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XXI. *Comparative Anatomy; or a slight Attempt to draw up a Comparison between Animal and Vegetable Life.* By Mrs. AGNES IBBETSON.

To Mr. Tilloch.

SIR, — AFTER having dissected most parts of vegetables, shown their different powers, and endeavoured as far as able to inquire into and explain the various uses to which each different part is applied, it struck me that it was now time to draw up something of a comparison between animal and vegetable life. I have often during the course of this work lamented the injury done to the anatomy of botany, from comparisons drawn only from human anatomy: because a surgeon would be but too apt to add many more powers than really exist in the vegetable, unless he had very exactly compared and studied the two dissections together. But as a perfect assistance may be procured in the description of the human body, that, joined to a *thorough knowledge* of the *vegetable*, would not, I think, be liable to the same objection. I shall, however, try it: and if I should make any mistake, it will be pardoned in one who can claim but very imperfect knowledge in *human anatomy*, and who will (but in a very few cases) attempt (in *animal anatomy*) to borrow from her own dissections.

In reading books of anatomy, and viewing the dissections of animal life, when contrasted with a vegetable being; it is impossible not to be struck with the studied care and elaborate pains *seemingly* exhausted in forming the first, and the clearness of invention and simplicity of formation observed in the second. To display this, I shall first give a slight sketch of the human figure, contrasting it, as I proceed, with a more finished picture of the vegetable frame; touching most lightly on those parts which admit not of being compared with plants, but dwelling as *strongly and clearly as possible* on those features which do, or are supposed to, admit of some resemblance to the human structure. In viewing the figure of a *man* and of a *tree*, it is hardly possible to conceive two things more completely dissimilar; and in beholding the *skeleton* of each, they would appear too much *unlike* to be compared, not seeming at a first view to offer *any* of those *similitudes* which are necessary in such cases.

But though no general resemblance can be discovered, yet a sort of comparison may be drawn up, perhaps advantageous to both, as more clearly impressing on the mind the beautiful diversity to be found in *two beings*, both possessed of a different kind of existence; showing also a *few instances* in which there is some resemblance; fixing the similitude which *does* or *does not*

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exist; but which in contemplation must continually remind us, that the same *great* and *benevolent* Being formed and created both.

To give some idea, though an imperfect one, of the nature of the two different beings to be compared, "the human form and vegetable," it is first necessary to fix on those parts which can in any measure be assimilated to each other. To the brain, spinal medulla, and heart of an animal, we can only with justice contrast *the line of life of a tree*. But how different! how inferior! The spiral wire is, however, a more faithful image of the muscle: indeed, as the plant is apparently a mechanical being, we might expect to find the strongest similitude in these parts; and as the muscle is in *both* the *only* part which seems to possess a *self-existing motion*, we can be in no danger of mistaking in the vegetable the wrong *situation*, since the *spiral* is the only part which is *vis insita*. The wood and the bones also have some curious analogies. The blood, with the bark, juice, and sap, may be compared. The *oil* of the *muscles* and *spiral wire* are the *same*. The womb and seed-vessel are something alike. The stomach, the place of digestion; the liver, the secreter of bile; the kidneys, the bladder,—all belong to a being that digests; which the plant does not. The skin and the upper cuticle have no resemblance whatever. The plant has no *nerves*; nor are the *muscles at all* attached to the line of life, or *brain* of the *plant*. Both beings have *lymphatics*, both have *glands*, but the vegetable is *different* from the animal gland; since the vegetable has no *secretions* from the blood, but receives the juices of *this kind* all pure from the *hairs*. Does not every part of this selection prove the vegetable to be a mere *mechanical agent*? a great and bold line, drawn by the Almighty hand to diversify and beautify creation, and fill up the link which would otherwise be wanting between the organized and unorganized matters! Let us then descend to the minutiae of the existing difference.

First then (to borrow Hunter's words and plan), we must form a human being. The MIND (the immaterial agent) must be provided with a place of *immediate residence*, which shall have all the requisites for the union of spirit and body: accordingly she is provided with a brain, where she dwells as governor and superintendant of the whole fabric. In the next place, as she is to hold a correspondence with all the material beings around her, she must be supplied with organs fitted to receive the different kinds of impressions which they will make: in fact, therefore, we see that she is provided with the organs of sense; the eye to see, &c. &c., Further, she must be furnished with other organs between herself in the brain and those organs of sense; and she must have other organs *between herself in the brain and every other*

other part of the body, fitted to convey her commands and influence over the whole. For both these purposes, *nerves* are *adapted*; they convey all the sensations to the mind, and give notice of all suffering. It is evident, therefore, that all sensations arise from the impression of some active substance on some *nerve* of the *human body*; and that the same is represented to the mind by the means of the nerves connected with the brain: every nerve, therefore, that is irritated produces a sense of pain; and if certain parts of the brain are *compressed*, from which *particular nerves* arise, then those *senses* are *lost* which depend on *those nerves*. But in the *injuries* of the spinal medulla (which is a continuation of the brain down the *vertebræ* of the back) this is *still more evident*; for those parts which receive their nerves arising from the place injured in the medulla, are either *convulsed* if that be *irritated*, or rendered *paralytic* if that be *compressed* (and if the greater part of the brain *suffers*, the *whole body* loses its power of motion). These things considered, there seems to be *no doubt* that the *cause* of all *sensibility* arises from the *nerves* being connected with the *brain* or *spinal medulla*; and that all *voluntary motion* equally arises from the *connexion* of the *nerves* with the muscles, thus conveying its orders to and from the brain. Therefore it cannot reside in the *nerves* themselves; because otherwise the moving cause would continue *to act* after being *separated* from the *brain*, nor would it be increased by its irritation.

Of all this important and admirable formation of the human body, what part does the vegetable possess? Scarcely any that can deserve to be assimilated to so wonderful and marvellous a structure of *senses* and *feelings*; though it has certainly great beauty, not only from its simplicity, but arising also from the fitness of its form, so admirably adapted to its situation in the grand scale of *beings*; but without *volition*, without *sensibility*, even without *senses*. The line of life can only be said to be the *brain*, *spinal medulla*, and *heart* to the plant, *to stand for all three*, though it resembles the heart only as the first visible life, and the brain alone as the chief source of existence, and the spinal medulla as passing like the line of life through the body. But how inferior an image of all! It has not the action of the heart, having neither *arteries* nor blood to circulate; nor the *brain*, having no *nerves*. I have entered more minutely into this than I intended, in order to impress on my readers a conviction I feel myself, that, *thus formed*, there can be no *volition* in plants.

To begin then with the description of the *line of life* (the only part that can be compared to the brain and spine of an animal), The line is formed of a matter firmer than the bark, not so hard as the wood, generally of a white colour, but sometimes green,

sometimes yellow, always *black* when *dead*. When a vegetable is really killed, this *line* is the *first part to die*:—thus, when struck with lightning or a *hard frost*, in a moment this line turns *black*, and can never again be revived, though the bark and leaves may for a time retain their verdure; as, like the hair and nails of an animal, they possess but little life. The line of life consists of three or four rows of cylinders hollow in the middle, and within them are generally found the juices of the nectary; but this mixture formed in the middle root, seldom, I believe, flows up the vessels till after the *flower* has *passed up them*: about the end of February the *flower* (formed in the root) enters *these vessels*, which *enlarge* for the purpose, and run *up them*, till they arrive at the buds, which were empty till then, having only their scales (*prepared some time before*), and smeared with an oil which protects the interior from all danger. The embryo then quits the vessels, and enters those buds which are properly their cradles in the bark, situated in the axillæ of the leaves. The vessels, after this service done, are restored to their usual size, and remain all the rest of the year unaltered, still conveying the nectareous juices. It is only three weeks of the year that this phænomenon can be seen; it appears in every plant nearly a month before the flowering season. With respect to life, this line more resembles the *heart* than brain of a human being; as it is *evidently* the *first place* which *exhibits life*; and though it does not show it by *motion*, having neither *arteries* nor *blood* in this part, yet it is *this line which gives life to the bud, to the seed, and to the flower*.

There is a curious similitude between the animal and vegetable that should be displayed here, as belonging to this part principally. I have shown that the brain and spinal medulla are the sources of life in the animal, as the line of life is to the *vegetable*. I have also mentioned that the muscle and *spiral wire* are the sources of *involuntary motion to both*. Now if they are each struck with a quick death, that is not lightning, the irritability in the muscle will remain in both objects for a time after death; but the *animal* struck with *lightning* or the *plague*, and the *vegetable* with *lightning* or a *hard frost*, will *directly* lose that irritability, and immediate decomposition will come on; each body will grow soft, *pappy*, and *watery*, *putrefaction* will suddenly succeed; nay, this is often the case in both even *before death*. Many have supposed that there might be some volition in plants. But how can that be? What is the cause of *will* in the human frame? It is alone *supported* by the connexion of the nerve with the brain; and in motion, that nerve being also fixed on the muscle, by its *immediate action* proves its *obedience to orders sent it from that superior power*: but there is no *nerve* in the *vegetable*; nor does the muscle (if it could be substituted)

stituted) at all join to the *line of life*, or form any connexion with it. How then can *will* be *announced* or *executed*?

There can therefore be no volition in plants, and they can only be a *piece of living mechanism*. No person who has seen and dissected a plant killed by *electricity*, can doubt which is the line of life, since this line is *directly marked* from the root to every fibre, and turned completely black in a moment.

I shall now turn to the animal and vegetable muscle. And here the strongest *similitude* is to be discovered; since it is the *only part* that in *both beings* can be said to move by *involuntary motion* or *vis insita*. It is well known that in the human body there are three sorts of motion; the voluntary, the involuntary, and the mixed: but the first two will serve our purpose here. The first is caused by the will, *enforced* by the *nerve*, and executed by the *muscle*; but the last is spontaneous, proceeds from the muscle alone, the cause *unknown*. It remains often in the muscle after death, and, after it is divided from the brain, even exercises its full force in this situation. The human muscle forms part of the flesh; it consists of two parts, the wide (which alone is active), and the thin shining extremity called the tendon. The only purpose of the last is to fix the muscle to the moveable bones, which it does with a force not to be conceived but by feeling it. They are thus fastened in a concentrated manner, in which a greater power is permitted to act, as labours are assisted by ropes in moving weighty bodies; each muscle *contracts both ends* towards the centre, which serving as a *fixed point*, draws the bones with it. The wide part of the muscle is the moving part, and is most curiously formed. The muscles differ in the number of their cases, some animal muscles have two, or even three; but the vegetable *never but one*. In the human muscle a number of long, soft, fleshy fibres are seen inclosing many bundles of hair-like figures, which are the *nerves*, and which *split without end*. They appear to me to pass through every part of the muscle, *case and all*; when the muscle is quite fresh, they seem to move with *light* and *moisture* if *suddenly applied*. But I am not *sure of this*, having but *once* been able to get them fresh enough for this examination. It is difficult to discover how solid the *nerves* are, since they contract at the end the moment they are cut, and with such instantaneous effect, that though I have divided them with the microscope at my eye, I could not catch a view up the pipe. There is no part of the body which may be properly called fleshy (and which is in truth the muscle) which is not *penetrated* in every *direction* by *nervous fibres*; their sensibility *pervades the whole muscular substance*, even its smallest portions; and though they appear not to move themselves, yet they are supposed to be by some means

the cause of all *voluntary motion* to the muscles. Cuvier thinks that they are the cause of *all* motion, both voluntary and involuntary; but *that certainly cannot be*, since the muscles of a *plant* have the same *vis insita*, without possessing *any nerves*. But there may undoubtedly be a sort of *vapour*, which may pass through the nerves from the brain, and cause a most powerful effect, but still be entirely *separate* from that *vis insita* which is *so peculiar* to the *muscles*, that no one who has *seen it act* both in the *human body* and *vegetables* can confound it with *any other sort of motion*. The human muscle is a bundle of vessels: the oil lubricates them, that they may not be hurt by constant friction: and this is exactly the case also with the vegetable; but the cases of *both muscles* are even more wonderful than the hair-like fibril they each contain. The human case appears to be formed of two sorts of vessels; the fibril already described (which also enters into the formation of the case, and runs *longitudinally* in it), and another sort of vessel which forms a line and space, and passes across the muscle, and gives such a beautiful shining *lucid* appearance to the *muscle case*, and by its help draws up both vessels. The crossing vessels are alternately filled with a white oily matter, and the spaces between (being perfectly empty) by the help of the nerve which gathers up longitudinally, the cross vessels are drawn into *ribs* one above and one below, which running in a forked manner produce that *lucid appearance* admired by surgeons. When a piece of the *muscle case* is drawn out, and left to dry, it becomes *clear* and *horny*; and if when in this state it is bent to and fro *very often*, the place *swells up*, and appears of a *blueish milky colour*, which I *supposed to be caused* by the oil given out *from the cross vessels*. The *nerves* also (which pass through the muscles) are with this management *broken* and dispersed out of their cases; and it is *then* they are seen running in an undulating manner through the oily compound, which, now the vessels are destroyed, retain only a matter much resembling the impervious skin of the vegetable, only a more oily composition. The vegetable muscle-case, like the human, has also the *fibril* muscle in it: it is formed of straight vessels, replete with oil; but often so *brittle* they will not bear to be bent. These vessels are at some distance from each other, and laced up by the spiral wire. Though the figure of each case does not possess a very strong resemblance, yet their effects are *the same*: they have both the *moveable fibrils within*, the oil to lubricate, the case to protect the white oily vessels also; no point is wanting to prove that they are intended to produce the same effect, though perhaps set in motion by a *different cause*. There can be no doubt that light and moisture are the *hidden causes* of the vegetable motion, since their direct obedience

dience when excited by those powers speaks for itself. But what is the human cause I leave to better heads than my own. The involuntary motion of the human muscle seems always to take place with a jerk or by impulses. This is exactly the case with the vegetable, nor can they either move again till the relaxation of the muscle has again taken place. It would be curious to ascertain whether the measure is as exact in both as in the vegetable*. In the plant there are two impulses, a long and short one; the latter, half the length of the former; the first from ball to ball, the second from knot to knot. Both these measures are seen in the *Mimosa sensitiva*; when the whole leaflet drops, the spiral is moved from ball to ball; but when it is a leaf only, then the spiral moves from knot to knot. When the stamens rub together to throw their dust on the pistil in the mosses, then it is a single impulse; and when a leaf is moved it is the same; and the moisture it occasions undoes the spiral, and prepares it for a new contraction; and so delicate and sensible is it to each increasing light or decreasing moisture, that each minute almost brings its variation; certainly each passing cloud over the sun, its change. A few words, however, I must add on the unknown cause of the muscular motion. The human muscle lying so near the outward skin, (a cuticle which though doubled, nay trebled, is so pierced with pores which must admit much light and moisture,) would seem to suggest some cause for its motion, of the same nature as the vegetable, Did not the peculiar sort of cross action in the muscle-cases seem to suggest a difference: and yet there is one circumstance which is so exactly contrived respecting the nerves, as it is in the vegetable in the muscles, as to carry some impression with it: "The sense of touch is supposed to arise from the nervous extremities of the papillæ being more numerous, or covered with a thicker or a thinner skin in some places than in others, and thus bestowing a grosser or a finer degree of feeling to the different parts. Now this is exactly the case with the muscles: they increase their irritability in proportion to their advancement to the outward cuticle, and as they become more sensible of the effects of the atmosphere.

In all trees and shrubs whose branches live through the winter, and are therefore exposed to severe changes, the muscles are concealed within the wood: but in other plants (rising each year from the earth) they are discovered next the alburnum vessels; and in all very sensitive plants the outward cylinders of the rind are few in number and very thin, and the more irritable the muscle the thinner they are. Now there is some analogy here

* But in the human, I believe, it depends on the length of the muscle.

which if followed up and closely investigated might perhaps lead to a discovery of the causes of motion.

I shall now turn to the bone of the animal and wood of the vegetable, which may from some curious particulars be compared together. The first has a skeleton or system of bones which gives firmness and shape to the fabric, keeps the soft parts in their places, affords fixed points to the organs of motion, and gives them their proper direction, and protects some of the most tender parts from external injury. To connect the bones together, there are *ligaments*; and to afford smooth surfaces for them to play easily on one another, their extremities are furnished with *cartilages* or *gristle*. The bones consist of an interior, which is a species of honeycomb, and an exterior surface, which has many *layers* formed in a particular manner; the last if cut with a very sharp knife, and very thin, appears composed of many meandering vessels *filled with atoms*, which seem to be *rather solid*, from the clear spaces they show between them; while the honeycomb parts are *plates*, *thick* in the middle and meeting in their *thin edges*. This is also the same as the formation of the large bones of the skull, which increase also towards their centres; but the most extraordinary part of the wood is, that the foundation *exactly resembles* the thin surface of the bone, and is really composed of diminutive vessels filled *with atoms*: but this is only to be *seen in both* when excessively *magnified*, then they exactly resemble each other. But the system of wood, though it gives firmness to the fabric, yet obeys most *strictly* the *laws* of the *line of life* in its shape: it preserves, however, this important part from injury, but is within every other *soft ingredient*, and therefore cannot defend it.

In trees and shrubs it serves as some *support* to the *muscle*, but in annuals and herbaceous plants the *muscle changes its place*, and is at the *external part* of the *wood*. It cannot be said to afford a fixed point for the organs of motion; for it is the *gristle* which does this, which forms the *balls* round which the spiral winds itself, and which covers the ends of the wood in such a manner as to enable them to slip *over* or *into each other*, like a *cup and ball*. I never saw the *knee* or elbow of a human *skeleton* that it did not remind me of a *Galium*, *Selene*, or some of the stems of those plants which *swell at the joint*. It is a sort of *gristle* which serves *this purpose* and sheathes the wood, a kind of *thick matter*, which performs, in its *solid* or *liquid* state, many *important functions* in the *vegetable æconomy*, and makes a part, I doubt not, of that resinous compound Dr. Thomson discovered in the wood.

But how curious it would be to possess and be able to examine *that liquid* which performs that *extraordinary office* of
clearing

clearing the way through the *hard wood* for the buds; probably it might serve as a good comparison to the *gastric juice*; for great must be its *dissolving powers*. When the bud is first formed on the line of life in the root, and runs up to that part from which it is to *start* and make its way to the bark, the wood opens it a passage; and this is apparently done, even through *iron wood*, by a *liquid* which no sooner *touches* the *fibres*, than they divide and bend, and thus make a sort of *covered way* for the bud. That the bud passes from the interior no one can, I think, *deny*, who examines a *tree* after it has been *barked*: at every time of the year, but particularly in the *autumn*, a quantity of buds may be seen running from the line of life, to fix themselves in the bark. This is merely the embryo of the bud, or empty seed-vessel, with the nectareous passages and the corolla, all *rolled up together* into a little ball. These, when they start from the line of life, possess a juice of a peculiar kind which *precedes them*, and arranges the wood-vessels as it passes, making them all bend from it thus

: so that there is actually

a large space between the *bud* and the *wood* filled up with sap-jelly: nor is it possible the bud can be *even touched*, much more injured; since this hollow space is left for it till it reaches its scales, already prepared in the bark for its *reception*. There is not, perhaps, any of the contrivances of Nature more beautiful than this, or which has been so *strangely misunderstood*: if the bud had had to force its way, it would have been *destroyed*. In following the process, it is but cutting away the wood near where there *are buds*; as you approach one it becomes softer and softer, at last the liquid is discovered, and in the midst of it the *little delicate embryo*, lying in its bath or jelly-case, while a covered way near an inch before it is already prepared for its advancement. As it approaches the bark, its inclosure or cradle is ready for it, with all the conveniences selected for its preservation; and generally a quantity of hairs or points covering the outward scales of the bud, to introduce into the interior, *or the ball*, all the nourishment the most delicate creature can require; for there are few buds that are not at that time of the year loaded with hairs and instruments. Though I can find no analogy in the human frame for this process, yet I doubt not, *if* we possessed the *liquid*, it would assimilate well with the gastric juice. That so delicate, so soft a matter as a bud should pass unhurt through perhaps a foot or two of hard wood (for it must do so in the stem of a very large tree) is really almost miraculous till the method is explained.

Having

Having now described those parts of the human body and vegetable frame, on *which their figure, support, strength, and motion depend*; we must next examine those *juices which are intended to replace the waste of both the machines, and to supply them with new energies*. In the animal body are many more sorts of liquid than in the vegetable, because these are so many secretions from the blood: now this is unknown in plants. The animal blood is a rich store of nutritious fluid, fine enough to *penetrate its minutest parts*, and which constantly circulates through its whole machine: the elements of its composition are furnished by all our food. Now in the vegetable there are but *two sorts* of liquid that can be said to replace the waste of its substance,—the bark-juice and sap: the first, far from being formed in the body, is merely collected there from the atmosphere by the hairs, in one of the layers of the leaf, from which place it runs to the inner bark-vessels. It has no circulation like the blood; nor is it formed by the food, but taken in when separate, and mixed in the pabulum of the leaf. The bark-juices are so far from being capable of circulating, that their tendency to *coagulate is such*, that the bark is full of large species of matter escaped from its liquid state; and even in the vessels of the inner bark (if it was not for their *peculiar construction*) it would *never retain its liquid form*, since it is forced through apertures not half the size of the vessels in which it runs; and this *impetus, by increasing the violence of the action, tends to its fluidity*. The sap is, however, better adapted to play the part of the blood, were not a *circulating medium totally unfit and unsuited to the vegetable form*. A *being increasing at each of its numerous extremities*, receiving its blood from another body, and that *blood coagulating into a jelly by rest and suspension, before it can form its compound*,—can such a make be compatible with a constant circulation of blood? which cannot stop without destroying life. The proving that the sap-juices do not circulate is of the greatest consequence: if they circulate, and all the juices that should (when they arrive at the extremities) instead of forming the new shoot, run down again through the bark,—how is the new shoot to be completed? since all *that matter* which was to form it is employed in returning through the bark, leaving the only part which at that time required support and moisture. Is it not more natural to suppose that the juices (as they always become a jelly before they are wood) are arrested to be converted into that matter, and then complete their change? The idea of circulation is drawn from the comparison of animal life, *just only in a few instances, misleading in almost every other*. Is there not a great difference between an animal which grows not at its extremities, but which after the first few years ceases to increase, and

and one which increases every season at every joint, whose juices are independent of itself, and taken from another, and may naturally be supposed, *therefore*, to draw up *only that liquid* which is necessary for that increase? But if there were a circulating law established by Nature for the sap, it would most probably be a *universal law*, general to all plants: What then would become of those *trees* and *shrubs* which lose their bark in the winter? whose vessels are supposed by some botanists to convey the sap? If they remain, they would be doubly conspicuous, when the rest had *departed*; and they are certainly not to be found. A trifling piece of the green bark is discovered in the winter, and the rest of the space is *empty*, and the inner bark vessels are generally deprived of their juices. How is then the sap to convey its circulation? If we are to assert that the sap descends again after its ascent, we must *show in what vessels*. If in the wood-vessels? the bark could not hold a tenth part, as I shall shew. If in the bark-vessels? then must we discover the anastomoses or joinings of both series of vessels, that is, the communication between the *cortical* and *ligneous* cylinders, the meeting of the wood and bark-vessels. I injected a weak quantity of sugar of lead into a plant, and sent the German test after it; but no joinings of vessels were to be perceived: they gave the result indeed, but traced it to the terminations of the wood-vessels in each fresh forming twig. This is always the method I pursue when puzzled respecting the terminating vessels, and it rarely fails me. It is often given as a proof, that the sap circulates in trees, instead of flowing up, as, I think, only to form the different productions it has to complete: "that when the fellers and peelers set about barking, they continually find the young shoot so full of juice as to be ready to pour over, while in the larger shoot, or lower part of the tree, they are almost dry, at least there is a much smaller quantity of liquid; so that the men often exclaim that the sap enters at the ends of the twigs: but this is *the very circumstance* that proves the truth of what I advance. It must be recollected that they do not begin to bark till after a quantity of liquid has passed up the tree *from the root*, loosening the bark all the way from the wood: therefore it is almost at *the end* of its *flowing time* when they begin to peel, or it is very difficult to *tear off* the bark. The liquid is therefore already arrested in the young shoots. Now its arresting is always the time it takes to become jelly, and soon to receive the wood-vessels and complete the shoot. This, therefore, is the cause of the quantity of sap being always found in the young twigs at this time; *three weeks sooner* the sap would have been discovered in the middle root. I have often drawn a pint from them *at this time*.

The quantity of sap always found in the sap-vessels plainly shows their office: if then there were *returning* sap-vessels, would they not be equally *plain* and *visible*, whether in the *bark* or *wood*? Besides, *except* the *inner-bark vessels*, all the *cylinders* that can convey juices pass either *round the tree* or in a *transverse* direction.

I have but one more argument with which I shall trouble the reader. It is said that the sap after mounting to the top of the *tree* all *descends again*, and returns through the bark. Now the bark is in summer one-tenth or eighth part of the wood, and preserves in its *decrease* (as it mounts the tree) nearly the *same ratio*. Suppose, therefore, *aa* to be the bark; and *bb* the wood; and as the wood was full of sap-vessels, it is not possible to cram them in less than *half that space*: the ratio *bc* must, therefore, be added to *aa*, yet not increase *its size*. This is indeed adding much to a little and making it less. Had Nature intended the sap-vessels or juices to *return into the bark*, a conspicuous place would have been allotted for them; but they are now sought in vain. It will be remembered that it is at all times the sap is supposed to circulate when the bark is quite full of its own juices, the sap must indeed then be *invisible*.

The absorbent vessels are perhaps both in the animal and vegetable one of the most curious parts of their formation. In the human body they are various: those that open their extremities under the different surfaces of the skin are called exhalants—of these the vegetables possess but a few, since they perspire not, and it is only under the first cuticle of the leaf they are discovered: but there are *other absorbent* vessels which take in from the atmosphere (even in the human frame) many *juices* and *gases* favourable to health, and which I doubt not increase the nourishment of the body; and though they are not near so *numerous* as the hairs of vegetables (which are of such a variety of kinds), yet they so increase with the *vigour of the body*, and in hard-working people, that I doubt not they are intended to *supply much nutriment*. In the vegetable it is well known that they do so, and that they have absorbent vessels leading to each hair, to throw the matter thus acquired into the nourishing vessels; and probably they would not increase under such existing circumstances in the human body, but for some such purpose. I doubt not but that those who eradicate hairs, from the silly notion of beautifying their Maker's work, acquire many disorders in the skin that would never be theirs but for this foolish custom. All hairs arise from two distinct capsules, one within the other, having a certain degree of moisture between them; and the only difference between the human and *common* vegetable hair is, that the *latter* has many more valves, and has frequently
a spiral

a spiral within the interior *cylinder*. The human hair shows not that variety of shape; three or four sorts are all that are ever discovered. But in the vegetable there is scarcely a form possible that is not imitated: but these I call *instruments*, not *hairs*, since they much more resemble the various invented glasses of a laboratory than the simplicity of a hair; to each of these, however, an absorbent vessel is added to convey the juices thus acquired to their various places of destination; while those vessels in the human body are thin pellucid cylinders arising from the various surfaces of the skin, and running to a common duct called the thoracic duct. They are of two kinds, the *lymphatics* and the *lacteals*. The first the vegetables possess, but not the last. The lymphatics take up the colourless fluid called lymph (whence they have received their name), and convey it from all the parts of the body to the same point. Thus the parts of the blood, which either from their thin oily or nutritive qualities had been separated from the red blood or circulating mass and thrown out by the exhaling arteries, are absorbed after having performed their various uses, and are again conducted by the lymphatics into the circulation. But the vegetable having no secretions from the blood, the lymphatics receive from the absorbent vessels those juices introduced from the atmosphere by particular hairs, and which are partly secreted in the glands till wanted. The rest (after performing their various purposes) are carried into the nourishing or sap-vessels. But in one point of resemblance both agree;—absorption in both bodies helps to remove those injuries which happen to the frame by accidents. If a tumour proceed from a blow or cut, the absorbents will soon begin to *act*: a fluid poured from its ruptured vessels will be absorbed by its lymphatics and carried again into circulation. The black or green spot which is left will disappear, and be taken up in both; fresh supplies of wholesome nourishment are brought from every part to recruit the bad flesh or wood that *has been injured*: and in the plant, so great is the haste made to remedy the defect of this kind, that it rarely happens that a wound is made without such a quantity of nutriment being sent to the part that it generally finishes by being a nursery for new buds. The absorbents of both beings are full of valves; and as to the glands which secrete the oil and other matters, they are certainly in the vegetable as well as the human form, though not so numerous: the two necessities of the flower are of this kind. Some *excretory ducts* also *plants must possess*; since much matter is conveyed away that would otherwise impede the flow of the sap: for when the new wood is formed, all the old divisions of the piece which had been before *bark*, disappear quickly, but not so hastily as not to show it is drawn off by degrees by some vessels *appropriated* for the *purpose*.

purpose. The broken wood also is in the same predicament, and equally well managed.

The analogy between the animal and vegetable *fœtus*, in respect to their *production*, nutriment, and *oxygenation*, is indeed very striking and forcible.

The ovum in the *female* is discovered at an early period in the virgin state, as is the seed of the tree; and like that, many years pass before the tree arrives at its proper maturity; but they both attain that point of perfection at an earlier period in warm countries than in cold. The ovum in the female resembles a *bunch of grapes* fastened as they are to the umbilical cord; and when the seed is first formed in the side roots, it is an apparent *gross powder*, which soon becomes *regular balls*, and which tied to the line of life, may well be likened to grapes also;—but in one respect they evidently differ. The *ovum moves* not till after impregnation has taken place; whereas the seed has travelled far and gone almost all its journey, before it receives the powder of the stamen.

Mirbel says, the vessels in the style unite with those in the peduncle and form the umbilical cord. But Mirbel was not aware that the seed rising from the root had already received (from the first moment of its existence) its umbilical cord (which is indeed its life), when it is fixed in the flower (at the time he alludes to), a long season after its real birth; it then first runs up the interior of the style (which had till then been empty) and increases greatly; when the seed is to be impregnated it swells, and serves as the vehicle to receive the pollen, which soon dissolving in the sweet juices of the line of life, runs down again to each seed, which it touches; when the heart is directly filled up, and the seminal leaves (the lungs of the embryo) proceeding from the interior cavity under the heart, *begin to grow*.

In the first months of pregnancy the *involucra* bear a large proportion to their contents, but afterwards this proportion is *reversed*. This is also the case with the seed, which evidently changes in this respect, though much quicker than the *fœtus*. The *placenta* (which is the medium through which the blood is conveyed from the mother to the fœtus) is a soft spongy substance like a cake, *closely adhering* to the inner surface of the womb; and the arteries of the uterus discharge their contents into this substance of the cake, and thus form the umbilical cord which is to nourish the child. Now this is most exactly imitated in the seed, except in the last *circumstance*, where *another vessel* called the nourishing vessel supplies the place of the umbilical cord, in respect to *giving nutriment to the embryo*: since there is a broad spongy substance on the interior surface of the seed, *exactly resembling a cake*; and before the seed is divided from its mother

mother tree, a certain set of veins arising in the *branch* from which the *seed proceeds*, and passing through the cover into the interior, is *thoroughly filled* with a *proper liquid*, to be used as soon as the division takes place: the seed is then divided from the *tree*, and the vein closed, which has in the mean time spread all its *meandering branches on the cake*, and now open their tiny mouths to produce (with the joint juices of that spongy matter) the sort of *milky fluid* to nourish the young plant, till the root is formed for the purpose. But the seed has one advantage unknown to the foetus: "if at the first shooting of the root it is *destroyed*, the cake again receives the last juices remaining in the nourishing vessels, and forms with its assistance milk sufficient to supply the young one with support till the growth of the root is renewed." It may however be said, that the child is not exposed to a similar disaster, and requires not therefore such a remedy. This exact imitation of the foetus with the embryo shows that I was right in persisting that the seminal leaves had nothing to do in nourishing the plant, and were merely formed to protect the embryo when leaving its exterior cover, and to serve as *lungs* to the *young plant*; and that, so far from bestowing nutriment, it required more itself than any other part. I showed this before I knew *how* the human foetus was managed in this respect, and could not therefore be misled by the analogy, which is but too often the case when the knowledge of human anatomy precedes the dissection of botanical objects. The different covers also of the seed may be compared to the true and spongy chorion; the last is opaque and thick like the white cover of the seed, and the interior clear, as is the first *envelope* of the young one, while the heart of the seed first floats in a liquor that may well be compared to the *liquor amnii*. It is curious that in the latter months of pregnancy the spongy chorion becomes gradually thinner and more connected with the true chorion, which is also the case with the stony fruit and seed. The seed is so easily divided from the mother plant, is obliged to receive that assistance from the *cover of its seed* the *child* receives from its *mother*, and which nutriment the seed took in from its *parent plant* as long as it preserved its hold. The innumerable open-mouthed vessels in the outward exterior of its case, take in both *juices* and *gases*, to be seen flowing into the interior and changing constantly. It is truly astonishing to see the *excessive assistance* of this sort the seed receives daily before it is again placed in the ground, and before it forms its *radicle*: in opening one seed each day, I have rarely found it without some *new vessels* running from the exterior. The seed is of course infinitely quicker in forming than the foetus; for scarcely

scarcely a fortnight elapses after the *impregnation* of the seed, before all the important parts that can precede *maturity* are *completed*.

There are some curious changes in the form of a child before it breathes, and there is also a most curious difference in the seminal leaves in a plant when compared with other plants. They have no spiral wire, and of course no motion, and no midrib or side-ribs: this is very conspicuous in the *Mimosa sensitiva*, since it is the only part that does not move if touched. It was one of the proofs that enabled me to ascertain that the spiral wire was the real muscle of the plant.

There is little resemblance between the lungs of a human being and the leaves of trees—nevertheless they perform for *each being* the same office; and yet it is difficult to draw a comparison between them. The human lungs fill the greater part of the cavity of the breast; they are of a soft spongy texture, and are divided into two lobes, which are separated from each other by the mediastinum, and externally covered by a production of the pleura: each of these is divided into two or three lesser lobes, are commonly three in the right and two in the left side of the cavity. There are two series of arteries which carry blood to the lungs, and it is the exposition of this blood on the surface which changes its tint from a darker colour to a lighter red. The pulmonary artery and veins are not intended for the nutriment of the lungs; but the blood in its passage *through them* is destined to undergo those changes, and become florid by a greater mixture of oxygen. Respiration constitutes one of those functions which are properly termed vital, as being essential to life: it consists of an alternate *contraction* and dilatation of the thorax, by first *inspiring air* into the lungs, and then expelling it from them *by expiration*. When an animal has once breathed, it is easy to see how the motion may be continued; but what occasioned the first inspiration is not so easy to discover.

Now the difference to be discovered in the lungs of plants is, that they have little inspiration of air except in water-plants,—but most of the oxygen given out is taken in as water, then decomposed; the hydrogen drawn off, and secreted for the seeds, while the oxygen is again given out to the atmosphere to *purify* and *invigorate it*. The two upper cuticles of the leaf yield oxygen, the under cuticle *takes in carbonic acid gas* in the night, which is quickly converted into a purer air as soon as the sun has power sufficient in the morning, and again *returned* to the *public stock*. Many plants fold their leaves at night; but the atmosphere loses not, since they give no gas at that time, but the edges and hairs of their leaves are taking in quantities of water;

water; nor do they open them in the morning till the sun has power enough to *decompose* the *liquid*. Then what clouds of apparent smoke pour from every hedge or tree, filling the morning air with vapour! I doubt not also that much of this pure gas is given out when the leaf forms its pabulum, from the decomposition of the several juices the hairs have collected to compose this new compound, in which all vital air is banished. Nor is it improbable that the hairy points may help in a bright day to decompose and set at liberty the oxygen of the bubbles of water without further process, as it certainly occurs to the green matter or *fresh water conferva* in Priestley's experiment, which is owing to the fine points of both. As those insects which have spiracula or breathing apertures, as *wasps* and *flies*, are immediately suffocated if oil be poured on them, so the leaves (if a brush is merely passed over them, giving them a simple varnish of oil) directly *grow black* and *die*. The confining the air within them, and stopping all their natural functions, is sufficient to kill them. That some thick flowers serve as respiratory organs as well as the leaves, I have no doubt, since there are in most of them *open air-vessels* for the purpose: when without leaves, therefore, the petals serve as lungs to the plant, as they always have that circular vessel alternately holding air or water surrounding them.

A tree in the winter will bear the closest confinement; but the moment its leaves appear and open, if it has *not* plenty of air it *dies*: hence the number killed in a hot day in spring. Nothing can be more different than the skin of a human being and the cuticle of a plant: in one point only they agree—that they have both many layers. The human *cutis* which covers the flesh is composed of *fibres* closely compacted, through which the ends of the nerves appear which give out perspiration, and on which skin innumerable *papillæ* are discovered coiled up, or spread out, and which seem to be calculated to receive the impressions of the touch, being the most in quantity where the sense of feeling is the most delicate, as in the palms of the hands and the fingers. This skin, which will stretch to any extent and *contract again*, has been known in cases of dropsy to stretch a foot or two, and reduce itself when the water was *discharged*. It is always of a white colour, while the matter which covers it and lies between the cutis and epidermis is that which gives the tint to the fair, brown, or black person. This is called the *rete mucosum*; it is a mucous substance which may be dissolved in water, and which in *negroes* is *quite black*. Next to this is the epidermis or *scarf skin*. It is a fine transparent *insensible pellicle*, destitute of nerves and blood-vessels, and every where covering the true skin, which invests the body. It is in reality composed of several laminæ or scales, and is full of pores, through which the perspiration passes

from the ends of the nerves on the cutis. The use of this last skin is to protect the delicate nervous fibres which stand out from the true skin: it increases by pressure; and the more scales are added, the less that *nervous sensibility* is *felt*. This is the reason that hard-working people can put their hands in the fire or in extreme hot water, without being sensible of pain: the more this skin is increased, the less feeling they possess.

As the plant has no *nerves*, it can have no *feeling*; and as it has no *perspiration*, it can have no *pores*. The *marks* seen in the skin are merely the effect of the opening of the *balis* in the second and third cuticle, which contain first the water and then the oxygen. The first cuticle is perfectly impervious to water, and completely like gold-beater's skin, without figure. Air, however, passes it freely: but for this skin, how could the water be retained to be decomposed?

I have said that there is no perspiration in plants; indeed it was perfectly *impossible* that the vegetables could decompose water to give out oxygen, and at the *same time* perspire such *quantities*—and yet have juices enough *left* to support the plant. It seems to me that the incomparable Mirbel almost owned his unbelief long ago:—that those bubbles taken for water have proved to be *instruments* of various kinds and forms, and show themselves to be *undoubtedly* the most beautiful and *complicated part* of the vegetable arrangement. As in the animal body there are such a variety of secretions from the blood, which require an *immense mechanism*, not suited to the general simplicity of the form of a plant, so in its stead Nature has contrived that it should *receive* from the *atmosphere*, by means of these instruments or hairs, all the juices necessary to the vegetable, in lieu of forming them by *secretion*: but they are not received in their perfect state, but often alter greatly between their entering the *valve* and flowing into the plant: nay, I have frequently known two liquids enter the *hairs* and secrete themselves between the two different valves; then meeting explode, and compose a *third juice*, and thus form by chemical affinity the matter which the plant requires. This is really the most *beautiful part* of the study of plants; and to chemists would (I should conceive) serve as an *elucidation to many points*, if they would condescend to try them. Even oil is received by the hairs in a sort of vapour, and only becomes oil when it reaches the first liquid; and they both enter the third valve purified and completed. I have watched the various liquids innumerable times; nay, I might truly say, for months together—their manner of filling and emptying their hairs—the variety of their juices—the curious changes made in them—and the getting rid of the obnoxious part by means of the outward cuticle of the hair, and then sending down
into

into the plant that which is completed. This account would fill volumes instead of a few pages, if thorough justice were done to so beautiful and inimitable a contrivance. But what pen or what tongue can properly display the works of Him who can conceive and form such productions !

Between the skin or cutis, and the muscles or flesh, there is interposed a loose oily substance. It is continued without interruption over the whole exterior of the muscles, and is called the *cellular substance*, filling up their depressions, and affording a smooth and regular surface for the skin to lie upon. This substance is composed of a cellular texture and *fat*: the latter is fluid in the body, and is *deposited* in *cells* in the former for facilitating muscular motion; and though found in the greatest quantity in the cells of the *membrane* filling up the space *between* the most external muscles of the skin, yet it may be met with in most other parts of the body. Just so is the *vegetable pith*, composed of a cellular texture, filling up the depressions the line of life frequently makes in its curious undulations, which every other part is obliged to follow: the only difference is, that it is not placed in the *same situation*, but owing to the softness of its texture it admits of the wood in very vigorous trees *increasing* both ways, and allowing also of the yearly swelling of the line of life, when the bud passes up its cylinders, from the root upwards. The pith serves also to contain water, instead of fat; and by its quick growth supplies each vacancy till the wood is able to fill its situation.

Having now brought forward (though in *so imperfect a sketch*) each different ingredient possible to compare together in the *human form* and *vegetable frame*; let me now see *what results may be drawn* from the comparison. First it proves, I think, that the vegetable frame is a mere *muscular creature*, *having life only*, but *no sensation*—*no sensibility*, but possessing alone the property of the muscles (*irritability*). The comparison proves also a matter of *great consequence* to the vegetable, *which is*, that as the only part in the *human* body possessing self-motion (independent of all other parts) or *vis insita* is *the muscle*, so the only part in the plant possessing the *same motion* or *vis insita* is *the spiral wire*: that part therefore *must be the muscle of the vegetable*, as I have long ago endeavoured to show by other arguments, as I never yet could find motion in any part that did not possess the spiral wire, and that the motion was always in proportion to the *quantity* or peculiar formation of the muscle: as the tendril of the vine admirably shows, which is composed of little else. We learn also that there are no secretions either from bark-juice or sap, but that Nature supplies them in the vegetable in a *different way*, drawing

them from the atmosphere, and then completing them in the hairs by chemical affinity.

Most of the accounts descriptive of the human body are selected from our best surgical books; Hunter, Haller, Monro, Burk, and Cooper. I have since, however, regretted I did not form the comparison between the *insect* or *amphibia* tribe and the vegetable, as, certainly approaching nearer together, they would admit a more perfect similitude; but I was fearful the dissection of the insect tribe would not be *sufficiently known, to interest*;—or the lungs of the frog's foetus are so like the part of the *leaf* which serves as lungs *to the plant*; and the admirable manner in which the muscles of the snail display themselves, so well discriminate its *different parts* of tendon, muscle *or moving* part, and the nerve to which it is attached, as to take away all obscurity from the subject; which is however with the least attention plain enough. The inimitable Swammerdam, who studied the muscles most deeply, thinks their internal motion may arise from a similar cause with those of the vegetable.

I am, sir,

Your obliged servant,

AGNES IBBETSON.

XXII. On Citric Acid. By SAMUEL PARKES, F.L.S. M.G.S.
&c.

[Concluded from p. 60.]

THE juice of several other fruits, besides those of limes and lemons, will furnish the citric acid, either alone or mixed with other vegetable acids. Thus the cranberry (the *vaccinium oxycoccus** of Linnæus), the red whortleberry (*vaccinium vitis idæa*), the birds-cherry (*prunus padus*†), the berry of the nightshade (*solanum dulcamara*‡), and the hep, or fruit of the wild briar (*cynosbatus* vel *rosa canina*§), yield chiefly the citric acid||, while in the red gooseberry (*ribes grossularia*), the garden currant

* As the fruit of this shrub is largely employed in most families, some persons may be glad to be informed that these berries may be preserved perfect for several years, merely by drying them a little in the sun, and then stopping them closely in dry bottles.

† Although this fruit is of itself nauseous, yet when bruised and infused in wine or brandy, it gives it an agreeable flavour.

‡ Linnæus says that an infusion of the young twigs of this plant is an admirable medicine in acute rheumatism.

§ The pulp of these berries, beat up with sugar, makes the conserve of heps of the pharmacopœia. Mixed with wine it is an acceptable treat in the north of Europe.

|| Westrumb has shown that the juice of the common cherry contains scarcely any other acid than the citric.

(*ribes*