another example of the like kind is described and figured as it presented itself in an old Oak on the banks of the Wear, a few miles from Durham. In this case, the roots that were sent down from the upper part of the decayed bole, not only made their way down and struck into the ground; but being cabined and confined within the chasm which they

* Published by J. W. Parker : 3d ed. Pp. 30, 31.

occupied, seemed to grow together and coalesce, completely filling up this chasm, and ultimately presenting all the characters of wood—or at least giving to the once decayed Oak the aspect of a sound and entire tree.

4. Mr Jesse, in his *Gleanings in Natural History*, gives two instances of the like occurrence—the one in an Oak, the other in an Alder; and Professor Balfour, in his *Class-Book of Botany* (p. 446), refers to two others—the one in a species of Willow (*Salix viminalis*) near Sleaford, in Lincolnshire; and the other in a large specimen of Mountain Ash at Prestonhall, near Edinburgh. Mr Jesse's account of it in the Alder is so much to my present purpose that I quote it entire. "Some years ago, I remarked an old Alder that seemed to have been decayed and hollow for a great length of time, and I observed from a flourishing *branch* in the upper part of the tree *a sort of roots* coming down, as if in search of the earth for nourishment. Mr Nicholson and I have frequently visited it, and found that the roots crept down the hollow amongst the decayed wood till they reached the ground; and there deriving nourishment, swelled, united, and became as the bole of the tree, filling up the cavity, and displacing all the mouldering wood till the whole is now nearly a solid tree." And Professor Balfour's account of the Mountain Ash at Prestonhall might stand for a literal description of the Elm

at North Stoneham. "A large branch was broken off, laying bare the interior of the stem to a considerable extent. The tree still lived, and from the upper branches distinct roots were sent downwards, which gradually covered a large portion of the wound. The growth was traced in a downward direction, and the root-like appearance of the fibres was quite evident."

5. Further, examine carefully the naked trunk of an Oak, or other hardwood tree, which has been felled and stript of its bark, particularly after it has lain some time exposed to the weather. Look at the general course and disposition of the fibres, and particularly at the way in which they comport themselves where the main branches join the trunk, or where two branches meet, or in the neighbourhood of hollows or clefts; and I think you will be satisfied that I spoke truly in my last letter (§ 14), when I said, that it is by no means a full account of those fibres to describe them as formed *in situ*, and evolved by an *elongation* of certain of the cells of the Cambium-layer. Were this all that could be said of them, we might expect to find the fibres disposed in tolerably straight lines and perpendicularly to the axis. But what do we actually see? We see the fibres, as a whole, pursuing a *spiral* course downwards—winding round the trunk;—meandering, however, and twisting in all directions in their course to the ground,—turning round knots or other obstacles that lie in their way—even ascending to steer

clear of them and then creeping round them; often, besides, without apparent reason, reversing their course, again returning upon themselves, and forming circles, or portions of circles, or duplications of various sorts and shapes; and after resuming their usual oblique or spiral direction downwards, again going through the like evolutions.

6. Attentively examining such a piece of timber, and observing that singular disposition—and as one may say, those strange vagaries of the fibres, one cannot help identifying those fibres with roots, or regarding the whole as "a mass of roots." Less free to do so, they yet disport themselves as roots do.—I have said that in many trees, the fibres run as a whole in a spiral direction round the trunk—not in straight lines downwards; and there is this further peculiarity, that individual sets of fibres which form part and parcel of branches stretching in one direction—say to the south, may often be traced, as they make their way down, gradually to wind round the trunk and pass under ground into a division of the "root" which strikes in a direction directly opposite. The *final* cause of this is obvious enough,—the *physical* cause probably beyond our reach. It looks as if the fibres were actuated by a sort of instinct, and were led thereby to arrange themselves in the manner best adapted to enable the entire tree, or particular parts of it, to sustain the superincumbent weight, and

Fig. 18.

YEW-TREE.

effectually to resist the agency of wind and storm. This at least is manifestly the effect of the arrangement, and is doubtless in part the intention of it.

7. Other and more striking illustrations of the view here taken of the nature of the woody layers and their constituent fibres, are furnished by such trees as assume a *columnar* disposition in the bole or trunk,—and of which we have examples in the Thorn, the Lombardy Poplar, the Birch, the Beech, but perhaps best of all in the Yew. Look at the wood-cut facing you. It is the portrait of an old Yew-tree standing by a Church,—a locality in which such Yews are oftenest to be met with—not, by the way, that they were originally planted near Churches, but because in the olden time Churches were often planted near them. What, let me ask, strikes you most on looking at the trunk of this tree? Is it not that it consists of one entire mass of roots—the several bundles being most curiously plaited together, and inextricably interwoven?

8. There is a singular fact mentioned by Mr Jesse respecting the Thorn, which may be regarded as an extreme degree of the grouping which is so manifest in that Yew, and which goes far to demonstrate the actual identity between the "trunk" and the "root" of trees. You may remember that in one of my earlier letters I remarked, that, however the woody fibres may keep together in the trunk, and give to

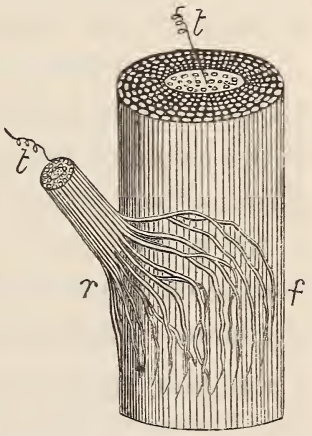
this an aspect of its own, they no sooner reach the ground than they part company, and spread hither and thither. Now, when the Thorn has become old, the trunk in some way breaks up into separate stems, —some Thorns, Mr Jesse tells us, having four, or five, or even six stems, which were originally one,—and these stems, "as they separate, become regularly barked round, forming to appearance so many distinct trees closely planted together, except that they all meet at the butt of the tree." Mr Jesse mentions that some of the Thorns in Bushy Park are now undergoing this process of separation, "having already thrown out one stem, while in other parts they are deeply indented with seams down the whole stem. These gradually deepening (he adds) from opposite sides towards the centre, will at last split the tree into a number of separate stems, which are barked round." *

9. There is yet another fact bearing on our present subject which demands very special consideration. Under ordinary circumstances no fibres can be seen creeping down from the base of the buds in trees. The fact is, or seems to be, that, under such circumstances, the bud has no need to do so. It is done for

* *Gleanings in Natural History*, p. 89. The resemblance which this process of separation in the Thorn bears to the woody bundles in the Yew is also pointed out by this writer. "The Yew-trees I have observed are sometimes strongly marked with seams, especially those which have arrived at a great age; but I have not seen any in which the separation has actually taken place."

it by the Cambium, whose proper office it is to provide the roots. The two forming but one body—the Cambium being but an appendage to the bud—each exerts its own innate tendency; and, while the bud sends up the shoot or stem of the plant, the Cambium-layer (or that particular portion of this which stands immediately related to that particular bud) evolves the root—superseding thereby the necessity of any effort in this direction on the part of the bud. That the bud, however, is *capable* of successfully exerting itself in this way appears from what is represented in the adjoining figure (Fig. 19), as occurring in the *Dracœna;* and likewise from a circumstance mentioned by M. Richard. He states that he had seen in the possession of M. Du Petit-Thouars, a branch of *Robinia pseudo-acacia* on which *Robinia hispida* had been grafted. The stock had *died;* but the graft had continued to grow notwithstanding. And thus growing, it had given off from its base a sort of plaster (une sorte d'empate-

Fig. 19.*



* Truncated stem of a Dracœna after maceration, shewing the radicular woody fibres of the branch (*r*) overspreading a portion of the stem (*f*): *t, t,* the tracheæ of the stem and branch.—From Balfour's *Class-Book of Botany,* p. 447.

ment), formed of very distinct fibres, which surrounded the extremity of the stock to some distance, forming a kind of sheath. It was quite easy to perceive that fibres had proceeded from the base of the graft, and had spread themselves over the stock.*

10. Here the stock had *died*. There was no *living* Cambium-layer to unite with the bud of the graft; and as this bud lived and continued to grow, it had no help, so to speak, but to push out and send down roots. No doubt the instance given by Richard is altogether a rare one. It is but very seldom that a graft will under such circumstances hold. But it is not on that account the less valuable in relation to my argument.†

11. But what is a rare event with the bud of the Exogen, and a singular phenomenon when it does occur, is the rule and order in that of the Endogen. The terminal bud of the Palm cut off the tree and planted in the ground, sends out roots. The bud of the Palm resting on the summit of the tree, fifty feet high, does the same—sending down through the cellular tissue

* Richard, *Elémens de Botanique*, 5ième Ed. p. 105; Lindley's *Introduction to Botany*, 4th Ed. vol. ii. p. 193.

† In the matter of grafting, it is found to be almost invariably requisite that the graft and the stock should be of the same natural family. May not the reason be, that as the bud of the graft and the Cambium-layer of the stock are to be joined together in the closest relationship, a certain organic *suitableness* between them is part of the ordering of Nature—a suitableness of the like kind and involving the like principle with that which restricts the pairing of animals within certain degrees of consanguinity ?

fibres precisely similar to those which in the former case, it sends down into the soil. But different from what obtains in the Exogen, the Endogen is destitute of Cambium. And this difference seems to go far to explain the respective peculiarities in the buds of these two divisions of trees. But however this may be, there remains the fact that the bud of the Endogen, in the ordinary course of its development and growth, does send down genuine roots within the trunk of the tree —which roots, in some kinds, as in the Screw Pine, even pierce through the trunk and ultimately reach the ground. And this general fact I add to the evidence already adduced in favour of the assumption that the woody layers formed annually in exogenous trees,— and which comprise the far greater portion of the woody mass both above and below ground, are in point of fact, physiologically and structurally, of the nature of roots.

12. In maintaining that the woody tissue in the trunk, developed from the Cambium, is of the nature of roots, I have allowed that it is nevertheless formed *in situ*, or as it lies. It is impossible, however, to overlook the fact, so often and in so many forms brought under your notice, that this tissue is naturally evolved not merely in the *vertical* direction (which all allow), but in such manner that when occasion requires, it can (and seemingly without an effort), do that which it as naturally does at all times at its

extreme point in the ground—viz. *grow downwards.* And it seems equally impossible to miss the conclusion, that, as evolved ordinarily in the trunk, there is more in the process of formation than meets the eye,—in short (as I remarked at the close of Letter IV.), that the woody fibres of the trunk—the roots of the young plants that issue from the buds, do virtually though not actually, potentially and in effect, though not really, grow and creep downwards.

13. And this view has the sanction of a very high authority in vegetable physiology—I mean Dr Lindley. Adverting to that disposition of the fibres which I brought under your notice a little ago (§ 5, 6, and 7), as seen in the *Lilac*, and in *Guaiacum* wood, the fibres in the latter "crossing and interlacing," and in the former "turning off at every projection which impedes them, just as the water of a steady but rapid current would be diverted from its course by obstacles in its stream," Dr Lindley observes of the disposition in question, that it is "*unintelligible* upon the supposition of wood being formed by a *mere deposit* of secreted matter." And he observes further, that if the new wood were a mere deposit of such matter, "the latter, as it is applied to every part of the old wood, would deposit the new wood *equally over the whole surface* of the latter, and the *deviation* of the fibres from *obstacles* in their downward course *would scarcely occur.*" *—I am, &c.

* *Introduction to Botany,* 4th ed., vol. ii. p. 193.

LETTER XIV.

"Setting aside mere hypothesis, it seems incontestable that wood, in whatever manner it is deposited, is created out of organisable matter prepared in the *leaves*, or their equivalents, and therefore *derived* from them. This being so, it matters nothing whether the matter descending from leaves, and acquiring the condition of wood, be theoretically called *roots*, or by some other name: *it is certainly descending matter*."—Dr Lindley.

April 30, 1855.

My Dear Sons,

1. The object of my last letter was to show you that the woody tissue of the Cambium is of the nature of roots—in other words, that the concentric woody cylinders formed annually in the trunk of the Exogen are none other than the roots of the plants annually evolved from the buds, and growing at the upper part of the tree. And I would fain hope that the evidence there laid before you in support of that view was such as to satisfy you that it is a correct view.

2. The evidence, indeed, is singularly diverse. It is also wonderfully cumulative. When I finished that letter, I fancied I had said all that there was any need to say in that behalf. I find, however, that I had

omitted one consideration, not inferior in importance to any of those then adduced.

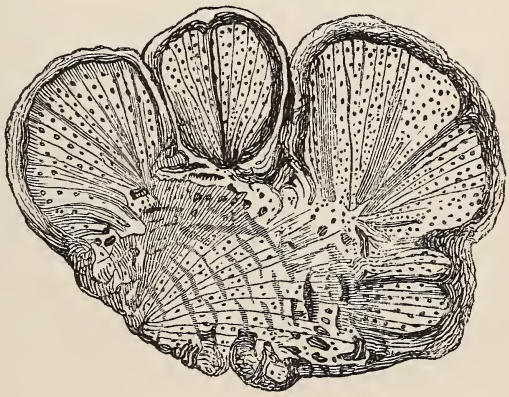
3. It is this: That the Cambium is wholly *subordinate* to the buds, and its development into woody tissue entirely *dependent* on the plants that issue from the buds—while, further, the *degree* or *extent* to which it is developed is very exactly proportioned to the *number* of the plants, the *vigour* of their growth, and their *position* on the tree. It is true that the Cambium cannot grow without supplies of duly "elaborated" sap, and that the leaves are the organs in which this elaboration is effected. But were the layer in question *otherwise* independent of the leaves, it ought to grow uniformly all round the tree, without reference to the number, or the position, or the vigour of the plants above. Its own inherent powers of growth would be equably exerted on every side, while the "attractive" force thence resulting would ensure for it not merely an adequate supply, but a uniform distribution of the nutritive materials prepared in the leaves. There is nothing that I know of in the structure of that layer, and there ought in this view to be nothing in its connection with the leaves, to hinder the freest access of the descending sap to every part where supplies are needed.

4. But what do we find on examining the concentric woody circles? Look again at the adjoining figures, to which I formerly directed your attention,

and say whether the circles be not singularly *eccentric?* Not only do we see the circles of different years of very different thickness, but different sides—different portions or segments of the same circle, widely different in that respect. Now, what I allege is, that all this is very exactly proportioned, as before observed, to differences in the number and position of the plants growing on the tree, and likewise to differences in their vigour, as influenced by situation or exposure, and by the character of the seasons.

Fig. 20.

Fig. 21.



5. Take a tree, for example, from the middle of a plantation of Firs, thickly set together—in which part the trees grow only at the top, and rise up as bare, narrow poles—and compare its woody cylinders with those of another tree taken from the outskirts of the plantation, where the side plants of the trees as well as the vertical have had full scope. Compare, again, the circles in a tree taken from the south side of such a plantation with those in a tree taken from the north side. Carry the comparison a step farther, and note the differences between the circles in any one or all of these trees and those of a Fir of the same species that has grown by itself in an open but well sheltered park, where it has had room to grow freely, and to spread in all directions. If the Cambium-layer be essentially an independent structure, and possessed of innate powers of growth, whence the differences, which you cannot fail to perceive, in the thickness of the woody layers, and whence the uniformity in the relation which they bear in that respect to the amount and to the character of the vegetation going on above? The legitimate inference from the facts, and the proper answer to the questions, is, that the Cambium-layer is not an independent tissue, but one subordinate to the buds, and that it is ill or well developed, equally all round or partially here and there, and differently in different years, just because it is virtually the roots of the plants that come of the buds, and because the

fibres of these roots are regulated as to their amount and distribution by the number, and disposition, and quality of the plants.

6. Nor is this all. The crowning argument for the subordination of the Cambium to the buds, and for its absolute dependence on these for its transformation into woody tissue, — and that in a way altogether irrespective of supplies of nourishment, is furnished by one or two very simple experiments, which leave those supplies intact. Cut off in spring, before the process of vegetation is begun, all the buds from one of the branches of a tree; and at a later period, but in the early part of summer, cut off all the leaves from another branch of the same tree,—leaving however the buds and leaves of the other branches uninjured. In the one case the transformation of the Cambium into wood will be *prevented*, — in the other, the further transformation of it into wood will be *arrested*, — while the buds and leaves of all the other branches being left to grow, the Cambium-layer in every other part of the tree will be duly developed. It is difficult or impossible to understand why this should be, on the supposition that the Cambium-layer is an independent structure, and no farther dependent on the leaves for its development than as these effect the requisite changes in the sap. It is true that the mutilated branches receive no sap from the time they are deprived of their buds or

leaves. But the effect of the mutilation, on their Cambium, cannot be owing merely to this privation,—because nothing need hinder it from drawing the needful supplies from the adjoining branches. It is easy, however, to understand it on the supposition that the Cambium is only an extension of the buds and the matrix of the roots of the plants that issue from the buds. Take away the buds, or take away the young plants themselves: you deprive the Cambium of the only office it has to serve; and, doing this, you destroy its capacity of growth.

7. One thing I must add, not to qualify what has just been said, but to obviate misapprehension. It might chance to happen that from the *sides* and through the bark of a branch thus mutilated, shoots would sprout, and the Cambium-layer be in consequence more or less transformed into wood. But this would be an instance not of the Cambium exerting independent powers of growth, but of buds interspersed here and there through its substance pushing out. The Cambium-layer of many kinds of trees, the Elm in particular, is thus furnished with buds over its whole extent. Under ordinary circumstances these buds commonly remain "latent" or "dormant,"—and that because of the divergent influence resulting from the development and growth of the proper buds. Independently of this, in some trees, these Cambium-buds push out every season, concurrently with the

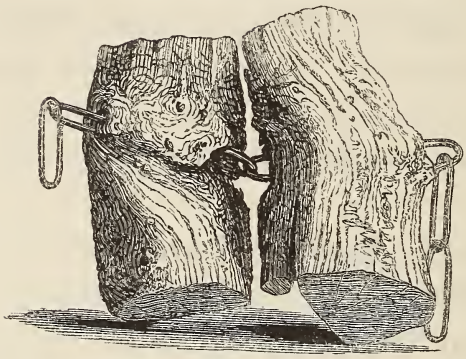
other buds, although from the cause mentioned their shoots are small or but imperfectly developed.* The phenomenon is best exhibited, in those trees that admit of it, after the trunk has been cut close to the ground, when large and vigorous "suckers" spring from the stump, and even from the roots.

8. What passes, then, from the leaves into the stems and trunk appears "certainly," from what we have seen in this and the preceding letter, to be "descending matter." Nor is it "elaborated" sap merely which passes down, — but woody tissue also. However paradoxical it may seem, this tissue is at once formed *in situ* and by growth downwards. Ordinarily, it does not *actually* creep downwards from the top to the bottom of a tree. It has no need to do so. Yet even then it does so *virtually*. And when occasion requires or opportunity offers it does so in reality. Let me recall to your recollection the leading

* These Cambium-buds commonly undergo imperfect development — often evolving externally little else than leaves or leaflets, but reproducing themselves and vegetating year after year at the same points, give rise to nodosities or swellings (which often attain a considerable size) on different parts of the trunk of many trees. I am inclined to think that a close inspection of these nodosities would shew that they are chiefly accumulations of woody tissue evolved from the leaflets of those buds; and if so, the fact would furnish another argument, and be a peculiarly valuable addition to the evidence already adduced, in favour of the doctrine contended for in the text.

features of the *Holly-and-chain* piece (Fig. 22.) in my possession, which we have often examined together, and for which I am indebted to the kindness of a friend.* It reveals several particulars of interest in relation to the habitudes of the woody tissue. The piece itself is a block from the trunk of a Holly-tree, within which a portion of chain is more or less completely embedded. The block had been cleft in twain after the tree was felled.

Fig. 22.



9. The history of it is briefly this :—The tree inclining, when alive and young, too far on one side, a chain was placed around it and firmly secured behind. In process of time, as the tree grew and became thicker —the chain being unyielding, and the pressure against this from within augmenting—the old bark gave way under the chain, and the woody fibres developed from the Cambium-layer grew over and enclosed it. By the growth-in-situ theory, the woody matter should merely have pushed out on either side of the chain—and as well below as above—and so forming an open gutter have left it lying there. But instead of this,

* Alexander Hoyes, Esq. of Bitterne-Grove, near Southampton.

it had bridged it over. And if you examine the piece more narrowly you will discover something more. On one side, you will perceive that the bridging is but partial: the woody matter has overlapped the chain but not enclosed it. Now observe the direction in which the overlapping occurs. It is not from below, but from above—the direction in which, according to the views of MM. Du Petit-Thouars and Gaudichaud, it might have been expected to occur. Not the slightest effort appears to have been made in the contrary direction. Nor is this all: like the Box-tree, figured in section 4, this Holly-tree had grown vigorously on one side and only feebly on the other. Its growth had been eccentric. And it had so chanced that the chain was placed around it in such manner as to embrace one half of each side. Now, on the well-favoured side, the fibres, pushing down boldly and in the strength of numbers, have gone right over and buried the chain to some depth—while on the lean or ill-favoured side, the resistance presented by the chain has been too great for them to overcome, and, accordingly, they have only partially succeeded in the effort—the greater number of the fibres, indeed, like a slowly-moving or feeble stream, having turned round the obstacle instead of seeking to rise over it—a circumstance which is quite apparent on an inspection of the piece.

10. In bringing to a close this branch of our sub-

ject, I must not omit to mention that sundry specific objections have been advanced against the view here taken of the relation of the woody tissue to the leaves, and, likewise, against the notion of the tissue in question being in any sense "descending matter." These objections are fully stated by Dr Lindley in his *Introduction to Botany*,* and are, I think, very satisfactorily met and answered by him. One or two of them, indeed, are such as even Dr Lindley himself feels compelled to allow, strongly favour the view of the woody tissue being formed *in situ*. Any objection, however, raised on this ground—that is, on the ground that the facts do not admit of explanation on any other view—may, I think, at once be met by the admission that in point of fact the woody tissue is ordinarily formed in that way,—an admission, however, it seems to me, which does not, in the smallest degree, invalidate the inferences drawn from the facts already laid before you, as to the relation of the woody tissue to the leaves, or its *capacity* for downward growth. Instead, however, of carrying the discussion farther here, I shall take another opportunity of placing before you what Dr Lindley says on the subject.†—I am, &c.

* Vol. ii. Pp. 197–201.

† See NOTE A at the end of the volume.

LETTER XV.

"Nothing seems more difficult than to see a thing as it really is, unless it be the right interpretation of observed phenomena."

PROFESSOR OWEN.

May 15, 1855.

MY DEAR SONS,

1. We have still to deal with other objections to our theory of trees, and these perhaps more formidable than any we have yet encountered. At least they are advanced by one, who, in rank and authority as a physiologist, stands second to none—I mean Dr Carpenter.

2. In his *Principles of Physiology, General and Comparative,* this distinguished physiologist brings under his review this theory of mine—as contained in a paper which I published several years ago in the *Edinburgh New Philosophical Journal;* and he urges certain considerations which he regards as fatal to it. The theory itself he states so well in his own way that I cannot forbear here quoting his

account of it,—and, the rather, because he gives it in connection with an illustration which has always seemed to me the happiest, as well as to furnish one of the strongest arguments in its favour:—

"Another view has been suggested, which at first sight appears more worthy of adoption; namely, that a *tree* may be regarded as a collection of *annual plants;* the buds of each year giving origin to those of the next, when their own term of existence is expired. In a potato, for example, it is argued that each year's growth terminates in the production of tubers or underground stems, which contain the buds that are developed into distinct and independent plants in the ensuing season; these in their turn giving origin to tubers, whose buds are to be developed in a subsequent year. Now, what is true of the potato, it is urged, is true of an ordinary tree: the only difference being, that the remains of the previous growths are persistent, although dead, and that thus a permament stem is formed, on which every generation of plants is developed, as it were parasitically, and to which each generation makes an addition that is left behind when the leaves decay."*

3. The other view with which mine is compared is one suggested by Professor Owen, in his Essay on *Parthenogenesis.* This physiologist, besides holding in common with myself, that "a tree is to be regarded as not one individual, but an *agregate* of *individuals,* and that each series of buds should rank as a *distinct generation,*" holds also that "every leaf and even every modified form of the same fundamental type,—

* 3d Edition,. p. 903.

each sepal, petal, stamen, and carpel of a flower, is entitled to rank as a distinct being."*

4. Before proceeding to grapple with the objections to my theory advanced by Dr. Carpenter, I cannot help giving expression to the satisfaction I feel that in entering the lists with a physiologist so eminent, I am supported by another of equal rank and authority, at least in this department of physiology; and that in contending in behalf of my favourite theory, I may have recourse, if need be, to the weapons lying ready to my hand in the armoury of *Parthenogenesis.*

5. The first objection which Dr Carpenter urges is, that "too much account is made of the *leaves*, and too little of the other parts;" and he adds, as exhibiting the force of this objection, that "the leaf is by no means, as some have represented it, the entire plant," but "only the most important of the vegetative organs of the plant." † Now, I am not aware that in my former paper any more than in these letters, I have taken so exclusive a view of the bud as to have regard only to the leaves; nor do I see that such a view of it is involved in my theory. In my own mind, the leaf has held no such prominency as that represented by Dr Carpenter. I have throughout regarded and

* Carpenter. *Ibid*, pp. 901, 902.—Owen, *Parthenogenesis*, p. 54, *et seq.*

† *Ibid*, p. 903.

spoken of the "bud" as producing stem, and root, and flowers, and fruit, as well as leaves,—in short, all the parts entering into the constitution of the most perfect seedling-plant. Nor need I remind you that to substantiate this,—to shew that the bud is adequate to the production of every thing that the seed is, forms the burden of a large part of the reasoning in that paper. I then thought, and still think, that I succeeded in doing so; and therefore see nothing in this objection that is of weight or value against the theory. At the same time, I readily allow that in relation to the production of the concentric woody layers, the leaf is the part of the plant essentially concerned; and I will, by and by, endeavour to shew, that in regarding it as *only* the most important of the vegetative organs of the plant, and as having for its *sole* office that of *elaborating* the sap, Dr Carpenter has very inadequately represented the character and relations of the leaf.

6. The part of the plant, of which in Dr Carpenter's estimation too little account is made, is, the *general cellular basis;* and it is here that the full force of the objection is brought out. After stating, that "whilst too much account is made of the leaves as integral components of the plant," Dr Carpenter goes on to say, "too little is made of the general cellular basis, from which the leaves originate, and which retains its vitality in every stem, through the whole period of its existence." And he adds,—

"This cellular basis is the *continuous* product of that in which the whole fabric has its origin; it is that of which the leaves are offsets, developed for a *particular* purpose (the *elaboration* of nutriment for the axis and its other appendages), and ceasing to exist when that purpose is answered; and it retains the power of giving origin to buds from *any part of it* that may be stimulated to increased development. For although it may be quite true that, under *ordinary* circumstances, each year's growth of buds originates in the new tissue formed in the *preceding* year, yet this tissue is *but the extension* of the general cellular basis; and, under *extraordinary* circumstances, portions of this at a *great distance* from the last formed buds, may develope a new set of foliaceous organs." *

7. Reserving, for the present, all discussion of the main points embraced in the exceptions here taken, let us dwell for a little on one or two lesser points, that bear more immediately on two special circumstances which Dr Carpenter adduces, in connection with the general statements now before you,—the one as positively fatal to the theory, the other as not in accordance with it.

8. Admitting, which I freely do, — maintaining, however, that there is nothing in my theory which makes this admission a concession,—admitting that the common cellular tissue of every plant is the basis of the whole plant—just as a *single* primordial cell is the basis of every living being — I beg to observe that there are two allegations made regarding it which I cannot allow to pass unnoticed. Dr Carpenter says,

* *Ibid*, p. 903.

that "it retains the power of giving origin to buds from *any* part of it that may be stimulated to increased development;" and again, that "under extraordinary circumstances, portions of this at a *great distance* from the last-formed buds, may develope a new set of foliaceous organs." Now, if by these expressions Dr Carpenter means to assert that, under the circumstances mentioned by him, buds and leaves may be developed at a *great distance* from *any part* of the *new* Cambium-layer, *continuous* with the last-formed buds, and of the same year's formation with them—in short, from the *old* cellular tissue of *bygone* years, I demur to the accuracy of the statement. And we shall presently see that the "Elm," which he instances, gives no countenance to it. Again, he says of this general cellular basis, that "it retains its *vitality* in every stem *through the whole period of its existence.*" There is a mischievous ambiguity here, calculated to mislead and perplex you. The statement is true in a certain sense, but not in a sense that affects the argument pursued in my ninth letter, or in the slightest degree touches the theory. The *continued* vitality of the whole cellular tissue of every stem, is none other than the continued vitality of the hair of your head or the nails of your fingers and toes; and which, except at the points in *immediate* and very *temporary* contact with the skin where they are actually growing, and "of which they are offsets,

developed for a particular purpose," possess no more vitality than those portions of them which, from time to time, for your particular convenience and comfort, you pare or crop. That it is in this sense and no other that Dr Carpenter does or can speak of the continued vitality of the general cellular basis, may be inferred from his known views as to the very transient duration of vitality in any organised structure. And that it is, is clear from a more specific statement which he makes in regard to trees:—

"There need not be the least difficulty in admitting the continued vitality of the general cellular basis of the stem of an ordinary tree, notwithstanding that it may have attained the age of some hundreds, or even thousands of years. The parts *first formed* may have long since *decayed away*, but a *new* growth is *continually* taking place." *

9. I mentioned that, in connection with the general statements now before us, Dr Carpenter adduces two specific instances in opposition to my theory. Let us see whether they embrace anything not contained in those general statements. The first is that of an Elm:—

"An Elm-tree, which grew to the height of nearly thirty feet before it gave off any branches, had its upper part entirely broken off in a gale of wind, and the stem was left standing, entirely bare of foliage. Its death was considered almost inevitable (and such it was upon Dr Harvey's theory;) but it was thought desirable to give it a chance of recovery, and

* *Ibid.* p. 904.

nothing else was done than to slope off the top of the stump, so as to prevent the lodgement of rain. The next spring a great number of buds were developed, along nearly the whole length of the stump, where no buds or branches had grown for many previous years; these, in process of time, became branches; and the topmost branches having gradually changed their direction (in accordance with the well-known law) from the horizontal to the perpendicular, now appear like continuations of the stem; and the tree, after an interval of about twenty-seven years, has quite recovered its symmetrical appearance, although its aspect is of course very different from that which it presented before the accident." *

10. If it be maintained by Dr Carpenter, that, in this instance, the buds which were developed, the spring following the accident, along nearly the whole length of the stump, proceeded from the general cellular basis of an *older* date than the Cambium-layer formed the year the accident occurred, it may be asked on what grounds he forms his opinion. Nothing appears in the narrative to make it even probable that they did so. If, however, it be admitted that the buds proceeded from the Cambium-layer of the same year's formation with themselves, a very few considerations will, I think, serve to shew that this Elm proves nothing against the theory. Agreeably to this theory, the Cambium-layer is the source or matrix of the *roots* of the plants which emanate from the buds. Now, observe first of all what Professor

* *Ibid.* pp. 903–4.

Balfour says regarding roots : — "Roots have no proper leaf-buds; but in certain circumstances they are capable of producing them."* This statement seems to me to furnish a sufficient explanation of what occurred in the Elm, and to be a sufficient reply to the objection founded upon it. Let me observe further, however, that of the many different sorts of trees, in none perhaps is the capacity mentioned by Dr Balfour greater than in the Elm. It is matter of notoriety that growing naturally and entire, it continually throws out branches along almost the whole length of the trunk, and to such an extent often, as to present one unbroken mass of foliage from the ground to the summit of the tree. Moreover, the reduction of the Elm to the condition to which the gale of wind reduced Dr Carpenter's, is daily practised with a view to the propagation of it by grafting. "The mode of propagation resorted to in the case of the English Elm is usually by means of suckers from the parent-tree. And the best description of suckers are those which are produced by trees that have been cut *close* to the ground."† In short, to any one at all familiar

* *Class-Book of Botany*, p. 52. Roots in point of fact produce buds oftener and more generally than would appear from Dr Balfour's statement. Only under ordinary circumstances, *i. e.* from the divergent influence of the vegetation going on in the branches at the further end, they remain "latent" or "dormant."—(See Letter XIV. § 7.)

† *Book of Trees* (J. W. Parker), 3d ed. Pp. 137–8.

with the habitudes of the Elm, the death of such a tree from such an accident as that mentioned by Dr Carpenter, need not have been "considered almost inevitable." It would not have been so considered by the patriarch Job :—"There is hope of a tree, if it be cut down, that it will sprout again, and that the tender branch thereof will not cease. Though the root thereof wax old in the ground, and the stock thereof die in the ground; yet, through the scent of water, it will bud and bring forth boughs like a plant."*

11. The other instance is derived from the structure and constitution of the *Cactaceæ* : —

"The doctrine in question is entirely inapplicable to the case of the *leafless* Phanerogamia, such as the *Cactaceæ*. The succulent mass of which their stems are composed, is obviously homologous with that general cellular basis, of which the axis of all the higher plants consists at an early stage of their development, and from which the leaves are developed wherever they exist; whilst its foliaceous surface performs the functions of the leaf, the two organs not being here separated, nor their functions specialised. Now, it cannot but be admitted, that it is this cellular mass which in the Cactaceæ constitutes *the plant;* since here no separate leaves are evolved. And further, we must regard the whole as one integer, unless

* Chap. xiv. 7, 8, 9.—The French rendering of the last clause (ver. 9) whether more paraphrastic than ours or not, probably better expresses the idea present in the mind of the writer, and is certainly more in keeping with the quotation just made from the *Book of Trees* :—"Dès qu'il sentira l'eau, il regermera et produira des branches, comme un arbre nouvellement planté."

we are prepared to say that every separate portion of this mass, which can maintain an independent existence, is to be regarded as endowed with a distinct individuality. Now, the duration of this cellular stem of the Cactaceæ is extremely prolonged, its life being very slow; so that there are undoubted instances of plants of this order continuing to exist for 100 years; and their probable term of life is very much longer." *

12. I can see nothing in what is here said regarding the *Cactaceæ* at all at *variance* with my theory. But I see much which, on the principle of "*Exceptio probat regulam,*" goes to give support to it. The constitution indeed of the Cactus is less complex,—that is to say, it contains fewer distinct parts than ordinary plants, and, in particular, it is destitute of distinct and ordinarily constituted leaves. But, observe, whatever be the special object of its existence, it is plain that it was not made for the production of timber. And accordingly, whatever other reasons there may be for the simplicity of its structure,—and while it has in the foliaceous surface of its succulent stem just that sort of leaf which performs the only office that this plant needs, viz. the *elaboration* of sap,—it has not that sort of leaf which is required for that *other* office which (as we have already seen and shall see again by and bye) the leaf serves to timber-producing plants, to wit, a leaf in itself distinct and special, possessed of *ligneous* tissue, and, in some way,

* *Ibid,* p. 904.

directly or indirectly, itself producing or essentially contributing to the production of the ligneous tissue of the woody stem. As for the rest, the *Cactus* grows and extends itself in the same way as trees do,—by buds; and the individual growths that issue from these buds are I presume equally short lived, individually, as those from the buds of trees. Dr. Carpenter, it is true, speaking of the aggregate stem, remarks that its duration is extremely prolonged, its life being very slow. But I fancy the remark is to be taken in the same sense with that formerly adverted to in this letter.

13. As far then as these two instances go, I see nothing in Dr Carpenter's strictures that militates against my theory—nothing at least that is not embraced in his general statements—to the consideration of which I shall proceed in my next letter.—I am, &c.

LETTER XVI.

——" And darest thou then
To beard the Lion in his den,
The Douglas in his hall ?"

SIR WALTER SCOTT, Bart.

May 28, 1855.

MY DEAR SONS,

1. My last was an affair of outposts. We have now to do battle with Dr. Carpenter's main army, drawn up in two divisions—a right and a left. We shall in the first instance engage the former,—and routing it (as I hope we shall), next try our strength against the latter—to all appearance much the more formidable of the two. Let us first of all see what the enemy's forces are, and how they are disposed.

2. Dropping, now, this way of speaking, let me observe that the leading arguments advanced by Dr Carpenter in opposition to my theory, may be described as embracing two parts. The first is that which will alone occupy our consideration in this

letter; but it will be convenient before entering on the discussion, to put you in possession of both branches of the argument. The former I laid before you in section 6 of my last letter—which section I must beg you will now turn to and carefully read over. The latter is as follows:—

"There appears, then, to be no medium between, on the one hand, regarding the entire fabric developed from a single generative act (*i.e.*, the fertilisation of a single 'germ-cell' by the contents of a 'sperm-cell') as forming *one organism*, however great may be the multiplication of similar parts, or however independent these parts may be of each other; and the including every product of its own development, whether contemporaneous or successive, as *one generation;* or, on the other hand, attributing a distinct individuality to every component of the most complex organism, and designating every augmentation of the number of its cells, by the subdivision of those previously existing, as the production of a new generation."*

It is but fair to Dr Carpenter to subjoin what he further adds:—

"In either case, it must be freely admitted, we are forced to do a certain violence to our ordinary conceptions." "And it may be the wisest course, perhaps, to invent new terms, rather than to distort the meaning of those in common use."†

3. Putting together, now, what I have here quoted and what I quoted in my last letter (section 6), and having regard also to certain other relative state-

* Principles of Physiology, General and Comparative, 3d Edition, p. 904.

† *Ibid,* pp. 904, 905.

ments made by him, elsewhere, in his *Principles of General and Comparative Physiology*, Dr Carpenter's whole view of the subject under discussion may, I think, be thus fairly stated :—

First, The buds and the Cambium, together with the leaves and the wood and roots which proceed from them, if not also the flowers and fruit, are merely an *extension* (on its free side) of the general cellular basis, and the transformation of this basis into certain definite structures. And this extension and transformation are processes which, but for certain *periodic checks* put to them, would go on *uninterruptedly*. But for these, there would neither be the breaks which occur in them during the winter, nor would their permanent produce—the wood—present those lines of demarcation which we see in the "so-called" *annual* layers or rings.* But for those periodic checks, all our trees would be evergreens; there would be an unbroken succession in the formation and shedding of the leaves, and flowers, and fruits; and the wood would constitute one entire mass of ligneous and cellular tissue.—The buds and the Cambium are merely "*continuous* products" of the general cellular basis, evolved at the ends of the medullary rays in the case of the former, and *over* the whole exterior surface of the woody stem in the case of the latter; and it is from those checks alone, and from no other cause,

* *Ibid*, p. 790.

that an interrupted character is given to their evolution, and a seasonal aspect imparted to their development—which, however (striking as it is), denotes, after all, merely an "*epoch*" in their vegetation.* And,

Secondly, In accordance with these views, Dr Carpenter refuses to regard the buds and their produce, or the Cambium and its produce, as distinct, separate, or individual formations—still less as the representatives of a new generation. He refuses to co-ordinate the bud with the seed, or to allow to the wood the character of roots. And he further maintains, that only such an organism as has proceeded from a "seed," itself the product of two distinct kinds of cell—the one a "germ-cell," and the other a "sperm-cell"—can or ought to be regarded as an *individual* being.

4. These views are manifestly directly opposed to my theory; and, if sound, subversive of it. But they are, in my judgment, untenable; and that they are so I will now endeavour to shew you.

5. I begin by considering an assertion which Dr Carpenter makes in regard to the *general cellular basis*. And I do so, because I believe the discussion of it will bring out an issue that will serve as a touchstone to determine whether in the main his views or mine are the more worthy of adoption.

6. Speaking of the Cambium-layer, and of its being in a state of "continual increment," he says:—"The

* *Ibid*, p. 236.

proximity of *leaves* is *not* required for the growth of the additional layers of wood and bark into which it developes itself,—*nothing else* being needed *than a supply of elaborated sap* which may have been prepared by the leaves of *remote* parts of the fabric." * And in connection with this, let me again remind you of what he says of the leaves—viz. that they are " *only* the most important of the vegetative organs of the plant,"—" offsets from the general cellular basis, developed for a *particular purpose*, the *elaboration* of nutriment."

7. Turn now to Letter XIV., and read again what I said there on this very point, and that without any thought at the time of these statements of Dr Carpenter's. I said, and I again repeat, that if the Cambium were an independent structure—that is to say, possessed of inherent powers of growth, and *merely* dependent on the leaves for supplies of duly elaborated sap, it is impossible to understand why the cutting off in spring of the buds from a particular branch (the adjoining branches of the tree being left entire), should have the effect of *preventing* the transformation into wood of the Cambium-layer of that branch,—or why the cutting off, in the early part of summer, of all the leaves of another branch (the other branches not being thus mutilated), should have the effect of *arresting* the further development of the layer. That the facts are

* *Ibid*, p. 904.

as I have stated, there can be no doubt. But on Dr Carpenter's assumption, no such results should follow any such mutilation of the branches, because nothing need hinder the Cambium-layer in either of them from drawing the requisite supplies of elaborated sap from the *neighbouring* branches, or even from "*remote* parts of the fabric."

8. This single consideration seems to me to have all the value of an *experimentum crucis*, and to possess besides a double value. It is clearly adverse to Dr Carpenter's assumption; but in the measure and degree in which it is so, it is favourable to mine. And I would beg particularly to observe, that, while (as before remarked) I have nowhere taken so narrow a view of the growths that issue from the buds as to have regard merely to the leaves, I think the facts furnished by the mutilated branches shew decisively that, in relation to the Cambium, the leaves are somewhat *more* than *organs* for the *elaboration* of sap for the growth of this layer—have another office to serve *besides* this in relation to it;—and, conversely, that the layer in question is beholden to the leaves for somewhat *more* than a supply of sap, and is itself somewhat *besides* a *mere* continuous product of the general cellular basis.

9. It is true that, in a tree (a fir-tree for example) growing in the middle of a crowded plantation and growing only at the top—the lateral branches having

died off as the tree grew upwards, the Cambium-layer is duly transformed into wood even at its lower part, although this may be very "remote" from the leaves above. In this case, however, the Cambium is in the *direct line* of the leaves, *i. e.* (according to my theory) of the plants above, and, being the roots of these, is of course developed. And it may serve to give force to this consideration if I observe, in regard to the case of the mutilated branches, that were the terminal buds merely, or the terminal leaves merely, to be left uninjured (all the others being stript off), the Cambium-layer would in like manner be developed throughout. Nor is this all. The extent to which this layer is developed in the case both of the fir and the branches will be proportioned to the amount of the leaves; and the woody layer will be *thin* because these are *few*,—contrasting strongly with the much greater thickness it attains in the other branches and in other firs similarly circumstanced, but provided with side-branches and laden with foliage.

10. Add to all this, what I dwelt so much upon in Letter XIV., and which it would be tedious here to repeat, regarding the varying thickness of this layer as transformed into wood, on different *sides*, according to the *position* on the tree of the several buds and plants, — and likewise the facts and considerations relative to the *winding* course of the ligneous fibres in most if not in all trees,—and their otherwise *singular*

disposition in the Yew, the Thorn, and others,—in all which the development of the layer in question manifestly follows a rule widely different from any included in Dr Carpenter's assumption. In that letter, I adduced the facts now referred to, and others besides, to shew that the ligneous fibres are none other than the *roots* of the young plants that emanate from the buds. And to what I there stated I may add this other observation, that, as regards all that portion of the Cambium (and of the general cellular basis) which retains its *cellular* character, and serves to *warp* the portion which is converted into wood or roots, it is manifestly *subordinate* to this portion — being turned aside, and in divers manners disposed of by the ligneous fibres or roots, as they list.

11. One other consideration connected with this part of our subject seems to me too important to be omitted. Dr Carpenter's representation of the Cambium and buds being but "continuous products" and a "mere extension" of the general cellular basis, is scarcely in keeping with the fact, that both they and their products have as definite a character, in point of size and shape and form, as have the flowers and seeds. Further, if this representation were correct, and if nothing save *extrinsic* causes *periodically* checking the *extension*, gives to the produce of the buds and Cambium the definite character they possess, why should not the leaves, for example, go on growing

and lengthening the whole season through, *i. e.* until nipped by the frosts of autumn; and why should not the leaves formed the first in spring be larger and longer than those formed many weeks later in the summer? Dr Carpenter's theory will not explain this; and I will make bold to say, that quite independently of all extrinsic causes periodically checking the vegetative processes, there is a definite succession observed by Nature in the formation of the Cambium and of the buds of trees, and a definite character imparted to the structures evolved from them. It may be that, in certain circumstances and in certain climates peculiarly favouring the vegetative processes, such a succession may occur twice in one year, or even three times,—or five times in two years;* but each is separate from every other, and one is completed before another is begun. And although the lines of demarcation between the several layers of wood, thus formed, may be fainter than in those of trees in colder climates, or even be scarcely distinguishable, a sufficiently minute inspection of the woody tissue will yet demonstrate, that it nowhere presents an unbroken continuity of substance,—such a contitnuity or homogeneousness, for example, as we can easily discover in the woody matter of the annual shoot or stem.

* Carpenter, *Ibid.*, p. 790.

12. But in Dr Carpenter's view, the bud is not the counterpart—the *alter ego* of the seed. He refuses to place the bud on a level with the seed, or to regard as an *individual* being any other than an organism that has come of a seed.

13. There can be no question that every organism thence resulting is truly an individual. But to refuse the appellation to every other is, I think, physiologically unreasonable. The distinction aimed at by Dr Carpenter seems to me to create greater difficulties than it can obviate; and to violate to a greater extent than it can preserve, the general analogy of organic life. This subject, however, is too extensive and too important to be entered on at the close of a letter already quite long enough.—I am, &c.

LETTER XVII.

" Jusqu'à présent pour nous, la vie ne nait que de la vie ; nous la voyons se transmettre, jamais se produire ; et quoique l'impossibilité d'une génération spontanée ne puisse pas se démontrer absolument, tous les efforts des physiologistes qui croient cette sorte de génération possible ne sont point encore parvenus à en faire voir une seule instance."—Baron Cuvier.

" Things that are equal to the same are equal to one another."—Euclid.

June 2, 1855.

My Dear Sons,

1. I had not space in the preceding letter to consider the last of the objections which Dr Carpenter urges against my theory. I wished besides, from the weight and importance attaching to it, to make it the subject of a separate letter.

2. That objection you will remember is, that while the seed is the product of the union of two distinct kinds of cell, a " sperm-cell " and a " germ-cell,"—and while the seed is the source and the representative of a new being and of a true individual, distinct from its parent, and altogether independent of it,—the bud is but an " extension," a mere " continuous product " of the general cellular basis ; or, as he else-

where expresses it, a mere multiplication of the cells of the parent by a process of *continuous growth*,* represents accordingly nothing more than the continuous growth of the *parent*, and neither in itself nor in its produce is possessed of any proper individuality.

3. That this view is a mistaken one, I shall endeavour to shew you.

4. In the *first* place, to adopt and apply to the seed Dr Carpenter's language regarding the bud,—what is the seed after all but an "extension," a "continuous product" of the general cellular basis? Its involving the union of two distinct kinds of cell is merely the mode of extension adopted by Nature in this particular case,—not involving any principle different from that concerned in the bud, but merely a modification of it in order to the attainment of certain ends which can only be accomplished thereby. The seed differs indeed from the bud in this, that it drops when ripe from the parent plant, while the other continues adherent to it. But this is not a necessary element in the constitution of the bud. It obtains in the bud of the tree, because the purposes of Nature in the formation of trees require that it should. In the potato, however, and still more in the *Marchantia polymorpha*, the *Lilium bulbiferum*, and the *Dentaria bulbifera*, both the bud and the seed stand on precisely the same footing in that respect. The potato seed and the potato bud

* *Brit. and For. Med. Chir. Review*, vol. i. p. 193.

germinate both of them apart from the parent plant, and give rise each of them to an organism which has no connection with that plant.

5. Dr Carpenter's language, in fact, however well it may serve to convey his meaning, is expressive of no *essential* difference between the seed and the bud. It would serve equally well, in an argument directed against the doctrine of the "*spontaneous generation*" of living beings, to express the fact, that, while, as far as our knowledge yet extends, all living beings come of a germ, this germ originates in no other way than as an extension—a continuous product of a pre-existing living being. It is such language as Cuvier might have introduced into the beautiful passage which I have placed at the head of this letter. He might have said,—"Jusqu'à présent pour nous, la vie ne nait que de la vie—'et comme une extension de la vie;' nous la voyons se transmettre—'et comme produit continué de la vie,'—jamais se produire."

6. In the *second* place, what is there in the seed that is not equally in the bud? What can the seed evolve that the bud cannot evolve also? Nay, the bud can do all that the seed can, and more. It can equally with it reproduce the species, and it can reproduce also its own *variety* of the species, which the seed seldom does, and for which at least it can never be relied on.

7. What difference is there, either in their own

nature or in our ordinary conceptions of what constitutes *individuality*, between two potato plants growing side by side in the same garden, the one raised from a seed, the other from a bud? What real difference between two Willow-trees growing together by the same water-course, the one the produce of a seed, the other the produce of a bud? None certainly in those respects; and only this other difference (already indicated), that the one will represent the species, and this only, while the other will represent besides this, its own variety of the species. But does this imply any *fundamental* difference? Dr Carpenter does not expressly assert that it does, but he speaks as if he seemed to think it did. After observing that, whilst the seed "continues the species only," the bud "reproduces the particular variety;" and that "hence when it is desired to multiply a certain kind of fruit-tree, the buds are employed rather than the seeds," he adds—"But this method of reproduction *cannot be carried to an indefinite extent.*" And for this reason, that "although it may not be true (as stated by some) that the life of the 'graft' will only last as long as that of the 'stock' from which it was taken, yet it is almost invariably found that varieties of trees and plants which are thus multiplied *lose their vigour* and '*die out*,' after a certain lapse of time."*

8. There is I suspect a little injustice here done to

* *Principles of Physiology, Gen. and Compar.*, p. 901.

the graft in order to keep the bud "in its right place" in Dr Carpenter's system. The "dying-out" is, I apprehend, merely a *reverting-back* to the *species*, not the actual death and extinction of the plant or tree,—the *loss* of that *elevation* in the scale of vegetation, which is commonly the result of "high" cultivation, and which, being an accidental, or at least a superinduced quality, is not so tenaciously retained as the primitive qualities. These, however, the bud will retain equally with the seed, and as indefinitely as it can. To say that trees raised from buds or grafts lose their vigour sooner than trees of the same species raised from seed, is, I am persuaded, incorrect as expressive of a general fact, and a misapprehension of what is occasionally seen to occur. The remark has reference to our common fruit-trees; and it may be true that of two Apple-trees, raised, the one from a seed, and therefore a "Crab,"—the other from a graft, and therefore a "cultivated variety," both being of the same age and growing under the like circumstances as to soil and situation, the Crab will last longer than the cultivated variety, and continue longer to grow vigorously. But the circumstances *in other respects* are different. The cultivated variety is a more prolific tree than the Crab, and bears a much larger fruit. And just in proportion as its vital energies are directed to the formation and ripening of a fruit which is larger and more abundant than is

really natural, in the same ratio will the wood and the bark formed by it be less perfectly developed and less thoroughly matured than is requisite for its full vigour and permanency as a tree. Its wood will be more perishable, and its bark less defensive; and therefore external influences will the sooner and the more effectually act upon it to its destruction. This I believe to be the true explanation of the comparatively early decay of some or many of our fruit-trees, and of the observation founded on the occurrence by Dr Carpenter—an observation, however, which is inapplicable, as a general fact at least, to the Willow, the Elm, and to most, if not to all of our forest-trees that admit of being propagated from grafts or buds.

9. In illustration of the distinction which he draws between the seed and the bud, Dr Carpenter makes another observation which seems to me not only misapplied, but detrimental to his own argument. "If the *individuality* of leaf-buds be maintained, because they will continue to exist as grafts, the same attribute ought to be allowed to parts of animals, *e.g.* teeth, &c., which have been removed from one animal and implanted in another, and which have formed new attachments to the latter, and have continued to grow."* To this, it seems a sufficient answer to say, that the parts which he specifies have none of the attributes of the bud. In claiming for the bud the

* Op. Cit., p. 902.

rank of a seed, I found nothing on the mere fact that a part of a tree furnished with a bud may be removed from one tree and implanted in another, and that this part may form new attachments to the latter and continue to grow. I rest it on this ground, that from the bud there will come a plant and ultimately a tree, in every respect as complete and perfect as the plant and tree whence it was taken, and equally capable of producing seed after its kind as well as buds after its kind, and that the tree may be thus perpetuated and indefinitely multiplied. Nothing of this sort ever comes of the transference of parts spoken of by Dr Carpenter. But (to make the parallelism complete), supposing there did. Suppose that, in the ordering of Nature, there should issue from the tooth of a dog, transferred to the comb of a cock, and growing there (as once there issued from a human rib a perfect human form), an organism so like a dog as to be undistinguishable from one, and capable of reproducing in the ordinary way that sort of animal, I think Dr Carpenter himself would be puzzled how otherwise to account of it than as a dog. He would not, I presume, dispute *Eve's* proper individuality.

10. I have yet two or three things further to say in opposition to Dr Carpenter's view. The *first* is, that if the evolution of the bud be but a process of continuous growth, it is one in connection with a *dead* mass. Strange anomaly, if the bud and its produce

be but an extension and integral part of this mass! An entire being alive in all its parts, growing on such a mass, and deriving from it at once nourishment and support, this one can understand. But an entire being alive only at its surface, and this living surface the continuous extension and a constituent part of a dead carcass, this it is very difficult to understand.

11. The *second* is, that the distinction insisted on by Dr Carpenter as existing between the seed and the bud, and of course between their respective produce, creates far greater difficulties than it can possibly obviate. It mystifies our simplest notions of individual being and of personal identity and relationship. It also invests with an unreal character—or rather it divests of all reality of character many of the noblest objects of the vegetable world, and casts a doubt around all of whose origin from a seed we have not the clearest evidence. Two stately Elms might be growing side by side in the same park, each as like the other as it is possible for two trees to be, and both performing exactly alike all the functions of vegetable life,—and yet only one of them—and that by reason of its origin from a seed, could be accounted a real tree and a true individual! The other, sprung from a sucker, would be merely the continuous product, and would still in fact be forming an integral part of another tree, all of which, save this part, may have long since passed away.

12. The *third* is, that Dr Carpenter's notion as to the bud being but the continuous product and a mere extension of the general cellular basis, possessed of no proper individuality, and as to the whole series and succession of parts in the same tree forming but one individual plant, involves this violation of the general analogy of organic nature, that it invests the tree thus regarded as "one integer" with the attribute of *immortality*. It makes that true of the individual which heretofore we have been taught to regard as true only of the race to which it belongs.

13. There is yet one other consideration, the force of which is to my own mind irresistible and conclusive. *The bud can evolve the seed.* This consideration indeed has already been repeatedly adduced, and is included in the general statement made in the earlier part of this letter, that the bud can evolve all that the seed can. But it is one which well deserves being dwelt upon separately, and which cannot, I think, have been duly weighed by Dr Carpenter. What, let me ask, is included in the statement that the bud can evolve a perfect and complete plant,—that it can evolve the flower and the seed? This: that it must *contain within itself* the *two kinds of cell* regarded by Dr. Carpenter as essential to the constitution of the seed—as forming the essential characteristics of the seed, viz. the "sperm-cell" and the "germ-cell."—Dispute the force of this consideration, and, as it seems

to me, you may as well dispute any or all of the axioms in Euclid.

14. "For the conclusion of this, let me just take notice of the danger of over-great refinements; of going besides or beyond the plain, obvious, first appearance of things." Bishop Butler, from whom I quote, makes this observation with reference to "religion and morals." But it is equally applicable, I think, to our present subject. And he adds, what seems also pertinent to it: "Persons of superior capacity and improvement have often fallen into errors which no one of mere common understanding could."* No one of mere common understanding, I think, could make, or could well be brought to acquiesce in the distinction which Dr Carpenter draws, — and which he is compelled by his theory to draw, between two potato-plants, or two Willow-trees, or two Elms, raised the one from a seed, the other from a bud; and in the face of the plain, obvious, first appearance of them, indicating that each one in its kind is in every respect the counterpart of its fellow, to regard the one as a real plant and a true individual being, the other as something altogether different. Such an one, too, would, I think, rather distrust the soundness of the theory which required this distinction at his hands, than admit that the

* "*Fifteen Sermons*," Serm. V.

appearances on which he grounded his belief in the common character of the objects were fallacious.

15. Nay, even Dr Carpenter himself appears to have misgivings as to the entire validity of his objections. For, after passing in review this theory of mine, and certain others more or less akin to it, and stating the objections to which he deems them liable, he concludes with an observation which seems to me to involve a compromise of his own views. Refusing to allow a proper individuality of the several products which come of the bud, or to regard them as representing a new generation, he says—"It must be freely admitted that we are forced to do a certain violence to our ordinary conceptions." "And it may be the wisest course, perhaps (he adds), to invent new terms, rather than to distort the meaning of those in common use." I need scarcely say that, in my judgment, such refusal is doing a *real* violence to those conceptions; and that, in order to maintain the sole distinction that obtains between the product of the bud and the product of the seed, we need no other terms than those already in use, to wit, the terms *gemmiparous* and *oviparous* generation.

16. That these two modes of organic genesis stand on precisely the same footing, in all that relates to the *essentials* of the reproductive process, seems to me a fair inference from the facts that have passed under our view. That in the *seed* the union of two distinct

kinds of cell—the "sperm-cell" and the "germ-cell"—is *essential* to *its* constitution, I readily allow. But were I to hazard a conjecture on a subject so obscure, I would say that it is essential *only* in reference to the *objects* intended by nature to be accomplished through the seed—not to the reproductive process itself. And I would say also, that the true original of that process is a *single* cell, and this a "sperm-cell;"—and that the primary seat or *nidus* of this cell is a *bud*, the latter containing every thing ("germ-cells" included) that is needed for the evolution of that primordial cell. According to this view, the notions of our grandfathers and of the old patriarchs were literally true. Physiologically, as well as by our laws and the common consent of mankind, the child peculiarly represents the father. And St Paul was as sound in his physiology as in his logic when he argued that "Levi, who receiveth tithes, paid tithes in Abraham,"—because, although at the time unbegotten, "he was yet in the loins of his father when Melchesedec met him," and received of him "a tenth part of all."—I am, &c.

LETTER XVIII.

" The provisions of Nature in the constitution of each individual of the human species are not confined to his own immediate wants: they extend to his adaptation for social intercourse ; to the relief of his sufferings by the sympathy, and the increase of his enjoyments by the participation of others, and to the cordial union and co-operation of numbers in prosecuting objects and surmounting difficulties for which the exertions of individuals would be inadequate."

William Pulteney Alison.

" No sin his face defiling,
The Heir of Nature stood,
And God, benignly smiling,
Beheld that all was good !

Yet in that house of blessing,
A single want was known ;
A wish the heart distressing ;
For Adam was alone ! "

Reginald Heber.

" Amid Nature's infinitely diversified productions, we find but one original model or pattern." Dr Edward Hitchcock.

August 18, 1855.

My Dear Sons,

1. In bringing to a close my argument with Dr Carpenter, and, with it, the whole proof and defence of my theory of trees, I will venture to suggest and

lay side by side of his, another view as to the mutual relations of the seed and the bud—the view which I briefly touched upon at the close of my last letter.

2. What if the bud be the primary mode or form of the reproductive process, the true original and the proper type and representative of that process? And what if the seed be but a *modification* of the bud, for the accomplishment of certain ends in the organic economy of Nature for which the bud is inadequate? And what if that modification, although introduced and extensively applied, in both the vegetable and animal kingdoms, long anterior to the creation of man, were introduced at the first with a prospective reference to him, and have its root in him,—its primary source in man's moral nature, and its true significancy in the institution of marriage, and in the family and social relationships of humanity?

3. There seems nothing unreasonable in this view, while there is much in the history of this earth, in what we see around us in the world, and indirectly in the teaching of Revelation, to give countenance to it. "The Heavens are the Lord's, but the Earth hath He given to the children of men." Teeming though it be with countless myriads of innumerable kinds of vegetables and animals, this earth has yet been created for man. It has been the scene of many successive and progressive changes extending over vast periods of time—in all probability over millions of

years—to make it a fit habitation for him. And changed yet once more, as we are told it will be, it may hereafter be the seat of his final home.

4. And what is man? For the purpose I have in view, it will be necessary to consider him in his very highest and in his very lowest relations,—on the one hand, as an organised being and in relation to this earth and the living creatures that inhabit it along with him,—and, on the other, as a spiritual being and in relation to the Creator and to the place or rank which he holds in the scale of being.

5. Let us first of all consider him in his lowest relations. In relation to this Earth which he inhabits, man may properly be said to form a constituent part of it. He is literally taken from its very dust—of which indeed he is described as forming the highest part,* and when he dies he is resolved back into this dust again. So true is the quaint remark of Jeremy Taylor: "Our very graves were once living; we dig through our forefathers, and must speedily become earth ourselves to bury our posterity." As an organised being, he is constructed of the like materials, fashioned after the same general pattern, and subject to the same conditions of existence with the beasts that perish, and even with the corn that sustains him —in short, with the whole organised creation. And in his merely animal relations, he is altogether so

* Prov. viii. 26.

allied to the higher orders of the lower animals, that all the phenomena of life as occurring in him may be illustrated by the corresponding phenomena as occurring in them.* Even in his instincts he partakes with them of a common nature.

6. But man is somewhat more than this. The organised body is merely the material tabernacle in which man dwells, and through the medium of which he has "a local habitation and a name." It is but the seat and the instrument of the immaterial principle which constitutes his proper self. And identical as it is, in structure and in function with the organised bodies of the lower animals, there is yet that in it, different from theirs—its erect altitude and the peculiar conformation of the head and face and hands, which bespeaks for its occupant a higher nature than theirs.

7. What, then, is man, viewed as an immaterial spirit; and what his relations to his Maker, and what his rank in creation? These are questions which it is more easy to ask than satisfactorily to resolve. Nor do I see that without Revelation to guide us we can advance far in this inquiry. In times past, unassisted human reason did but grope in the dark, and arrived at no definite conclusion. Yet reason thus enlightened may approximate towards a satisfactory solution of them. I say approximate, because we must bear in mind that much of the information given us in Scrip-

* Alison. *Outlines of Physiology*, 3d ed. p. 9.

ture on this subject is rather obscurely hinted at than directly stated; and by a satisfactory solution, I mean such a solution as, when presented to her, though beyond her power to discover, reason can recognise as true—a solution which she can acquiesce in, as in harmony with what she has herself discovered of "the Constitution and Course of Nature."

8. So far, indeed, we may proceed in this inquiry without any guidance from Revelation. Natural reason can see that man is a spirit, endowed with understanding and conscience, with emotional susceptibilities and with voluntary power. And the commonest observation is sufficient to demonstrate that he is the highest and the greatest of the living creatures that dwell on this earth. But it is from Revelation alone that we learn that he only, of all those creatures, has been made in the image and after the likeness of God; and, vast as must ever be the distance between the creature and the Creator, that he has been made as high as "a little lower than the Divine Nature;" * that he holds

* Psalm viii. 5.—"A little lower than the angels." Milton has it—"Scarce to be less than Gods." Not to enter on an exegetical question which lies beyond my province, I would merely observe, on the authority of my friend the Rev. J. G. Wright, of St Andrew's Presbyterian Church, Southampton (to whom I am indebted for the view taken in the text), that in the original Hebrew, the word which our translators (herein following the Septuagint version) have rendered "angels," is the same plural noun (Elohim) that occurs in the first verse of the first chapter of Genesis, and is there

to his Creator the relation of a "son," and by delegation from Him the rank of a "king;" and that, as exercising kingly sway over the works of the Divine Hand, which have been "put under his feet," he has been "crowned with glory and honour." True: "we see not yet all things put under him," neither do we see him yet thus "crowned." But this, as Revelation assures us, is because man has fallen from his first estate. The kingdom that was appointed unto him, and which he held on condition of suit and service to be done, he forfeited by one fatal act of treason. The language of Scripture, therefore, is descriptive, not of what man is actually, but of what he was once, and might still have been. Rather is it descriptive of what man's condition is as restored. For it tells us that fallen man has been redeemed; that by the interposition of One who for him became man, and because of His exaltation to the throne of the universe, whereon he now sits as Man as well as God—man's Head and Elder brother—man has been taken back into his Royal Father's favour, all things have been again put under him, and his lost kingdom restored to him.

9. Marvellous as it is, incredible but for the evidence on which it rests, such is, in truth, man's relation to the Creator, such his rank in the scale of creation:—the offspring of God, partaker of the

rendered "God." "In the beginning God created," &c.—See Note B, at the end.

Divine Nature, of the "blood royal of creation;"* invested with kingly dignity—crowned with glory and honour and immortality.

10. Can we go further? We may at least inquire whether man's position in creation be not "unique;" whether,—excepting the angels which are but ministering spirits, and unto none of which hath God ever said "Thou art my son,"—man be not at once the only and the highest of created intelligences? Whether this earth be not the only world that is inhabited by rational creatures? Such is the view recently put forth by the author of the Essay "*Of the Plurality of Worlds*," and argued by him with an ability which has at least excited the attention, if it has not commanded the assent, of the greatest of our philosophers. Such a view, I need scarcely say, would, if well-founded, lend the strongest conceivable support to the speculation which forms the proper subject of this letter.

11. But we need not rest the speculation on so unstable a footing as this. Revelation is silent on the question of a plurality of inhabited worlds, and philosophers are not agreed. Our whole race occupies "but a spec in space, and *as yet* a spec in time."† It may be, that there are other intelligences besides the race of man, and other worlds inhabited

* Rev. R. C. Trench, B. D. *Hulsean Lectures* for 1846, Lecture iii.

† Professor Powell.

besides this—worlds older and larger and more glorious than ours, and intelligences higher and purer and more noble than man—whose origin also may date from myriads of ages before his. Be it so. None *can* have been more highly favoured than he has been; and there is surely warrant enough from Scripture, and from reason enlightened by Scripture, for the belief that there are no creatures in existence that are at once higher and *different in kind* from man,—however they may differ in the modes or the conditions of their existence. We may therefore regard man as being, at the least, the *type* and *representative* of the highest order of created being. And this "more modest," and it may be, "juster estimate of his place," will answer the purpose I have in view. If those other intelligences be not "clothed upon" as man is, their condition will not affect our speculation. If they be — if they have organised bodies and reproduce their kind, we may infer that in *essential* particulars, their constitution will be modelled after the pattern which has been followed in man's.

12. Let us pause here for a little, and look at a principle which gives to the considerations now submitted to you, all their force and value. It is the principle of "unity of composition"—of *uniformity* of *plan* as a ruling element in the constitution of the organic world. Of this principle I cannot give you a better idea than by laying before you a very clear

and forcible statement of it by Professor Powell. It is as follows :—

"Throughout all formations, the grand truth to which every accession of geological discovery bears witness in a more remarkable manner, is the principle of unity of plan continually exemplified in all the varieties of organic structures disclosed. Even the most seemingly monstrous and incongruous forms of animated existence in times past are all, without exception, constituted according to regular modifications of a common plan, and with parts, organs, and functions related by the closest analogies to each other; so that no sooner is a new specimen detected than it immediately finds its proper position in the scheme of nature; no sooner is a new form discovered than it is instantly assimilated with some known type, and found to hold an assignable place in the system. Whether a given organic fossil (as in some instances in more recent beds) exhibit characters differing from some known form only as a variety or sub-species, or whether (as in earlier cases) it present features unknown to any existing genus or order, or (as in other instances) offer conditions in any degree intermediate, still in all cases alike the remarkable point is always, that a place and a name can be immediately assigned to every new form as it presents itself; and this too invariably in such a manner that it either tends to supply a link in affinity between orders of being already related, or indicates some new and unexpected point of analogy. There is never any deviation from system and regular plan; we never light upon a fossil centaur or palæozoic mermaid; there never occurs any junction of heterogeneous members, any real departure from type and system. The *invariableness* of the results *through such enormous series of ages* cannot but impress the mind, when duly considered, with the highest idea of the *preservation of continuity*." *

* *Essays*. Ess. III.—*On the Philosophy of Creation*, pp. 337–8.

13. Taking, then, the view we have done of man and of his relations, — having regard to his rank in the scale of being, and to the links that bind him as well to his Creator as to this earth and the organic world therein, of which he forms a part, — viewing him also as at least *representing* the highest of created intelligences, — and taking specially into account the manifest *uniformity* in his plans observed by the Creator, is it, let me ask, a vain imagination to suppose that, in the constitution of the lower forms of vegetable and animal life, which were made by Him thousands, nay, millions of years before man, He, to whom "a thousand years are as one day," and who "seeth the end from the beginning," should have had an eye to the constitution of him whom He so regarded, and has so highly exalted, and who, as an organised being himself, was one day to occupy the highest place in the organic world — and so have carried into *their* constitution a plan or scheme of organization befitting *his*,—befitting *mind*,—nay, not mind merely, for the brutes have this, but REASON — that principle which, with its organ SPEECH, has been denied to the brutes, which is in itself divine, and human only in that it has a place in man? *

14. The supposition seems to me both a reasonable

* "La raison est elle humaine, à parler rigoureusement, — ou bien n'est elle humaine que par cela seulement qu' elle fait son apparition dans l'homme ?"— Victor Cousin, *Introduction à l' Histoire de la Philosophie.* And as to speech being a divinely

and a probable one. Let us apply it to the subject before us.

15. As far as I can see, all plants might have been made to reproduce their kind from buds alone, certain of these being "adherent," as in the buds of trees, certain others of them being "free," like seeds, as in the *Lilium bulbiferum*, but not otherwise resembling seeds; and, as far as I can see, the same plan of reproduction might have been followed with the lower animals. It might have obtained also, for anything that appears, in the case of man. He might have been so constituted as of himself to fulfil his twofold mission of replenishing and subduing the earth. And, in point of fact, single and alone, man did at the first reproduce the species. In the history of our race, the bud in principle took precedence of the seed, introduced the seed, and having introduced it was withdrawn. Cain was the first-born of mankind, the joint offspring of Adam and Eve; but Eve was herself the prior offspring of Adam. From a rib in his side, as from a bud, there sprang her who was the Mother of us all,—

"'Bone of his bone;' fair offspring of his side." *

And nothing need have hindered the like mode of reproduction being continued. But the Creator judged

imparted gift to man, and a standing evidence of divine interposition in the world, see Archbishop Whately, in *Introductory Lessons on the History of Religious Worship*, Lesson I.

* W. S. Oke, M.D., *The Atonement, and other Poems*, p. 4.

another to be the better plan:—"It is not good that the man should be alone. I will make him an help meet for him." An help meet for him! One of his bone and flesh, one with him in heart and mind, but of a softer mould and a gentler spirit: one to share his mission with him, and, sharing it, at once to cheer and soothe and refine him; to take upon herself, besides, the main burden of one part of that mission (leaving him the freer to fulfil the other), and in so doing, and exercising a mother's influence over their common offspring, to elevate the race of man!

16. Nor is this all. The gift to man of an helpmate is spoken of as if it had been an *after-thought*. The work of creation finished, God "saw everything that he had made, and behold it was very good." Yet afterwards—after the "Heir of Nature" had been "put into the garden of Eden to dress it and to keep it," where he lived some time, longer perhaps than we are wont to imagine, single and alone, it is said—"It is not good that the man should be alone." Not that there can be after-thought with the Creator; not that the man was not at the first formed with a view to the gift he was afterwards to receive; but as if to indicate that he might have been so organised as by himself, and without an helpmate, to replenish the earth as well as to subdue it; and as if to indicate also that the principle of reproduction by seed in contradistinction to that by buds, had, as our view

assumes, its real origin in man, its primary source in man's moral nature, and its true meaning in the institution of marriage;—an institution which, as it has been beautifully said by Bishop Taylor, "is the mother of the world and the nursery of heaven, filling cities and churches and heaven itself—the proper scene of piety and patience, of the duty of parents and the charity of relatives—promotes the interests of mankind, and is that state of good things to which God has designed the present constitution of the world." *

17. Hence a distinction of sexes, and hence a necessity for such a modification of the bud as we meet with in the seed. Hence also, peradventure, the real occasion of the seed.

18. But if this whole view should be deemed too transcendental, I shall not insist upon it. Only grant me that the seed and the bud are co-ordinate and co-equal, different forms merely of one and the same thing, both answering the same end, but each in a way that the other cannot. Grant me this and I am content. You grant my whole theory of trees.

19. And, now, not to pursue these speculations farther, but with the view merely of showing how truly identical in character and constitution both the bud and the seed are, let us glance for a moment at the skill and adaptation to circumstances, with which

* Sermon *On the Marriage Ring*, passim.

in two or three familiar instances in the vegetable world, sometimes the seed alone, and sometimes the bud and the seed together, are made use of.

20. Take first the *Cereals*, including Wheat, Rye, Oats, Barley, and others,—their relations to man and man's relations to them. In much that he should himself be capable of through his reason, man has been left to the resources of his reason and the labour of his hands. He has been so left, and that very expressly, in the matter of his daily bread. The Cereals, accordingly, which supply this bread, and constitute in fact the staple article of his sustenance, bear seed only, are incapable of being propagated otherwise than by seed, and can be raised only in sufficient quantities for man's needs, by being sown by man's own hand, and in ground which his own hands have tilled. I have said in *sufficient quantities*. I should have said, can only thus be raised *at all*. For left to themselves, they disappear. Cultivated varieties as they all are, or rather *abnormal* conditions of some unknown species of Grass, they will not grow in the wild state. Not that when left to themselves they return (as do most cultivated varieties of plants) to their natural state and so become worthless,—but that they literally die out—wild plants, "thorns and thistles," and even the common grasses (their congeners) supplant them. Brought into their present state we know not when or how, they can be

preserved for man's use only by careful husbandry. How strikingly does this accord with what we read of the curse passed on the ground for man's sake and the natural result of this—"Thorns and thistles shall it yield thee;" and of the terms imposed on man in order to the procuring of his means of support—"In the sweat of my face shalt thou eat bread,"—terms no sooner imposed than man is "sent forth to till the ground."

21. Consider next the "Grass of the field," which may be said to be the main-stay of the lower animals, and contrast it with the Cereals. Cursed for man's sake as the ground has been, Nature has yet made provision for those of her creatures that can "neither sow nor reap." And thus, strictly annual as, according to my theory, all plants are, the common grass, producing *buds* as well as seeds, is by means of buds preserved in a *permanent* form on the earth's surface. Capable of being propagated by seed, largely propagated in this way from year to year by man himself, and thus chiefly in the first instance spread over the earth, sown broad-cast by Nature's own hand, it is also capable of being propagated by buds; and from buds it now springs up annually, for the sustentation of animals, and that *spontaneously*, in far larger quantities than from seed.

22. And to advert, as we appropriately may, to tree-plants, let us dwell for a little on some striking

points both of resemblance and contrast between them and the grasses. Slender and short-lived like them, annuals in fact as they are, they reproduce themselves also both by seeds and buds. And, as in the case of the grasses, the seeds of tree-plants serve to diffuse their species over the surface of the ground, while the buds cause sets of them to cluster together. Grass-plants and tree-plants differ only in this, that the former cluster together *sideways*, each plant striking down directly into the soil, and so they come to cover the ground as with a *carpet*, while tree-plants cluster together in the *vertical* direction, and parasitically one set above another, and so they come at length to form masses which rise upwards—*columns* which point to the heavens above.

23. Compare them next with the cereals, and consider the mutual relations of both to man. Created as expressly for man's use as the cereals have been, and remotely as essential to his existence as these are, tree-plants have yet been differently constituted in respect of the conditions of their existence. The cereals, as we have seen, cannot exist without man's toil and care. Tree-plants can and do exist independently of this. It might have been otherwise ordered, however. They might (like the cereals) have been made dependent for their growth on him ; and man, as he can both sow and plant them, might have been left thus to provide himself with timber as he has been

with bread. Nature, however, has been pleased not to lay this additional burden on him. Enough for her that he should toil and sweat for the supply of his daily recurring wants. She has herself anticipated and supplied his higher but more prospective wants in respect of timber. Nay, her supplies have ever been in advance and greatly in excess of man's numbers and man's wants, while they have been co-extensive with man's occupancy of all "the habitable parts of the earth."

24. Further still. Both by buds producing trees and by seeds multiplying their numbers, and likewise by appliances (such as geology is conversant with) as well for preserving from decay the timber thus produced as for changing its physical qualities, provision has been made quite independently of man, and long before man's appearance on the earth, for the production of *Coal*. The manifold uses of this substance lie beyond my province, as do those of timber. But I beg you will bear in mind that since trees, as such, come and can come only of the *bud*, so to the bud is man beholden for the advantages which both timber and coal have given him. So important in the economy of Nature is the Bud !—I am, &c.

LETTER XIX.

"All knowledge is to be referred to use and action."

LORD BACON.

"Be aye stickin' in a tree, Jock; it'll growe whaun ye're sleepin'."

SIR WALTER SCOTT, BART.

September 20, 1855.

MY DEAR SONS,

1. If my theory be a sound one, it should be worth something. It should supply a reasonable answer to the question—*Cui bono?*

2. One use it will clearly serve—that of explaining various phenomena occurring in trees, and that of solving sundry questions presenting themselves in connection with trees—such questions as those relating to their age and size, the very variable duration of trees of the same species or of different species—and such phenomena as the unequal growth of trees on different sides, the winding course, or the strange bundling and plaiting of the woody fibres in the trunk of some trees, the vigorous state of many trees, even after the trunk is in a state of decay and quite hollow, the existence of roots in the chasms, and of birds'

nests, frogs, stones, and such-like in the very heart of trees, enclosed and completely buried in sound wood. It will also have a religious and moral use, as I shall endeavour to show you in my next letter.

3. But the use and application of the theory which I have in view at present is a *material* one—such as the gardener may turn to account in the management of his fruit-trees, the farmer in that of his orchards, and, above all, the forester in that of his plantations, and of the park or ornamental timber. I have no doubt, indeed (assuming it now, as I think we may, to be a true theory), that it may be useful in that way; and I have in my mind one or two uses which it seems to me it may serve. But I beg to observe, in the *first* place, that having myself had no practical experience in matters of this kind—having lived all my days in towns (which Cowper says "man made," and in the making of which he ruthlessly lays the axe to the root of the aboriginal occupants of the ground), and not in the country (which the same authority says "God made," and where these find their proper field, and receive fitting treatment)—you will not expect that I should be so ready in the practical as in the theoretical department of my subject; and, in the *second* place, that it is no fair test of the merits of a theory that the proposer of it should be able to point out the applications of it. Galvanism was for a very long time little else than a barren theory, and Galvani, who first

brought it to light, had no idea of the use that has within your own recollection been made of it, in the all but instantaneous interchange of thought between persons living many thousand miles apart, or that will yet be made of it when the electric telegraph overspreads the globe. The discovery of the laws of latent caloric did not at once lead to the application of steam as a moving power.

4. In thus referring, therefore, to the uses of the theory, it is not in the hope or expectation of turning it to practical account myself, but rather with the view of showing you that I neither overlook Lord Bacon's maxim, nor feel indifferent as to the way in which the Author of Waverley's friend "*Jock*" may best carry out the advice given him, and so make two trees grow where only one grew before.

5. All that at present occurs to me on the subject may be comprised in one or two observations, which, moreover, I desire to submit less in the way of confident assertion than of "guesses at truth."

6. And, *first*, it seems clear from the view taken of the relation to the woody tissue, of the plants emanating from the buds, that, as the quantity of that tissue is always proportioned to the number of the plants, so caution should be exercised in the *pruning* of trees, — and precaution taken so to plant them in the first instance, and so to weed them afterwards, as to give the *side* plants air and room to grow, as they

naturally will, if allowed — taking due care where necessary, in conducting the latter operation (while not deferring it too long), not to withdraw, by over-thinning, the support and shelter which the trees give to one another. All this, indeed, the practical forester knows very well, and habitually acts upon; but I think my theory explains the reason better than the old.

7. *Secondly*, The fact of the tree-plants of one year being essentially independent of those of the past and the next, and of each year's crop of timber essentially standing by itself — varying in quality, no doubt, as in quantity, as is the case with the cereals and their produce, — may perhaps furnish a good ground of hope to the land-owner that a disease affecting his plantations this year—and even for a series of successive years—may be purely *temporary*, and not in the end blight his prospects in respect of them. No doubt, even on the supposition that every tree is "one integer," or an individual plant, that hope may be entertained. Disease, as a general fact, is in its own nature temporary, and on this ground alone a diseased plantation might be expected in the course of time — either spontaneously or by the aid of suitable appliances (among which efficient drainage* seems to

* "Since I came to Arniston as forester, I have recovered a considerable extent of young larch plantations, which were fast going back, and that simply by draining the soil, in order to draw

be the most important)—to recover itself. And this we know very well has happened. Some years ago, in many parts of the kingdom, in Scotland particularly, the larch plantations "went wrong." Several were almost destroyed by the disease that affected them; others, however, recovered, and are now to all appearance in as sound a state as ever. Still, I think my theory affords a better ground of hope in that respect than the old,—and that just to the extent and in the way that we may in general reasonably expect, that a child will escape a disease—incurable it may be—under which one or other, or even both of his parents labour, — or, if himself inheriting and participating in it, will not impart it to his own offspring; in other words, that a morbid taint attaching to one or two in the immediate succession will not in all probability be transmitted from generation to

away from it superfluous water, as well as to cleanse it from bad qualities which were natural to it, and formerly prevented the healthy development of the larch tree. These young larch plantations were under fifteen years of age when I drained them; but I cannot say if draining would recover plantations of older standing. In all cases where it is desirable to cultivate sound larch timber, the land should be drained with open cuts at from thirty to fifty feet distance, according to the nature of the soil, and not shallower at first than eighteen inches deep; and as the plantation advances in age, the drains should be gradually deepened, and kept properly clean; for however well land may be drained at first, if those drains are not kept in a clean running state, they will ultimately be of very little benefit to the rearing of healthy larch."—"*The Forester*," *&c.* by James Brown, forester, Arniston, 2d Ed. pp. 412–13.

generation indefinitely, and so be perpetuated in the family.

8. And this observation we may, I think, apply to the Potato and its "disease," and likewise to the Vine, the Hop, the Peach, and their "diseases." Heretofore, the diseases which have so widely prevailed—in fact epidemically—among the plants in question, and which have proved so destructive to them and so disastrous in their issues to the people of many countries, have eluded all attempts to ascertain either their real nature or their exciting causes, as well as baffled the skill of man either to prevent or cure them. And our main hope, it appears to me, must lie in the evanescent character of the diseases themselves and the restriction of them to individual generations only, of the race to which the plants respectively belong.

9. One qualifying observation I must needs add in regard to trees, which is, that it may be a question, even in the point of view just adverted to, whether the timber produced by diseased plants, overlying, on the one side, and overlaid by, on the other, the sound timber of pre-existing and succeeding healthy plants, may not affect the quality of the entire "Timber-stack."—May not the seeds of the "dry-rot" in timber, for example, attach themselves primarily to particular rings or cylinders of the tree, and have their origin, not so much—or at least so exclusively,

as some have fancied, in the felling of the tree at a time when it is full of sap,—as in the ill-developed and ill-conditioned woody-tissue, the produce of the diseased plants of a particular year or series of years? Such tissue, it is conceivable, may be as perishable in its degree and as prone to decay as the diseased potato-tuber, but the tendency thereto be prevented, as long as the tree is in the ground and growing, by the more complete exclusion of the tissue from external agencies than does or can obtain in the case of the latter—an exclusion becoming every year still more complete and perfect by the deposition of new woody-tissue around it, breaking forth, however, after the tree has been felled, sawn up, and exposed to air and moisture—to the latter especially. It would, I think, be worth while to examine microscopically and otherwise, the timber of trees which are known at a certain period of their growth to have been diseased, and to compare the woody tissue of the cylinders of the several years. There are marked organic differences, easily detected by the microscope, and sensible chemical peculiarities elicited by analysis, between the tubers of healthy and diseased potatoes. And like or equally notable differences may exist in the woody tissue of diseased and healthy tree-plants.—I am, &c.

LETTER XX.

"He hath given them a Law which shall not be broken."

PSALM cxlviii. 6.

"The Laws of Nature are the Thoughts of Nature; and these are the Thoughts of God." ŒRSTED.

"And this our life, exempt from public haunt,
Finds Tongues in Trees."

AS YOU LIKE IT.

November 29, 1855.

MY DEAR SONS,

1. I hope we may now consider ourselves fairly "out of the wood," and, standing where we do, entitled to congratulate ourselves that, in wending our way through it, we have neither stuck fast in the mire, nor been driven by a "lion in our path" into a course other than that we intended to pursue. Setting out as we did in the dim twilight, with a mere hypothesis for our guide, I would fain persuade myself that we have at length reached the stable platform of a sound theory; and that in the broad day and clear sunshine which now surrounds us, we can plainly

perceive in the facts that have passed under our view, one common principle running through and connecting them all, one general fact embracing and expressive of them all.

2. If so, I would wish to lead you one short step farther. If my theory be a sound one, it is the expression of a *Law of Nature;* if our inquiries have brought us within the view of a general fact or common principle, including and explaining a number of individual, and, in themselves, solitary phenomena, they have brought us within the view and to the grasp of a Law of Nature.

3. But what is a Law of Nature? To say that it is the expression of an *ultimate* fact in nature, of which no other account can be given than that it depends on the will of the Author of Nature;* to say that "Laws of Nature are *nothing else* but the most general facts relating to the operations of Nature, which include a great many particular facts under them,"† is, it seems to me, a definition which conveys but half the truth—nay, which by its *negative* form obscures it altogether. We may, I think, rise a step higher than this, and, defining it *positively,* say with Plato, that a Law of Nature is the expression of an *idea* in the divine mind — the manifestation of a *plan* or *purpose* in the mind of the Creator. To discover a Law of Nature is

* Alison, *Outlines of Physiology,* 3d Ed. p. 8.

† Reid's *Inquiry into the Human Mind,* chap. vi. § 13.

to get within the veil behind which the Creator works in secret. It is to come into contact with His mind, and see Him thinking and planning and ordering as seemeth unto Him good, in regard to that which forms the subject of the law.*

4. The happiest expression of this view is that given by Œrsted: "The Laws of Nature are the *thoughts* of Nature, and these are the thoughts of *God.*" That, I apprehend, is the proper notion of a Law of Nature. The term law, it seems to me, bears or should bear the same import in natural science that it does in ordinary jurisprudence. A law of this realm of England is an expression of the mind and will of the people of England, as declared through the legislature; and when doubt or difficulty arises in the interpretation of it, reference is continually made to the known or supposed design of the legislature in the enacting of it. To say of the laws which regulate the succession to property that they are statutes, of which no other account can be given than that they form part and parcel of the laws of the land, and depend on the will of the legislature, would probably be regarded as not altogether a satisfactory account of them by a student of English history, intent on getting at the root or principle, and mastering the

* See, for a fuller elucidation of this view, *Dialogues on Natural and Revealed Religion,* by the late Rev. Robert Morehead, D.D. (1830)—*Preliminary Inquiry.*

philosophy of our constitutional forms, and of our national traditions and social usages.

5. And this notion of law is distinct from that of power. Power, indeed, is itself regulated by law—*i. e.* by design or purpose, and is therefore expressive of mind—into which, in fact, all power as well as all law is resolvable. But still law is not power. The two are as distinct in the economy of Nature as they are in the economy of human affairs—as distinct in Nature as a law of this realm is distinct from the executive power of the realm by which it is enforced. The time-tables of a railway company set forth the *law—i. e.* the purpose of the company, in the person of the directors, in regard to the departure and arrival of the several trains at the different stations along the line. And the trains do in fact arrive and depart in obedience to that law. But the law in question is not the *power* by which the *movement* of the trains is effected; nor does it give us any insight into the nature of that power. So, also, the phenomena of Nature take place in accordance with (or in obedience to) the laws of Nature, and these laws are expressive of ideas in the Creator's mind—embodiments of His thoughts and purposes. But they are not the powers employed by Nature in the production of the phenomena, nor do they lead us one step towards the knowledge of them. The Creator has let us into many of the secrets of His counsel; but He has carefully hid

from us most of the secrets of His power, lest we should ourselves become as Gods, and work like Him. In the hands of Cuvier, a single fossil-bone, the only remains he had of an extinct animal, disclosed to that physiologist the entire animal—its structure and functions, its instincts and habits, the object of its existence—the whole purpose (one may say) of the Creator regarding it—a disclosure afterwards verified by the discovery of the complete remains of another specimen of the same animal. But it did not and could not disclose to him the *power* by which it was made, and by the knowledge of which he might himself make and put life into such an animal. In like manner, the falling of an apple (at least so the story goes) led Newton to the discovery of the great law of gravitation, in obedience to which the movements of the heavenly bodies take place. But it taught him nothing as to the efficient power of gravitation itself. The key which laid open to Newton and Cuvier the repository of laws—of plans, patterns, and specifications—was not the key that answers to the stronger lock which bars the tool-house and the work-shop of Nature.

6. What now is the law written upon trees? What the language which they speak? This: That though constructed to last for ages and generations, and to grow to an enormous size—without set limit to their age or size, they are yet fashioned after the same model with other plants—*modified* only with express reference and in manifest adaptation to a *special* end.

7. Do you ask what the general plan or idea is? The answer is, that short-lived, small, and slender *annuals* are the basis of the whole vegetable creation, the principle on which the whole is contrived, the true types and proper representatives of all plants.—"Trees come of us, not we of trees." So, as we tread it under foot, gazing at some majestic and venerable Oak—so might the little Daisy say, addressing us in the name and on the behalf of its fellow annuals. "Giant as that proud Oak is, reaching back though he may to ages earlier than the Conquest, he yet contains no element that is not to be found in us. The Grass of the field which in the morning groweth up and in the evening—its growth completed—is cut down and withereth, cometh of an older line than his."*

8. And do you ask next what the special end is, to meet which the general plan has been modified in the case of trees? It is mainly the production of *Timber*. And what the modification itself? Let us again

* "Kings come of us, not we of kings.—Nos no descendemos de los Reyes, sino los Reyes descendien de nos,"—is said to be the device of the *Manriquez* family.—"I think, Sir Edward, that you are of the family of the Duke of Somerset." "Pardon me, Sir, the Duke of Somerset is of *my* family." Reply of Sir Edward Seymour, the head of the elder branch of the Seymours, to William, Prince of Orange, who, at his first interview with Sir Edward, meaning to be very civil to him, had addressed him as above.—See Macaulay's *History of England*, vol. ii.

examine this a little in detail. It is so simple as almost to elude observation, yet, as soon as seen, so manifestly a scheme or contrivance—so like in kind to what we ourselves might any one of us have devised, that we cannot help identifying it with *mind;* and withal so in keeping with the general idea, that we cannot but regard both the idea and the scheme as the offspring of *one and the self-same* mind. The modification lies chiefly in this,—in the property bestowed on the tree-plant of growing *parasitically* on the root of its dead parent, and of so growing on this root as to cover it over, enclosing it on every side and throughout its length. It lies partly also in this,—that the root itself is made *somewhat* firmer, and therefore less quickly perishable than the root of the ordinary annual. I say somewhat, because it need be (and is in fact) only sufficiently firm to last till the following season, that it may then serve as the support or axis for the new plant of that season to rest and grow upon. This purpose served, the root in question is henceforth cut off, in the way just adverted to, from the destructive agency which external influences tend uniformly to exert on all dead organic matter. It is sheathed over, hermetically encased, and thus (though naturally very perishable), effectually protected against the joint and otherwise irresistable action of air and heat and moisture.

9. Physiologically, this modification of the general

plan is unimportant. The peculiarities which attach to the tribe of tree-plants are in that respect insignificant. Yet in their manifest intention and their actual result they are all important. For they plainly bespeak a plan or purpose in the mind of the Creator. Provisions they are of His, whereby out of short and slender annuals, He forms *timber* for the use of man, —and whereby in the ages that are past He formed *coal* also for the service of man—substances both of them which minister in a thousand different ways to the comfort and the well-being of man's race, but the production of which would have been impossible had not the economy of the plants in question thus differed from that of all other annuals.

10. Nor this alone. Those very peculiarities pointing, as they do, to a *common* plan as the basis on which tree-plants have been constructed, indirectly but all the more strikingly evince the essential *unity* of the plan in conformity to which *all* plants have been constructed. The whole vegetable kingdom, therefore,—the extremes of it thus meeting—is expressive of the same idea, and bears witness that it is the conception of one Divine mind, the handiwork of the same Almighty Power.

11. Thus and so unmistakably do Trees seem to me to testify of the Creator. Nor is this all that they tell us. Their language is rich and copious. It is expressive also as well of emotions as of ideas—of joy and

gladness, of sadness and sorrow, of awe and gratitude, as of truth and beauty, of power and might and majesty, of wisdom and goodness. To understand their language, however, in all its fulness and variety, and to hold familiar converse with them, is what few are equal to. It requires perceptive and suggestive faculties of a particular order, and peculiar emotional susceptibilities. Yet even we, as we stand beneath their shade or walk among them, though wanting in those gifts, may yet catch enough to make us wiser and better. The wind sweeping through them, and "made vocal" in their service, may perchance waft to us their morning or their evening hymn—their own *Jubilate Deo* :—

> "O be joyful in the Lord: Trees of the wood that rejoice before Him;
> It is He that hath made us; and not we ourselves—
> Monuments of His mind and hand, emblems of His years, and channels of His love to man."—

And the while, from the green sward on which we tread, we may hear still another voice coming to us in accents at once "gentle and unreproving," and saying to us individually—"Take thy shoes from off thy feet, for the place whereon thou standest is holy ground." Let our response be—"Surely the Lord is in this place, and I knew it not. This is none other than the house of God, and this the gate of Heaven." And lifting our eyes upward in this "Temple of

the Living God," and therein "seeing Him who is Invisible," let us with subdued yet cheerful hearts, whisper to ourselves, each one to himself, "I have heard of Thee by the hearing of the ear, but now mine eye seeth Thee!"—I am, &c.

POSTSCRIPT.

In *Letter* IX., section 21 (page 90), I speak of our having *annually* a *crop* of *timber*, just as we have annually a crop of corn. I might have added that the former has equally with the latter, a *money value*, which, though it cannot be so quickly realised or so accurately computed, as in the case of corn, may yet be approximatively estimated and shown to form an important item in the yearly rental, and the accruing value, of an estate on which extensive plantations exist. On this subject details of great interest are given by my friend and relative, Robert Smith, Esq., of Glenmillan, in a paper entitled "*Report of Planting on the Estate of Balgowan*," in Aberdeenshire,—for which Report the Highland and Agricultural Society of Scotland (to which it was presented) re-

cently awarded him a Gold Medal.* By permission, I am enabled to append certain details to these Letters. They relate exclusively to two kinds of timber — Larch and Scotch Fir — and are comprised under the head of "General Observations." They are as follows:—

"For the first twenty-five years, it may be prudent to assume, that, in a purely agricultural district, where there is not a scarcity of wood, no return whatever will be derived from a Larch and Scots Fir plantation,—any price obtained for thinnings being exhausted, if not more than exhausted, in the expense of cutting. In ordinary cases, after the lapse of twenty-five years,—or, say, thirty years at the most,—the thinnings become fit for fencing, coal-props, &c.; and if the plantation be a thriving one, and the locality within an average distance of conveyance by water or rail—suppose five miles,—the returns become considerable. It were a very moderate estimate to assume, that, for the period of the plantation's age, between thirty and forty, a free annual return of 10s. per acre may be obtained. At the end of forty years, we may assume that 450 trees per acre will remain—say one half Larch and one half Scots Firs.† If still in a thriving condition, few will be sold for some years; they are too old for coal-props and fencing, and, generally, too young for flooring, railway-sleepers, &c.

* This report will appear in the "*Transactions*" of the Society—to be published in January 1856.

† The plantation to which Mr Smith's report relates, was laid down (in 1851) in the proportion, *per acre*, of 2400 two-year-old seedling Scots Firs, and 600 two-year-old seedling Larches—and in such manner that the subsequent thinnings should be chiefly confined to the Scots Firs.

They are now in a state when their annual increase in growth and value is very great. At the end of sixty years, the intervening period from forty has probably disposed of 150 trees per acre, at an average price, we shall assume, of only one shilling per tree—after deducting expenses and allowing for dead trees—giving L.7, 10s. per acre. We have now 300 trees remaining for each acre, and shall suppose that they consist of Larches and Scots Firs equally. Of course, there will be considerable variety in the size, but, assuming that each acre contains

Fifty Larches, worth on an average only 5s. each, ...	L.12	10	0
And fifty Scots Firs, worth 2s. 6d., . .	6	5	0
With the remaining two hundred trees, at say on an average of only 1s. 6d., . .	15	0	0
We have a total value per acre of .	L.33	15	0

"The result of the foregoing estimate would stand thus :—

Original expense of planting and enclosing, L.1, 4s. 9d. per acre, or say . . .	L.1	5	0
Compound interest at 5 per cent for thirty years, the thinnings to that date being held as an equivalent for the expense of cutting, &c.,	5	8	0
Total per acre, . . .	L.6	13	0

"For the period of the wood's age, between thirty and forty, we held the thinnings as worth 10s. per annum, per acre ; but as the Reporter would rather have his estimate below than above the truth, we shall place the return for this period simply as equal to the current interest then accruing.

For the period of growth, from forty to sixty, we have estimated the return at only L.7, 10s. per acre, that being a time when it is desirable to cut as few trees from a thriving wood as possible—

Or, per acre, per annum, , . .	L.0	7	6
Less interest on L.6, 13s., amount of expense, and compound interest thereon, as before,	0	6	8
Leaving per acre, per annum, .	L.0	0	10
And giving for twenty years, per acre, .	L.0	16	8
The price at the end of sixty years was estimated as before, per acre, at	33	15	0
Making a total of . . .	L.34	11	8
From which deduct original outlay and compound interest, ...	6	13	0
Free balance per acre, . .	L.27	18	8

" Or, taking the full amount for a plantation of the extent of that reported on (190 acres), we have—

Original cost and compound interest, as before, one hundred and ninety at L.6, 13s.,	L.1263	10	0
Price, ditto, at L.34, 11s. 8d., . .	6570	16	8
Balance or gain, . .	L.5307	6	8

" This return is equal to a rent at the rate of 9s. 3d. per acre, per annum for sixty years, for ground *literally worth nothing before*, besides leaving a surface of decayed vegetable matter, growing pasture-grass in place of heath, and having all along afforded shelter and beauty to the adjoining grounds.

"By some the preceding estimate will be thought too high, by many too low. The Reporter admits that the value to which a young plantation will arrive cannot be predicated with certainty. There is an infinite variety of causes that may supervene to affect it—soil, seasons, state of markets, &c. He can point to a plantation, chiefly of Larches, on the Estate of Finzean, on Deeside, about fifty years of age, already worth about L.80 per acre; and, in other parts of the country, to plantations of almost equal age, not worth much more than L.5 per acre. But in any view, if the expense of planting be not above an average, and if the soil be not wholly unsuited for it, it is a good investment. The returns by way of shelter, amelioration of climate, increase of pasture-grass, and ready wood for smaller country purposes, if not for extensive sales, afford an ample remuneration for the original cost."

THE END.

APPENDIX.

NOTES

Note A.—Letter XIV., page 154.

Dr Lindley thus expresses himself in regard to the exceptions taken to the doctrine of the woody tissue of trees being descending matter:—

"The most important of the objections which have been taken to this opinion are the following:—If wood were really organised matter emanating from the leaves, it must necessarily happen that in grafted plants the stock would in time acquire the nature of the scion, because its wood would be formed entirely by the addition of new matter, said to be furnished by the leaves of the scion. So far is this, however, from being the fact, that it is well known that, in the oldest grafted trees, there is no action whatever exercised by the scion upon the stock; but that, on the contrary, a distinct line of organic demarcation separates the wood of one from the other, and the shoots emitted from the stock, by wood said to have been generated by the leaves of the scion, are in all respects of the nature of the stock. Again, if a ring of bark from a red-wooded tree is made to grow in the room of a similar ring of bark of a white-wooded tree, as it easily may be

made, the trunk will increase in diameter, but all the wood beneath the ring of red bark will be red, although it must have originated in the leaves of the tree which produces white wood. It is further urged, that, in grafted plants, the scion often overgrows the stock, increasing much the more rapidly in diameter; or that the reverse takes place, as when *Pavia lutea* is grafted upon the common horsechestnut; and that these circumstances are inconsistent with the supposition that wood is organic matter engendered by leaves. To these statements there is nothing to object as mere facts, for they are true; but they certainly do not warrant the conclusions which have been drawn from them. One most important point is overlooked by those who employ such arguments, namely, that in all plants there are two distinct simultaneous systems of growth, the cellular and the fibro-vascular, of which the former is horizontal, and the latter vertical. The cellular gives origin to the pith, the medullary rays, and the principal part of the cortical integument; the fibro-vascular to the wood and a portion of the bark: so that the axis of a plant may be not inaptly compared to a piece of linen, the cellular system being the woof, the fibro-vascular the warp. It has also been shewn by Knight and De Candolle that buds are exclusively generated by the cellular system, while roots are evolved by the fibro-vascular. Now, if these facts are rightly considered, they will be found to offer an obvious explanation of the phenomena appealed to by those botanists who think that wood cannot be matter generated in an organic state by the leaves. The character of wood is chiefly owing to the colour, quantity, size, and distortions of the medullary rays which belong to the horizontal system: it is for this reason that there is so distinct a line drawn between the wood of the graft and stock; for the horizontal systems of each are constantly pressing together with nearly equal force, and uniting as the trunk increases in diameter. As buds from which new branches elongate are

generated by cellular tissue, they also belong to the horizontal system; and hence it is that the stock will always produce branches like itself, notwithstanding the long superposition of new wood which has been taking place in it from the scion.

"The case of a ring of red bark always forming red wood beneath it, is precisely of the same nature. After the new bark has adhered to the mouths of the medullary rays of the stock, and so identified itself with the horizontal system, it is gradually pushed outwards by the descent of woody matter from above through it; but, in giving way, it is constantly generating red matter from its horizontal system, through which the wood descends, and thus acquires a colour not properly belonging to it. With regard to the instances of grafts overgrowing their stocks, or *vice versâ*, it seems that these are susceptible of explanation on the same principle. If the horizontal system of both stock and scion has an equal power of lateral extension, the diameter of each will remain the same; but, if one grows more rapidly than the other, the diameter will necessarily be different: where the scion has a horizontal system that developes more rapidly than that of the stock, the latter will be the smaller, and *vice versâ*. It is, however, to be observed, that in these cases plants are in a morbid state, and will not live for any considerable time.

"Another case was, that if a large ring of bark be taken from the trunk of a vigorous elm or other tree, without being replaced with anything, new beds of wood will be found in the lower as well as the upper part of the trunk; while no ligneous production will appear on the ring of wood left exposed by the removal of the bark. Now this is so directly at variance with the observations of others, that it is impossible to receive it as an objection until its truth shall have been demonstrated. It is well known, that, if the least continuous portion of liber be left upon the surface of a wound of this kind, that portion is alone sufficient to establish the communication between the

upper and the lower lips of the wound; but, without some such slight channel of union, it is contrary to experience that the part of a trunk below an annual incision should increase by the addition of new layers of wood until the lips of the wound are united, unless buds exist upon the trunk below the ring. The horizontal parenchymatous system may, however, go on growing, and so form new layers.

"Dutrochet mentions some cases of extraordinary longevity in the stock of *Pinus Picea*, after the trunk had been felled, and which he supposes fatal to the theory of wood being formed by the descent of organised matter. He says that, in the year 1836, a stock of Pinus Picea, felled in 1821, was still alive, and had formed fourteen thin new layers of wood—that is, one layer each year; and another, felled in 1743, was still in full vegetation, having formed ninety-two thin layers of wood, or one each year. But, it is now ascertained that these roots are connected with living stems in consequence of having become grafted, under ground, to the roots of the latter.

"The observations of Mirbel on the origin of the woody bundles of Palm-trees, from which it appears that the bundles first appear isolated in the cellular matter of the buds, and then direct themselves upwards into the leaves and downwards into the trunk, are certainly opposed to the possibility of regarding wood as the roots of leaves. And the difficulty of admitting the theory is much increased by the existence in bark of the embryo buds, already described; and by M. Decaisne's statement, that in the Beet-root, when new vascular tissue is produced, it, in the beginning, is distinct from the previously formed vascular tissue.

"The singular examples of carved figures being found in the interior of trees also militate somewhat against the theory of wood being a form of roots, and are better explicable upon the supposition of a gradual superficial deposit. A very curious example of this is to be found in the *Gardener's Chronicle* for

1841 (p. 828); others have been occasionally met with; and Link has figured one in his *Icones Selectæ* (Part ii., t. 2, fig. 7), which he speaks of thus:—'I found such letters in a Lime-tree near Berlin, on an estate belonging to the deceased minister, Count Von Luttum; the letters on the one side of the split piece were hollow, on the other elevated, and the cavity had evidently been filled up again with a woody substance. This filling-up substance, on making a transverse incision, exhibited rather irregular layers, with a moderate magnifying power. And on being magnified 315 diameters, it evidently consisted of strata of larger and smaller cells, partly filled up, partly empty, with interstices. The circumstance, however, which appears particularly remarkable, is, that the internal structure of the filling-up substance, on a longitudinal incision, corresponded very nearly with the old wood situated next to it, with the difference only, that spiroids existed in the latter, which were entirely absent in the new wood. It will be seen, therefore, that the formation of layers is peculiar to the wood, and is by no means caused by external influences.'"—Introduction to Botany, vol. ii. Pp. 197-201.

This whole extract bears on one particular view of the woody tissue and its mode of evolution—that which regards it, exclusively, as "*descending matter*," and evolved by the *actual* descent of this matter *from the leaves*. The greater number of the objections to this view seem to be satisfactorily met and answered by Dr Lindley. There are other objections, however, not so easily disposed of, regarded seemingly by Dr Lindley as real, and pointing to a superficial deposit *in situ*, from the Cambium, as the actual mode of its evolution. It appears to me that the view taken in the text, which recognises *both* modes of evolution—an evolution *in situ* as well as an evolution *by descent*—not merely solves all the difficulties, but is required to explain all the phenomena connected with the formation of the woody tissue.

Note B—Letter XVIII., page 193.

With regard to the exegetical question referred to in the foot-note, one or two additional remarks may be made here. And first, the late Professor Lee of Cambridge, in his *Lexicon*, under the head of the Hebrew word *Elohim*, observes :—" It has been supposed occasionally to signify *Angels*, but there is no real necessity for this,"—adding, in a foot-note, that—" The Jewish commentators and translators of the Scriptures, as well as their Samaritan neighbours, filled as they were with metaphysical notions of the Deity (which Dr Genesius terms *puriores*) have constantly had recourse to this interpretation, whenever the appearance of God was mentioned in the Scriptures." Again, in several parts of the Bible, the Divine presence is associated with that of Angelic presence :—Compare, for example, Exod. iii. 2 with Exod. iii. 4, 6, 7, 11, 13, and, particularly, 14, and with Acts vii. 30, 31, 32, 33, and 35 ; and, again, Acts vii. 38 with Exod. xix. 3. Further, as is maintained by the Rev. J. G. Wright, it might be shewn, from a consideration of the context and the general scope of the argument, that St Paul's meaning, in his reference to the eighth Psalm in Heb. ii. 7, although he uses the word *Angels* (herein following the Septuagint version, as our translators have done), is intelligible only when the word angels is used in its highest sense, *i. e.* the primary and proper sense of *Elohim*. The Apostle's object is to shew the superiority of our Lord Jesus Christ, in his human nature, over the nature of Angels, and this he does by shewing the superiority of *man's* nature.

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