ON

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IT is not many years since the very title of this paper would have been enough to insure its remaining unread by most professional men, or, if read, to excite their derision of him who should have so wasted his time as to write, or even think, of such vain abstractions, fit expressions of the useless imaginings of the half-crazy enthusiast Oken, and his only less crazy, because less gifted, disciples. And there are, even now, stern votaries of practical science who would scorn any attempt to raise their eyes above the mere facts of Nature which are as patent to the ignorant vision as to their own, and who refuse to seek an insight into those hidden relations, for the correct understanding of which their superior knowledge might be the surest preparation.

But there are others, and their number is increasing, who, believing in the existence of a general plan underlying all the more external phenomena of Nature, are willing to try to comprehend it in its greater and lesser manifestations; and they, in reading the "Physio-philosophy," may be able to discern, amongst much that is fanciful and absurd, many suggestions of a sound as well as original and striking philosophy. No apology, therefore, is now required for thinking or writing upon subjects which have engaged the attention of the most celebrated students of both animal and vegetable anatomy, and which, I am convinced, will, erelong, be acknowledged to be as essential to the proper understanding of these sciences as the classifications of which they form the only true basis.

To express the various relations which have been observed among the several parts and their functions, of animals and plants, the following terms have gradually come into use: *homology, affinity, morphology, analogy, teleology;* to these may be added *physiology,* which, though a term long employed to denote the general study of *function,* has now acquired a certain technical significance, equivalent to the more strictly scientific, and therefore preferable term, *teleology.*

Analogy is used to indicate similarity of function, which may be very close, when yet the two parts are widely dissimilar in structure; as, for instance, the organs of aërial locomotion of a bird and a butterfly, which both go by the name of *wings,* though one is built upon the vertebrate, and the other upon the articulate plan of structure. Of course the structure may correspond with the external form and function, and then the analogy is more complete, as between the foot of man and that of a bear.

Now the *general* function or use of a part is its *physiology;* the *special* or principal use of a part is its final cause or end, or *teleology;* and parts which are teleologically similar are said to be *analogous.*

It is evident that the external form and the function must to a great extent correspond, at least much more fully than either may with the internal structure, and here we observe the first distinction between the two groups of terms given above; for this intimate structure and arrangement, in other words, the pure anatomy of anything, is its *morphology,* and parts which are morphologically similar are said to be *homologous;* there is *homology* or *affinity,* or, in still plainer words, more or less *identity of structure* between them; and here again, as was seen in speaking of analogy, parts or organs which are homologous, that is, identical in their

general plan of structure, may be intended to perform functions most diverse, and their outward forms be in like degree modified. For instance, the fin-like flipper of the seal bears little resemblance to the anterior extremity of the ape, and yet they are identical in their general structure, — they are homologous.

It may have been inferred, from what has been said above, that we have necessarily two systems of nomenclature, according as morphology or teleology is taken as the basis. For it is the latter which confers common and popular names on objects of Natural History, and arranges them in a way which, though convenient enough under ordinary circumstances, utterly fails of precision for all scientific purposes; and the anatomist and zoölogist soon learn that morphology alone must be their guide in scientific nomenclature. Thus the name *fish* is applied to several animals in structure very unlike the true Pisces, merely because, like that group of Vertebrates, they live in the water: to certain Radiates, as the star-fish and sun-fish; to Articulates, as the cray-fish; and, formerly, even to the whale, an air-breathing Mammalian Vertebrate. So among Articulates, the monosyllable *fly* forms the ending of the common names of many insects, as butter-fly, dragon-fly, harvest-fly, ichneumon-fly, members respectively of the sub-orders Lepidoptera, Neuroptera, Hemiptera, and Hymenoptera, though it is only to the Diptera that the name *fly* properly belongs.

These are zoölogical ambiguities; anatomical ones are even more frequent. All organs of aërial locomotion are commonly called *wings*, whether they are articulate or vertebrate in type, or whether, within the latter group, they are avian or mammalian, as those of the bats; and the same is the case with other parts and organs, thorax, abdomen, heart, liver, and stomach.

I could not well pass over this most important branch of the subject; but the great necessity to the philosophical naturalist for a revised anatomical nomenclature has already been strongly urged by Professor Agassiz, before the Boston Society of Natural History.[1] Premising that the members of the four great types have nothing in common beyond their all being animals, and that, therefore, no parts, however similar in function, can possibly be homologous in animals belonging to any two of these types, he showed the propriety of restricting the common names mouth, stomach, heart, and the like, to one of these groups, the Vertebrates perhaps, and of applying other names to the analogous parts in the other three types. Perhaps the change should be even greater than this; for, since these new names would of course be classical in their derivation, and the common ones, though scientifically restricted, would in general discourse retain the same loose application, it would seem better to employ new terms for the various parts and organs in *each* of the four types, leaving the common ones as they are now. It is evident that much remains to be done in this matter of anatomical nomenclature, and that it is of as much importance to the anatomist as are the names of the animals themselves to the zoölogist.

Popular descriptive zoölogy concerns rather the teleological characters of animals, while the strictly scientific and systematic arrangements are based upon anatomy, and thus upon morphology.

We have noticed one distinction between the terms given above: that morphology and homology both refer to *structure*, while teleology and analogy both refer to *function*. Affinity is merely a common synonym for homology, and may therefore be omitted. And now the four principal terms pair off on another basis; morphology and teleology are *absolute* terms, as it were, and may refer to the structure or the function of but a single part or organ;

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[1] See also his section on Morphology and Nomenclature, in Contributions to the Natural History of the United States, vol. iii. chapter ii. section iv.; also section iii. p. 69.

while homology and analogy are the corresponding *relative* terms, and necessarily refer to two or more parts or organs which are morphologically or teleologically similar.

Morphology is not exactly synonymous with anatomy, for the latter term embraces *all* the characters of a part, external as well as internal; so that, strictly speaking, parts which are anatomically similar, are likewise physiologically so. But morphology refers rather to the general plan of structure of a part, without altering which, great modifications may be wrought in its outward aspect, with reference to the various functions it is to perform.

In like manner teleology is not exactly synonymous with physiology, for the latter term embraces all the functions which can be performed by the part, the less as well as the more essential, otherwise the converse of the previous proposition would be true, and parts which were teleologically similar would be also morphologically similar, which is not the case; every form or *morph* has a certain general use or function proper to it, and which may remain under many of its modifications.

It is thus of the utmost importance to discriminate between essential structure or morphology, and general structure or anatomy; so also between special function or teleology, and general function or physiology.

Most objects, whether animal or vegetable, and their various organs, possess more than one attribute; their anatomy is compound; their morphology is that simple essential structure which, as a foundation, underlies the more external attributes, one of which is specially developed for the performance of the function from which it has its name; by an easy transfer, the name is finally associated in our mind with the morphology; and then, if this primary attribute be overshadowed by an excessive development of one of the secondary attributes, although the function of the part may be entirely changed, yet, as the essential structure is still recognizable through the external mask, the name is unchanged. Morphologically it is the same, though teleologically it may be quite another thing. For examples, and, if I remember rightly, a clearer explanation of this transfer of the name of a part, see the opening paragraphs in Owen's Report on the "Homologies of the Vertebrate Skeleton," to the British Association for the Advancement of Science for the year 1846.

With things inanimate the teleology is the use which is made of them. As a familiar illustration, the round Dutch cheeses, used as missiles by one of the parties in a sea-fight years ago, were none the less cheeses, and perhaps excellent ones, because on this occasion put in the place of round shot, thus making the use for which they were intended and named subservient to one rendered possible by a secondary attribute, their extreme hardness. As a second example, far too familiar in these days, a shell may strike a victim before it explodes, and thus be teleologically a solid shot, while yet its structure, as adapted to its intended use, remains unaltered.

It is needless to multiply illustrations. Whenever anything, without alteration in its essential structure, even though its external form be somewhat modified, fulfils a function other than that for which it was originally intended, then its morphology and its teleology, previously coinciding, are at variance.

It thus appears that the teleology may differ from the morphology, as the *spirit* of the law from the *letter* thereof, as the *expression* of a face from the *features* composing it, as the *practical* from the *technical* or *theoretical*, as the *actual* or *virtual* from the *nominal* or *ostensible*; in short, as the *thing* may differ from its *name*, the *de facto* from the *de jure*.

Morphology is *substantive*; teleology is *adjective*. Morphology is the *noun*; teleology is its *modifier*. And as the noun with its modifier may be regarded as a compound substantive,

and may thus be further modified by other adjectives, so in comparative anatomy, nothing is absolutely morphological or teleological, but only with reference to some organ or function more general above, or more special below ; it is the possibility of the configuration of an organ being modified without change to a corresponding degree in the internal structure and arrangement of parts. Zoölogically speaking, it is the possibility of specific modifications of generic ideas, so that from a limited number of substantives, by adjective additions, are made designations of many more objects ; and few at this day dare affirm that this is only a matter of human invention for human convenience.

Every genus represents the morphology of the species embraced within it, and they are teleological modifications of the generic idea ; now this is the relation between each higher group and the next lower ; the further we recede from the species, from the individual in fact, the more occult and ideal becomes the morphology, till we reach at last the four great groups called types, which, as we shall see hereafter, may even be represented by geometrical figures. How far are these removed from the living sentient individuals which form the other zoölogical extreme ! And yet it does not follow that the existence of the order, the class, or even the type, is any less real and actual than that of the species or of the individual ; it is less *material,* but none the less *substantial ;* in fact, the higher the group, the more real and enduring it is, for it exists in all the members of all the groups embraced within it, though it would exist if it had but a single individual representative.

It was said above, that morphology refers only to the general plan of structure ; in a certain sense this is so, since it refers to a more hidden interior grade of anatomical characters than those which ordinarily appear upon the surface. The zoölogist will see that each of his categories of structure is based upon a different grade of morphology ; thus there is a type morphology, the most interior of all, beyond which there are no homologies, but within which are more and more apparent ones, the class homologies, the ordinal homologies, the homologies of the family, genus, and species. I do not mean to say that these groups, as at present characterized by Professor Agassiz, or by any other naturalist, are the true ones, or that they should bear these names, or even that there is just this number of categories of structure ; but I do believe that a classification does exist in Nature entirely independent of human thought ; that the various kinds of groups in this natural classification are founded upon categories of structure radically distinct, not at all merging or interchanging ; and finally, that these categories are simply statements of the various grades of morphology, upon which alone classifications are based.

But though this seems to carry us away from direct material function or use, it by no means negatives the idea that each natural group does really represent some use in the grand operations of Nature. Indeed, this would follow as the converse of what was said above, that every higher group represents the morphology of the groups next below, which are themselves teleological modifications of it ; conversely, each lower group is, with reference to the next higher, more directly teleological, and increasingly so as we approach the species and the individual. Even the types, ideal and unsubstantial as they seem, represent the four ways in which the powers of sensation and voluntary motion may be embodied and brought into use in the economy of Nature : the idea of an animal is distinct enough in our minds, but so hard to put into words that no really satisfactory definition has ever been proposed. What better evidence of the immaterial character of the principle which distinguishes the animal from the vegetable and mineral subdivisions of Nature.

It seems at first rather strange that the progress in philosophical *anatomy* may be esti-

mated by the more frequent occurrence of the term *homology*, especially in the works of Professor Owen, who has done so much toward dispelling the mystery and almost odium attached to the subject, and has cleared up some of its most difficult problems,[1] while the philosophy of *botany* is measured by the term *morphology*, although it has apparently never been perceived that they are corresponding terms, the one *relative*, the other *absolute*.

But much of the wonder vanishes when it is remembered that the unit of vegetable structure is very simple, consisting, in the Dicotyledones, of the phyton, or leaf with its segment of stem ; and that out of these, by wonderful transmutation and combination, the whole plant is built up. The morphology of a vegetable organ is enunciated when it is shown in what manner it is referable to the typical phyton; and since so few elements compose this, seldom would there arise questions of special and thus of general or serial homology. But with animals the case is otherwise. Having left the simple cell, of which vegetables also are composed, we find at once that their bodies are made up of many organs which cannot possibly be referred to any one unit of structure. The nervous, circulatory, and digestive systems are entirely isolated from each other, and differ, not only physiologically, but microscopically and chemically. Still more complex are the relations existing in the muscular and osseous systems, as presented in the Vertebrates ; for here the skeleton is made up of a series of segments called vertebræ, which are themselves composed of smaller parts or elements having definite relations and bearing distinct names, and by variation in the number, size, and shape of which an almost endless diversity is produced. And now the questions which arise are emphatically those of *relation*, of *homology :* what parts represent each other in different animals ; what position one element of a vertebra holds with reference to the others in the same ; and what elements in two different vertebræ repeat each other ; — questions of special, of general, and of serial homology, respectively. It is not, then, so strange that botanists have used the *absolute* term *morphology* with reference to the objects of their study, when so few parts or elements compose the *morph* or type of which the members of any one large group are built up, as that the anatomist, in his anxiety to determine the manifold relations existing in the bodies of animals, should look upon morphology only as the necessary guide to the more difficult questions of homology, which in itself implies more than one morph.

Teleological diversities are as of *more* and *less*, and the resulting varieties communicate with each other only by continuity ; by *continuous* degrees.

Morphological diversities are as of *interior* and *exterior*, as of *superior* and *inferior*, and the resulting varieties communicate only by *contiguity ;* by *discrete* degrees.

Here, if rightly appreciated, is contained the essence of two most interesting and not always easily understood generalizations, which are potent weapons of the modern zoölogist : the one defensive of his belief in a natural classification, the other offensive against those who assert the existence of a regular, uninterrupted succession of organic forms from lowest to highest, because, forsooth, they cannot see how else creation was effected ; thus profanely daring to limit Infinite power by their own wilfully diminished capacity.

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[1] In his elaborate and admirable *Report on the Homologies of the Vertebrate Skeleton*, Professor Owen defines three relations of homology : " 1st. When a part is said to occupy a certain position in its vertebra, its *general* homology is ennnciated. 2d. When such a part is said to repeat in its vertebra that which occupies a corresponding position in another vertebra before or behind, its *serial* homology is given. 3d. When a part is said to have the same relations in two different animals, then its *special* homology is indicated."

These definitions, as we shall see, do not cover *all* relations of homology.

These are, 1st, the law of Parallel Relations; and, 2d, the teleological rising above or sinking below their morphological level, of certain groups or species or individuals, whereby they *seem* to be of a higher or lower grade than the rest of the group of which they are generally the extreme aberrant forms.

Illustrations of either of these laws are almost superfluous; of the former many will have occurred to the naturalist who observes similar functions exercised by animals belonging to different groups, or even types: — the aërial bird and butterfly; the heavy, graminivorous cattle among Mammalia, and the phytophagous Scarabei among Coleoptera; the monkey and the parrot; the whole type of Articulates, and the vertebrate class Aves; the type of Mollusks, and the vertebrate class Reptilia; the three classes of Articulates, with the three orders of its highest class, Insecta; and, finally, the striking parallelism between the orders of the two groups of Mammalia, called by Dana Megasthenes and Microsthenes, (American Journal of Science and Art, vol. xxxv. p. 70,) with the less evident one between the Altrices and the Precoces among birds. Between all these pairs of groups is so evident a similarity as to have suggested the term "Parallel Relation;" but it is to be observed that the relation is one of *analogy*, not *homology;* that the differences are morphological, and the resemblances are comparatively teleological, while between component parts of the same group the resemblances are morphological and the differences teleological.

Many insects are *physiologically* more highly organized than the lowest fishes, and the eagle seems a creature vastly superior to the whale; but in each case the groups to which, according to their essential structure, the insect and the eagle belong, are, *as groups*, on a plane below the fishes and the mammals. The two relations are commonly expressed by representing the groups by parallel vertical lines; there may be such morphological differences between the groups as to clearly indicate which are higher and which lower, but the lines may be overlapped, to show that the lowest in one group is teleologically inferior to the highest of the next group, though, as said above, there would be no doubt concerning the groups taken as wholes.

There is not, at least among the higher groups, any such lineal shading off into each other as to afford any support to the idea of a regular, uninterrupted succession of organic forms, whether zoölogical or genealogical. Nor does the present state of Paleontology furnish the disciples of Darwin much assistance in this respect.

Position may determine a morphology in addition to that dependent upon structure, and nowhere is this more clear than with the teeth of Mammalia. Professor Owen, in his Odontography, has shown that every classification of these organs based upon their form, and thus upon their special masticatory function, utterly fails in precision on general application, and that the position of the teeth in the jaws is the only safe guide to their arrangement. In this case, it so happens that the teeth were originally named, from their shape and function, *incisors*, *canines*, and *molars;* and this is the order in which they stand in the jaws from before backward. But, while this would answer very well in designating the corresponding teeth in two animals having the same number, and where the variations in form were slight, it utterly failed, even in the hands of Cuvier, accurately to determine such correspondence when applied to the whole range of the mammalian series.

Without entering into details, which are given in abundance in the Odontography, it may be said that the teeth collectively are distinguished from all other parts and organs, hard or soft, by a peculiar structure or morphology of their own; but that, to ascertain the limits of the several groups of teeth in the jaws of a single species, or to point out corresponding or homologous teeth in animals having a different number, their position in the jaws is the only safe standard, this constituting a minor morphology.

Thus we have teeth *morphologically canine*, but *teleologically incisor*,—the outer pair of teeth in the incisive row in the lower jaw of the typical Ruminants, (sheep, cattle, &c.;) and, on the other hand, we have teeth which are *morphologically incisor*, but *teleologically canine*,—the only pair of teeth in the intermaxillary bone of the Camelidæ, in which aberrant group of Ruminants the lower canines above mentioned assume their proper form and function, as if to compensate for the absence of horns.

And this brings us at once to the consideration of the important question, whether every anatomical generalization is not an expression of morphology; whether every grouping of facts which we regard as natural, and which enables us better to comprehend and arrange other facts, is not morphology in the strictest sense of the word. If so, as I believe, then all anatomy is or should be morphology; for all particulars should be studied with reference to generals already ascertained or to be elucidated. And thus morphology comes to be a very simple thing, and not at all a mystery, and will be avoided only by those who confound rational philosophy with unprofitable imaginings of pretty, pleasing fancies. The Creator did not work with barren isolated facts; and only those who strive to rise above these, will ever gain an insight into the way in which He did work, with general laws first established, but only with reference to the particular ultimate facts which were grouped around them.

In the human body must exist just such complication of structure and arrangement of parts as best adapt it to be the fit and willing agent of the human mind; and as this is, if not always actually, yet potentially, on a plane superior to that of brutes, so we are prepared to find in its fleshy covering a perfection of structure and harmonious arrangement of parts, which, in their totality, far surpass what we observe in inferior animals.

In animals, it is true, there may often exist a higher development of one function or class of functions; but this, as we shall see, is always at the expense of the rest, besides marring that beauty of proportion which is really an important element in the human frame. The fish and the whale swim better than man, but the form and structure requisite for this simplest mode of locomotion render every other impossible; even the limbs of the seal, though rather more free, are awkward imitations of anything unless it be paddles. The teeth and stomachs of the strictly carnivorous or herbivorous animals are better adapted for seizing and lacerating or chewing, and for digesting certain kinds of food; but the necessary limitation, as regards other kinds, is an obvious imperfection, taking the creature as a whole. The bird flies through the air, with a velocity which man will probably never equal by any mechanical contrivance; but the necessary concentration of weight between the wings makes the anterior and posterior extremities mere bony supports for air and earth, the head taking the place of the hand as an organ of prehension, and becoming thereby incapable of speech or expression. The great strength of the ox, and the speed of the horse or of the deer, are gained by such an arrangement of the muscles of the limbs, and modification of their bony frame, as almost to preclude any other motion than simple flexion and extension forward and backward, involving also the loss of prehensile power in the hand. Even the ape, whose structure is so perfectly fitted for climbing, is, so far as regards the location of the organs of prehension and of progression, a man reversed;[1] and the power of free rotation in the forearm, with the great strength of the fingers, is specially adapted to its peculiar mode of progression, and not to the elevated uses which the human hand performs.

[1] Contributions to the Comparative Myology of the Chimpanzee, Boston Journal of Natural History, vol. vii.

In short, looking merely at man's body, beside being cosmopolitan and typically omnivorous, although it has a position and mode of locomotion peculiar to itself, and in which it certainly is unrivalled, it is also endowed with the power to assume with grace almost every conceivable attitude, and to employ at will the typical modes of locomotion of other Vertebrates, such as swimming, crawling, leaping, and climbing; and all these the human mind has found means to outstrip in point of speed; even the flying of the bird, though probably it can never be equalled in rapidity, has been imitated by the aërial mode of locomotion contrived by the same continent of man's essential superiority.

But, leaving the mind wholly out of view, the human body is so constituted as not only to best execute its own peculiar movements, but also to assume more readily than the brutes some which are peculiar to other species. In other words, while endowed with sufficient strength and firmness for all ordinary occasions, it has at the same time such flexibility and independence of action as to be able to apply this strength in many and very diverse ways.

For clearer illustration let us contrast two extremes, the arm of man with the fore-leg of the horse. The former can do nearly anything and everything except that of which alone the latter is capable, namely, to support and propel the body on the earth; yet in the two limbs are the same joints, and, except in the hand, the same bones and muscles; but in the quadruped the latter are short and thick, and so disposed on the front and back of the limb as to pull it with great force in those two directions, and in no other; while in man they are arranged evenly around the bony shafts, thus adding to the symmetry of the limb, as well as increasing its mobility.

But the most striking difference is, that, while the movements of each segment of the human arm are, if necessary, entirely independent of those of the other segments, iu the horse they are much less so, and flexion or extension at the elbow causes a mechanical movement at the wrist, and *vice versa :* the independence of the movements of these two joints seems to correspond with the degree of development of the humeral condyles; these processes, when they exist, are situated just above the insertions of the external and internal lateral ligaments of the elbow, at which two points there is of course no motion; the condyles lie a little above and therefore change position, though very slightly, during movement at the joint. The extensor muscles of the wrist and fingers arise from the external condyle, the flexors from the internal, both processes being very prominent in man; but it is evident that when the condyles are very small or absent, the origins of the muscles must in like degree reach above or below the centres of motion, and thus, with the parts into which they are inserted, be more or less affected by any movements at the joint. Now in the horse the condyles are almost wholly wanting, the flexors of the hand arising below the centre of motion on the inner side of the humerus, and the extensors above the corresponding point on the outer side; when, therefore, the hand is flexed, the humerus and fore-arm are also flexed at the elbow, and when the hand is extended, these other segments are also extended.

Hold the fore-leg of a horse horizontally by the part between the elbow and wrist, and flex the hand; the limb bends at the elbow also. Now if you rest the limb in its natural position upon the earth, the obliquity in the direction of the hoof tends to extend the hand at the wrist, and thus to straighten the limb at the elbow, so that the heavier you press upon the top of the humerus, the firmer the limb becomes. It is evident that this would be a mechanical aid in sustaining the weight of the animal, but I have had no opportunity to look for a similar arrangement in the posterior extremity. On account of this same

structure, however, the fore-leg gives way suddenly and completely when the animal stumbles so as to bear upon the tip of the hoof and so flex the hand at the wrist, for that brings the humerus down with it. In the hind-leg of the frog, which is used for little else than leaping, there is a somewhat similar arrangement, the great extensor of the foot being connected with that of the leg by a strong tendinous band on the inner side of the knee, so that extension of one segment is mechanically connected with that of the other. In the quadrumana and carnivora the condyles are present, though less prominent than in man ; and indeed the degree of their development seems to correspond nearly with that of the clavicle, both of them being concerned in the freedom and mobility of the anterior extremity.

The new relations of morphology observed among the muscles of the mammalian limbs are intimately connected with two other generalizations applying to these parts ; and these again are subordinate to the great anatomical law of " antero-posterior symmetry," as it has been hitherto called ; and since little or nothing has been published concerning this in the form it has of late assumed, it may be well to state the law here, chiefly according to the views of Professor Jeffries Wyman, by whom it was suggested to me, and who, almost alone in this country, has devoted time to eliminating, from the indefinite and often extravagant and absurd shape in which it was left by Oken, the real truth of a principle the most potent and elevated of which the vertebrate body, considered by itself, is capable.

Yet in my opinion even this is subordinate to a still higher law which pertains as well to the other types of the animal kingdom, and also coincides with a geometrical law so closely as to afford new ground for its belief. In order to appreciate the full force and value of lesser laws, it must first be shown how they depend upon greater ones ; and therefore the latter shall be first considered.

A partial statement of this higher law, which for reasons given further on I have called the *law of animal polarity*, was made by Professor Agassiz, at a meeting of the Boston Society of Natural History, December 4th, 1861.

He characterized the four leading types of the animal kingdom by four terms indicative of the general arrangement of their organs, or their plan of structure : the Radiates by " *radiality*," the Mollusks by " *laterality*," the Articulates by " *tergality*," and the Vertebrates by " *cephality*." In the Radiates all the parts are disposed about a common centre, encircling which also is the dynamic portion of the nervous system, a ganglion for each diverging segment or spheromere. These spheromeres are morphologically exact repetitions of each other, though their size and shape may be greatly modified, and even one of them may be entirely wanting, so that the animal appears as if divisible into two lateral halves, when really this is due to a teleological modification not at all affecting the real plan of structure, but only foreshadowing, as it were, the characteristic arrangement of the next higher type, just as the molluscan Bryozöa present an appearance of radiation in the disposition of their groups of tentacles. These two instances show the importance of always looking first at the more essential parts of the body, rather than at the outside, which, like other appearances, is often deceitful.

The *laterality* which Professor Agassiz considers characteristic of the Mollusks, must be carefully distinguished from the *bilaterality* or *bilateral symmetry* of all animals above Radiates : for the latter terms mean only that the body is composed of two lateral halves which are right and left repetitions of each other ; and this is often more conspicuous in

the Vertebrates, and especially in the Articulates with their sharply defined outlines, than in the almost amorphous forms of the Mollusca; but here again we must go beneath the surface, and then we find that in the Mollusks not only are the organs arranged upon the two sides of the body, but the "weight of organization," as Professor Agassiz expresses it, is thrown upon the sides, which even in common usage we recognize to have superior value over the front and hind ends, or the upper and lower edges; we examine and figure only the sides, and, except with the Cephalopoda, their natural position is such as to exhibit prominently one of the sides. This distinction between the *bilaterality* common to all above Radiates, and the *laterality* proper to the Mollusks, is well set forth by Mr. N. S. Shaler, in the Proceedings of the Boston Society of Natural History, December 4th, 1861.

With the type of Articulata, it is not the right and left sides that we chiefly regard in either a popular or a scientific examination, but the upper and lower regions, which are, as it were, set off against each other. We no more think of placing or viewing an insect on its side than a bivalve on its upper or lower edge, which correspond to the tergal and ventral regions of the Articulate. This seems to confirm the idea that the single ring representing the articulate unit is composed of an equal number of segments above and below a horizontally bisecting plane, and that the legs and wings when they exist are tergal and ventral repetitions of each other. But the internal anatomy is less satisfactory, at least as now understood, and I leave it to others, more familiar with its details, to determine whether this type, whose sharply defined outlines so clearly illustrate the law, has at the same time the most unsatisfactory internal arrangement; it is certain that in our present state of knowledge the laterality of the Mollusks is more apparent than either the tergality of the Articulates or the cephality of the Vertebrates.

This latter term, *cephality*, applied by Professor Agassiz to the highest type, indicates the extreme preponderance in function of one end of the body; which, at first on the same level with the other end, is gradually raised, till it attains the greatest possible elevation in the erect position of man. Professor Dana's term, "cephalization," is indicative of this gradual ennobling of one end of the vertebrate body, and, in man, of the devotion of the arms and hands to its requirements, a physiological return to an allegiance they always owed the head, to which, in fishes, they are actually attached.

In this connection it may be added, that, besides the overwhelming evidence adduced by Professor Owen in support of the view now generally received, that the scapular arch is really the modified pair of ribs of the posterior or occipital cranial vertebræ, there are other facts which indicate that in the early stages of even the higher Vertebrates, the shoulders and head are much nearer together than in their adult condition.

1st. The singular course of the inferior laryngeal nerve, whence comes its name of the *recurrent*, is inexplicable on any other than strictly morphological grounds; for, instead of proceeding by the shortest and most direct route to the larynx from its origin on the pneumogastric, it always forms a loop around the subclavian artery on the right side and the arch of the aorta on the left, even in the giraffe, where its length is several times as many feet as it would be inches on the ground of teleology alone. An account of a case of malformation, which first drew attention to this peculiarity, was published in the "Edinburgh Medical and Surgical Journal," for 1823, and the same Journal for the month of April, 1826, contains an account of a similar case, with an explanation of this apparent waste of nervous matter. Both of these accounts are quoted on page 379 of "Power's Surgical Anatomy of the Arteries."

2d. Professor Vrolik, in his work on Monstrosities, "Tabulæ ad illustrandam Embryogene-

sin Hominis et Mammalium," figures, and briefly describes, the skeleton of an anencephalous monster, in which one arm appears attached to the base of the skull, as if by arrest of development, while the other is in its normal position on the side of the thorax. With a view to ascertain whether, at any period, the shoulders of the mammalian fœtus are in actual contact with the cranium, I made careful examination of large numbers of fœtal pigs, and in the very smallest, just when the limbs begin to protrude from the sides as little fleshy buds, it is always at some distance from the head; so that, in the Mammalia at least, the fact of actual contact must be regarded as doubtful.

3d. But in most fishes they are firmly attached to the cranium, and in the tadpoles of the bull-frog (*Rana pipiens*) I have found the scapula closely connected with the posterior part of the cranium, either by muscle or ligament, which elongates as development proceeds.

Now the three terms, *laterality*, *tergality*, and *cephality*, are more or less complete expressions of the arrangement of organs at the *two poles* of the *three axes* of a *sphere*, the *lateral*, the *vertical*, and the *longitudinal*, one of which is specially prominent in each of the higher types, Mollusks, Articulates, and Vertebrates, while the Radiates are represented by the simple sphere itself, with no one axis more prominent than another; since the members of this type are not geometrical figures, but organic, living beings, they must have a structural axis around which their diverging segments or spheromeres are arranged; but this assumes such a variety of directions, being reversed between the Polyps and the Acalephs with most Echinoderms, and becoming horizontal in the Holothurians, as to entirely negative the idea of its having any such morphological significance as the axes of the other three types. These three are the main axes of a sphere, the only ones possible at right angles with each other; and they also correspond with the three dimensions of a solid, — breadth, thickness, and length, — while the sphere may be regarded as having no dimension, yet as capable of all. (See also Professor Agassiz's "Contributions to Natural History of the United States," vol. iii. chap. ii. sect. iv. on Morphology and Nomenclature, p. 76.) This gives us four plans, four *morphs* on which the animal kingdom is built, and this coincides with the number now believed to exist.

A strong corroboration from a different source is contained in the views of Professor Arnold Guyot, expressed in a course of lectures delivered during the winter of 1862, at the Smithsonian Institution, on the "Unity of Plan in Animals and Plants."

He presented, as an indication of the existence of no more nor less than four grand divisions among animals, the idea that the four types represent the four grand epochs in the life of a single animal; the Radiates are the starting-point, the germ, the simple cell, with life, but this of a low, indeterminate character, and inhabiting the water, the lowest medium; then comes a partial progress in one direction, with the development of the nutritive systems of organs, and this second stage is represented by the Mollusks, with their heavy bodies, devoted to digestion and circulation, and confined to the earth; then comes a partial progress in the opposite direction, with the development of the respiratory and motory apparatus, and this is well represented by the Articulates, chiefly inhabiting the air; and, finally, in the Vertebrates is typified the animal in its perfect state, with a more equal combination of both classes of functions.

Again, for the existence of four classes in the Vertebrates the same reason holds good: the Fishes are the starting-point, and, like the Radiates, dwell in the water; then come the Reptiles, with their heavy bodies attached to the earth, and characterized by special prominence of the nutritive functions, thus corresponding to the Mollusks; then the Birds, the

series

aërial Vertebrates, their very bones filled with the medium in which they dwell, and always in active motion; and the ~~cycle~~ is again completed by the Mammals, which embody a more equal and harmonious combination of all the systems of organs, living, like the Reptiles, on the earth, but elevated above it into the free space of air.

Professor Guyot considered the same law to prevail throughout all the lesser groups of Mammalia, and also in the three other types; and it is certainly worthy of remark, that in these latter are recognized only *three* subdivisions, while in the Vertebrates *four* are generally acknowledged; and so in every group containing man would be four lesser groups, but in all others only three, the highest being wanting, and the series thus incomplete.

In this connection *circle* seems as proper as *series*; for the most natural exhibition of the relative standing of the four types is by four equidistant points on the circumference of a circle, the Radiates below, the Mollusks above and to the left, the Articulates the same distance above and to the right, and the Vertebrates at the top; the two intermediate groups, the types of partial progress, being at the same distance from the lowest and highest, and thus of equal rank, though opposite nature. Nor can we overlook the fact that there are four regions of the body, pelvis, abdomen, thorax, and head; and that, as I think Oken has said, Fishes are *pelvic* animals, Reptiles *abdominal,* Birds *thoracic,* and Vertebrates *cephalic;* and that neither Radiates nor Mollusks nor Articulates possess a distinct anterior segment containing any such overruling portions of the nervous system as does the head of the Vertebrates.

There are four senses also, one general, the others special.

The sense of touch is universal, and only more or less developed in different regions of the body: it is most exquisitely perceived through the agency of water or moisture, especially in the tongue; for taste is a peculiar exaltation of the general sensibility, and forms, as it were, a transition therefrom to the smell, one of the three special senses with which, as anatomy clearly shows, it cannot be allied. Of these latter, smell is the lowest, and its exercise depends upon the presence of odoriferous particles of an earthy, solid nature. Hearing is the second special sense, and perceives vibrations in the atmosphere, the next higher medium; while sight, the highest, depends for the exercise of its functions, not upon this, but upon that invisible and imponderable yet material medium which is called *ether.*

Again, *sight* is directly related to the central nervous system, and properly belongs to the *head,* below which its organ does not extend. *Hearing* goes lower down, into the ~~pharynx,~~ *thorax* with which its organ is connected, anatomically by the Eustachian tube and physiologically when we listen to the speech of another. *Smell* and its accessory *taste* preside over the entrance to the alimentary canal, with which they descend through the head and thorax into the *abdomen.* Finally, in the *pelvis* is the organ which, as will be hereafter shown, is the posterior or reversed repetition of the tongue, and whose sensitiveness, like taste, is only a peculiar exaltation of the universal sense, the nerves in both cases being the common cranial or spinal nerves, and not special prolongations of the brain into the organ, as with the eye, the ear, and the nose.

Professor James D. Dana, in a paper "On the higher Subdivisions in the Classification of Mammalia," (American Journal of Science and Arts, vol. xxxv. January, 1863,) proposes a similar quaternary division of that class with special reference to the "cephalization" of the body, which he shows to increase as we ascend in the scale.

To those who make classification their study it belongs to decide how much influence these principles exert among the lower groups; but certainly among the higher ones the

coincidences are too striking to be disregarded by the most matter-of-fact philosopher. I subjoin a diagram exhibiting the more evident correspondences in the various departments

GEOMETRICAL	MORPHOLOGICAL		ZoÖLOGICAL					PHYSICAL	PHYSIOLOGICAL			
Dimension.	Prominent Axis.	Characteristic polarity.	Types.	Classes of				Element.	Region.	Sense.	Function.	State.
				Radiates.	Molluscs.	Articulates.	Vertebrates.					
Length.	VERT. LONG. LAT.	Longitudinality.	Vertebrata.			The highest subdivision is wanting because Man is not included.	Mammals.	Ether.	Head.	Sight.	Intellectual.	Thought.
Height.	VERT. LONG. LAT.	Verticality.	Articulata.	Echinoderms.	Cephalopods.	Insects. (Imago.)	Birds.	Air.	Thorax.	Hearing.	Motive.	Action.
Width.	VERT. LONG. LAT.	Laterality.	Mollusca.	Acalephs.	Gasteropods.	Crustaceans. (Pupa.)	Reptiles.	Earth.	Abdomen.	Smell.	Nutritive.	Growth.
Spherical.	VERT. LONG. LAT.	Radiality.	Radiata.	Polyps.	Acephala.	Worms. (Larva.)	Fishes.	Water.	Pelvis.	Touch.	Generative.	Germination.

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of Nature, and which seem to indicate that here is one and the same thought of the Creator expressed in terms *geometrical, morphological, physiological,* and *zoölogical.*

From what has been said concerning the axes of the three higher types, it will appear that they all exist in each of the types, just as they would in a geometrical sphere, variously compressed ; but that this *presence* of *all* must be carefully distinguished from the *prominence* of *one* axis in the type characterized thereby. Thus the *laterality* of Mollusks is something more than the *bilaterality* or *bilateral symmetry* which exists also in the Articulates and Vertebrates ; the *cephality,* or more properly the *longitudinality* of the latter type must be distinguished from the *antero-posterior symmetry* so evident in certain Articulates ; and the *tergality,* or more properly *verticality* of these, from any resemblance, if it should be observed, between the dorsal and ventral regions of the Mollusca ; even the *radiality* of the lowest type must not be confounded with the *appearance* of it in certain Mollusks above mentioned.

But, in fact, mere *resemblance* between any two regions of the body is not what we desire to express ; for, although it may exist, there is quite as often a striking contrast, as in the Gasteropoda among Mollusks, and in Man with most Mammalia among Vertebrates. Our term should refer rather to the direction of the axis which is specially prominent in any one type, at the poles of which are the two regions which are the external evidence of this prominence, and which morphologically repeat each other, but as has been instanced, may be teleologically most diverse ; and therefore if *radiality* and *laterality* are accepted for the two lower types, (for despite our morphological equality of Mollusks and Articulates, the latter are physiologically the higher of the two,) the corresponding terms for the other types are *verticality* and *longitudinality :* for *tergality* and *cephality* only express the prominence of the region at *one* end of the axis over that at the other, a prominence which is teleological, while our idea is strictly morphological. Radiality, laterality, verticality, and longitudinality are, morphologically, peculiar to and characteristic of Radiates, Mollusks, Articulates, and Vertebrates respectively, but, teleologically, they may be as it were ingrafted upon the others in the shape of radiation, bilaterality, tergality, and antero-posterior symmetry.

In accordance with the law of polarity, we shall expect to find the organs at the two poles of a prominent axis morphologically similar, and thus to observe relations of polar homology between them,—of lateral homology in the Mollusks, of vertical homology in the Articulates, and of longitudinal homology in the Vertebrates ; all existing more or less in each of these three, but specially prominent one in each ; while in the Radiates there is the radial homology so early recognized between the four or five diverging segments. These four kinds of polar homology are the most general.

We come now to consider more particularly that relation of homology which is characteristic of the Vertebrates, and included in the idea of longitudinality, otherwise expressed by the compound term antero-posterior symmetry ; both these terms are objectionable on the score of length, but the former is really significative of the idea we mean to convey.

It may be well at this point to find how fully our deductions are borne out by the facts.

It is fortunate indeed when our views *a priori* are confirmed by our investigations *a posteriori,* so that we safely ascend and descend the hill of science, without being dazzled and led astray by glittering and apparently correct generalizations, or losing our way amidst the labyrinth of facts, and, in our eagerness to advance, in place of steadily looking for the landmarks Nature has provided, becoming impatient and exhausting our strength in cutting down or rooting up, if possible to destroy, whatever stands in our way, or perhaps using it to bridge over gaps in our self-made path which never would have existed, if, at the outset, our aim had been to discover, not to create, to learn from God, not to be teachers ourselves.

If the previous reasoning is correct, it follows that the anterior and posterior regions of the vertebrate body, consequently of our own, are anterior and posterior repetitions of each other, but in opposite directions, like the right and left sides.

At first sight, nothing is more improbable to our thought or revolting to our feelings, and the evidence must be strong to overcome this natural repugnance to the relationship.

Yet why should it be objectionable, any more than that neither anatomy nor microscopy nor chemistry can detect the slightest difference between two human brains to indicate that one of them was the agent of a wicked and depraved, the other of a noble and lofty soul ? It is the universal distinction between morphology and teleology, between the thing as it is made and as it is used; and when this distinction is once rightly appreciated, we shall be no more shocked at the morphological identity of the two ends of our corporeal frame than we are, or ought to be, at the close anatomical relationship between the disgusting ape and ourselves, remembering in both cases that it is the use alone which can ennoble or debase.

Our evidence is as yet by no means complete as regards all the organs of the vertebrate body, but enough has been brought out to very strongly confirm the principle.

As was implied when treating of the general law of polarity, we must, if this is acknowledged, recognize a new relation of homology between parts representing each other at the two ends of the longitudinal axis, and, in fact, on opposite sides of the longitudinal centre, similar to, but by no means so obvious as, that existing between the right and left sides.

This is not the " serial homology," of Professor Owen, for he regarded all the vertebræ and their appendages as simple repetitions of each other from one end of the body to the other, without recognizing the fact, which we shall see most clearly in the limbs, that the anterior and posterior organs of the body are repetitions of each other, but in *opposite* directions ; so that the term " homotype," by which he designated parts serially homologous, really applies only to such as repeat each other on one and the same side of the longitudinal centre, and for the new relation between parts on opposite sides of this point a new term must be found.

Adopting the phraseology of Professor Owen we may call all parts which repeat each other as opposite ends of any axis " antitypes," and the antitypes of the lateral axis " latitypes," of the vertical axis " vertitypes," and of the longitudinal axis " longitypes," which will be specially characteristic of the three higher sub-kingdoms, Mollusks, Articulates, and Vertebrates, respectively, while the homologous diverging segments of the Radiata may be called " raditypes." In the Vertebrates the head and pelvis are longitypes ; and the thorax and abdomen bear the same relation. This is a very general homology.

There will now arise, with reference to the longitypes, or the homologous parts in the anterior and posterior regions of one animal, a question similar to that concerning corresponding parts in two different species ; which was whether they can be to the same extent homologous in animals bearing different degrees of zoölogical relationship: for example, the anterior extremities of all Vertebrates are homologous ; but surely the arm of the monkey is more closely related to the fore-leg of the cat than either is to the flipper of the porpoise or the pectoral fin of the fish ; and now, since the main axis or vertebral column begins to be formed at what is afterward the point of division between the fore and hind regions of the body, and the head and pelvis are situated at or near the ends of that axis, it does not seem possible that these parts can be as strictly homologous in animals having a different number of vertebræ as in those with the same number : in other words, the heads or the pelves of two animals may be cranial or pelvic modifications of vertebræ without being such modifications of the same identical vertebræ.

We have seen above that the vertebrate body is composed of four regions — head, thorax, abdomen, and pelvis. The tail is a pelvic prolongation, and not a distinct region, for though in the lowest class it constitutes so large a part of the whole body, and is the chief agent in locomotion, yet it contains no viscera, becomes more and more abbreviated, and at last disappears as we ascend, or, according to Prof. Dana, as the vertebrates become " cephalized." The number four at once furnishes a basis for a twofold longitudinal division, the head and thorax in front, the abdomen and pelvis behind ; the head and pelvis are the extreme, and the thorax and abdomen the intermediate, antero-posterior representatives or antitypes of each other. Superficially or physiologically, the thorax seems better to repeat the pelvis ; but this is due to the fact that in most vertebrates the anterior extremities are shifted back upon the sides of the thorax : which, of course, cannot be of importance in a morphological point of view ; so that, so far as the limbs are concerned, and we shall find in them the law of longitudinality beautifully carried out, the head is more clearly shown to be the anterior representative of the pelvis. It is, of course, assumed that the vertebral theory of the skull is true, and that it also applies to the other or caudal extremity of the vertebral column, where the physiological degradation is usually as great as is the elevation anteriorly ; with the difference that the tendency to linear multiplication is usually limited to four cranial vertebræ, while the tail may vary greatly in the number of its aborted vertebral segments. The four regions of the body are associated physiologically also in the same way : the two extremes are regions of *relation ;* their functions, sexual and mental, are exercised with direct reference to other individuals, and the latter is capable of elevation to the highest communion possible between the finite and the infinite. But the functions of the two intermediate regions are of a *personal* and *selfish* nature, those of the abdomen being concerned in the support of the life of the individual within *itself,* and those of the thorax evolving the power necessary for motion and for influence upon the *world.*

The question next arises, Where is the longitudinal centre of the body ? This cannot be indicated precisely, and perhaps varies in different species, but it undoubtedly lies between the two intermediate regions, thorax and abdomen, perhaps at that vertebra whose spinous process is upright, inclining neither backward like those of the dorsal, nor forward like those of the lumbar vertebræ ; but this point will seem to shift its position according to the various physiological requirements as to the length of the thorax or abdomen, or the strength and mobility of the extremities.

Questions of morphology are often determined by embryology ; — by reference to the early stages of development before teleological modifications have been superadded ; the development of the vertebral column and of the enclosed myelon, conclusively shows that the morphological centre of the body is at the middle of the back, notwithstanding the cephalic end afterward acquires such physiological superiority. Ossification of the vertebral column commences at the middle of its length, and proceeds forward and backward from this point : the size of the bodies, or *centra,* of the vertebræ at this early period, diminishes anteriorly and posteriorly, and only later becomes more equal, which latter proportion persists through life in the lower mammalia but in the quadrumana and especially in man the posterior centra become thicker and stronger, so as to give the column that slender pyramidal shape necessary for the preservation of their more or less erect position, while the upper or neural arch is anteriorly expanded to accommodate the enormously enlarged cerebral ganglia, the long axis of which forms a decided angle with that of the cord.

Perhaps nowhere is the distinction between morphology and teleology more evident than in the cerebro-spinal axis. At the first appearance of this in the embryo, there is no

such marked preponderance of the anterior portion as in the later periods, but the two ends present a nearly similar appearance, which similarity is persistent in the lowest fishes. There seems to be no good reason for regarding the anterior enlargement of the myelon as essentially or morphologically distinct from the posterior. The brain is an after-growth, for teleological cause, and the posterior enlargement is distinct, and, though entirely overbalanced by the immense development of the organs of the mind and special senses, is of no small importance even physiologically. No one who has suffered the excruciating pain in the small of the back, accompanying most febrile diseases, will question the importance of the portion of the myelon there situated, to which part also are referred the sensations of relief, more or less distinctly felt, upon the discharge of the contents of intestine, bladder, uterus or testis.

To avoid misconception, it may here be stated that from this morphological point of view, I consider the brain proper as a purely physiological addition with no posterior representative, and the so-called anterior and posterior enlargements of the spinal cord as bundles of the fibrous, that is, connecting or adynamic nervous substance, increased in size and number; but the medulla-oblongata as the true anterior morphological enlargement, the posterior representative or longitype of which is that apparently insignificant portion of the cord which lies behind the origins of the great lumbar nerves, but which contains a very large proportion of the gray or cellular or dynamic nervous matter.

But this point, and many others, demand investigations more rigid, minute, and even microscopic, and with reference to the principle involved. The idea of antero-posterior symmetry is as yet illustrated to us only by such parts and organs as conform to it more obviously by teleological likeness or unlikeness in the two regions of the body; and, though there is already enough to establish beyond a doubt, to my mind at least, the truth of this subdivision of the higher law of polarity, yet there is needed more time and labor than any one has yet been able to bestow, to demonstrate the more obscure relations of those parts which are only *morphologically* anterior and posterior repetitions of each other.

It is by no means unlikely that further investigations, broad and impartial, may show that, except between certain organs, the relation of polar homology is a *general* and not a *special* one; at any rate, I think we are not yet prepared to state what bones of the head and pelvis are longitypes; if mere consolidation and organic connection of the more anterior vertebræ constitutes the cranium, then many fishes have five or six, or even more cranial vertebræ, while in the frog the occipital segment is so divided that the two lateral elements, or *neurapophyses*, are separated from the *centrum* and *neural spine*, and so appear to constitute a distinct vertebra.

Perhaps the two or even the three anterior cranial vertebræ, the nasal, frontal, and parietal, are, like the special senses, not represented posteriorly. It may be said in favor of this view, that, while the universal sense of touch is perfected in the hands, which are the distal ends of the diverging appendages of the lower or hæmal arch of the posterior or occipital cranial vertebra, and taste, the modification of this universal sense, is located in the tongue which is supported by the hæmal arch of the next or parietal vertebra, the organs of the three special senses are located in or between the superior or neural arches of this and the two remaining segments, which indeed seem to exist only with reference to these and to the brain proper, none of which have posterior representatives; therefore, we might not expect to find in the pelvis any parts corresponding exactly to these special developments, but only the entire vertebra whose hæmal arch has for its diverging appendages the posterior extremities, with that portion, hæmapophysial, of the

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succeeding hæmal arch which supports the penis, the longitype of the tongue, the pleura-pophysial elements of the arch being deficient.

In most mammalia, but by no means in all vertebrates, the pubic bones support the male organ of generation; the ischiatic bones are certainly the posterior of the two pelvic arches, and may reasonably be supposed to represent the hyoid bone; at any rate, despite the vast teleological discrepancy, the anterior portion of the head seems, so far as morphology is concerned, to be the fixed longitype of the more or less movable series of vertebræ behind the fixed pelvis.

Having thus admitted a general homology between these two extreme regions of the body, we must wait for further evidence to show first, whether there is really any such special homology as at first appears probable, and if so, whether the clavicle and coracoid represent the ischium and pubis respectively, as the bones alone would indicate, or whether, regarding also the fleshy parts, the hyoid bone is the antitype of the ischium, and the clavicle that of the pubis, the coracoid being merely a process like the marsupial bone of the mammals characterized thereby.

The alimentary canal with its appendages next merits our attention.

The former is embryologically and morphologically a simple straight tube, with an anterior opening in the head and a posterior one in the pelvis. In the adult state, however, this tube is always more or less enlarged and convoluted, to afford a reservoir of the size, and an absorbent surface of the extent required by the nature of the food consumed; but all such modifications are purely teleological, and only conform to the general arrangement which assigns to the organs of nutrition a region below that in which are the organs of the motive forces, and above that devoted to generation.

There is at first but a single anterior and posterior opening, but the former is generally, and the latter in mammalia afterward, divided into a superior and an inferior opening; the nasal and oral, the anal and genital orifices, by transverse bands which bear the names of upper lip and perinæum.

With one exception, all sexual diversity is teleological, that is, resulting from a difference in the size or shape of parts which exist alike in both sexes. The exception is in the case of the ovary and the testis, which, being entirely distinct in every respect, constitute the only morphological difference between the two sexes; a true hermaphroditism is, of course, impossible, except between the two sides of the body; and this would be a positive condition, while all the so-called cases of hermaphroditism are merely negative and doubtful states.

In the anterior region, enumerating from above, that is, from the vertebral column downward, the parts are, the *nose*, or *anterior nares*, the *upper lip*, the *mouth*, the *tongue*, and the *chin;* posteriorly, the *anal opening*, the *perinæum*, the *vaginal opening*, the *penis* or the *clitoris*, and the *pubes*. The morphological correspondence is as evident as is the teleological difference.

There are two principal diverticula of the alimentary canal, the *lungs* and the *urinary bladder;* the former open forward and the latter opens backward, and their outlets are between the pharynx or mouth and the tongue, anteriorly, and between the vaginal opening and the clitoris posteriorly. There is a physiological relation also, for the bladder is a dilatation of the internal portion of the allantois, which was the fœtal organ of respiration. The thyroid gland is in relation with the larynx much as the prostate gland is with the neck of the bladder; but the former has no excretory duct as has the latter.

The heart, notwithstanding its lofty physiological preëminence, is, morphologically, only a more or less complicated enlargement and convolution of the great arterial trunk, just as the brain and stomach are teleological modifications of more simple fundamental parts; it and the stomach are examples of lateral displacement from their normal position as median organs. Terminating the vagina is the uterus, of which the longitype is not yet discovered; the mouth is the longitype of the vaginal opening into the alimentary canal, of which latter, however, it is the teleological inlet. Pathology seems to indicate that the testes and the parotid glands are longitudinally homologous; for inflammation of the former is very prone to invade the latter, by what is called metastasis, but which in this case may be a physiological indication of a morphological relation otherwise obscure. So, likewise, are connected the diseases and their remedies, of the genito-urinary and respiratory passages, and both these cases, with that of the irritation of the nostrils sympathetic with the presence of worms in the rectum, are simply analogous to what so often happens between parts which are laterally homologous. I am not aware that any disposition has yet been proposed of the other abdominal viscera, liver, spleen, pancreas, and kidneys; — and will merely refer to the view of J. Maclise concerning the two former, that they are laterally complementary, as stated on page 153 of his "Surgical Anatomy," where are also given several reasons for his opinion.

We come now to the limbs, of which there are, in vertebrates, two pairs: the one anterior, and the other posterior. Their general homology as diverging appendages of the hæmal arches of the occipital or posterior cranial, and of the anterior pelvic vertebræ, has been already indicated; and also the doubt as to the general and antitypical relations of the lower or hæmapophysial portions of those arches, supposed to be represented by the four bones, clavicle and coracoid, ischium and pubis. In many mammalia the two former exist only in the shape of processes from the scapula, which is the upper or pleurapophysial portion of the arch; this and its antitype the ilium, seem to follow the direction of the development of the vertebral column, the former pointing forward, and the latter backward. To the lower or distal ends of these elements, by the shoulder and hip joints, are articulated the proximal ends of the limbs proper; these are made up each of four segments; anteriorly, of the arm, fore-arm, hand, (wrist and palm,) and fingers; or, osteologically, of the humerus, ulna and radius, carpus and metacarpus, and phalanges; and posteriorly, of the thigh, leg foot, (ankle and instep,) and toes; or, of the femur, tibia and fibula, tarsus and metatarsus, and phalanges.

It is worthy of remark, that the number of component parts of the segments increases toward the distal ends, while their individual mobility is diminished in the same direction as if for mutual compensation, and in accordance with the general rule that the right of *discretion* increases and diminishes with *responsibility*.

Now the law of polarity is morphological; but in this case, the teleology also is very evident; the divergence of the scapula and ilium is on the principle of a pyramid, the base being wider than the top, so as to afford a firmer support; we shall find the same polarity carried out in the segments of the limbs themselves with one exception, the necessity of which is, however, as obvious as the grounds for the general arrangement therein departed from; and indeed throughout the limbs, which as a whole are teleological superadditions, the uses of the general laws are so apparent that the latter seem almost teleological, the two principles being, as it were, blended and thoroughly harmonious.

The general correspondence between the four segments of the anterior and posterior

limbs is evident; the arm or humerus and the thigh or femur, the fore-arm and the leg, the hand and the foot, the fingers and the toes are easily seen to occupy similar positions in the limbs to which they belong; but the law of longitudinality is further carried out among these segments according to what may be called corollaries thereof.

1st. Two corresponding segments in the fore and hind limbs point, and are flexed or extended, in absolutely opposite though relatively similar directions.

2d. Two contiguous segments of the same limb also point, and are flexed or extended in opposite directions, so that the *flexor* muscles of one segment lie on the same side of the limb with the *extensors* of the segment next above or below, and *vice versa*.

All this is easily seen in the mounted skeleton of any quadruped; the scapula and ilium diverging, the humerus and femur converging, the fore-arm and leg again diverging, the foot pointing forward, and the toes, since their flexion is in the direction opposite to that of the foot at the ankle, really pointing backward; but their antitypes, the hand and fingers, seem to point also in the same instead of the opposite direction, so that two and even three sets of muscles, which by their contraction shorten the arm, lie upon one and the same side of the limb.

To understand this apparent anomaly, it must first be remembered that the entire limbs are teleological, and that the influence of morphology diminishes as we recede from the morphological centre toward the distal extremities; moreover, the functions of the hands are various to the highest degree, and they, as the special agents of the brain, may be supposed to partake somewhat of its independence of morphological restraints.

Embryology throws light on this point. In the early fœtal periods, the two bones of the fore-arm are parallel, and this alone is sufficient indication of their morphological relation; in the course of development the hand is gradually pronated, so that the lower end of the radius, the outer bone, crosses the ulna, and so becomes internal, causing the palm to face downward and *backward*, instead of, downward and *forward*. In this relation, more or less firmly connected, the two bones remain in quadrupeds; for they, not being stationary geometrical figures, but organized living creatures intended to move from place to place, must be able to strike the earth alike with both pairs of limbs in order to propel the body in the opposite direction; but in monkeys and in man, where the anterior extremities are not merely for progression but for executing the higher mandates of the will, the radio-ulnar articulations remain free, and the parts may be restored to their normal condition by supinating the fore-arm, the palm still facing downward, but now also forward instead of backward; the fingers flex forward and the toes backward, although made to act as continuations of the larger segments, hand and foot.

Morphologically, the flexion of the hand at the wrist must be in a direction opposite to the flexion of the fore-arm at the elbow, and therefore the muscles which raise the so-called back of the hand toward the back of the fore-arm are really the *flexors* of the former segment, and correspond to the muscles which elevate the dorsum of the foot toward the front of the leg; and, *per contra*, the muscles which bend the palm of the hand toward the inside of the fore-arm, are really *extensors*, and correspond with those which in the posterior limb act upon the foot through the *tendo Achillis*; that is, the muscles now called *extensores carpi radialis* and *ulnaris*, are morphologically *flexors*, and their antagonists, now called *flexores carpi radialis* and *ulnaris*, are *extensors*, and will be so designated in this paper.

There are two apparent objections to the above interpretation of the antitypical rela-

tions between the fore and hind limbs, but as will be seen, they are only apparent, and against their entertainment may be urged all that has been, and much more that might be, said concerning the distinctions between morphology and teleology, and the fallacy of deductions from either respecting the other.

The first is, that by rotating back so as to leave the ulna and the radius parallel, the former must correspond to the inner bone of the leg, *tibia*, and the latter to the outer bone, *fibula*; yet the radius forms most of the wrist joint, and the tibia forms the ankle, and, as the power of rotation gradually disappears in the mammalian series, it is the ulna in the fore leg, and the fibula in the hind leg, which decreases in size through the carnivora, till in the permanently pronated fore-arm of the ruminants, solipeds, and some pachyderms, the ulna is represented only by the olecranon process and the upper half of the shaft soldered to the radius, while in the posterior limb scarce a trace of the fibula remains; in other words, the homologous bones of the two extremities are developed in an inverse instead of a direct ratio; but relations of *more* and *less*, like those of *form*, are always dependent upon function, and therefore not safe guides to homology, so that this cannot be taken as a real objection to the law of longitudinality, borne out as it is by the entire vertebrate structure wherever the original plan is retained or can be detected under its various teleological modifications. We may however connect this fact with another, so that it shall to us seem to have, what with all things in nature it certainly must have, a more or less remote foundation in use. As we have seen above, in a morphological point of view, the ulna is the inner, and the radius the outer, bone. This is the relation which they bear in the fœtus and which harmonizes best with other parts; but this admits of such variation that in nearly all mammals below the quadrumana, the radius becomes inner and the ulna outer. Now, for some cause not yet understood, it is best for both hand and foot in quadrupeds to be connected with the inner bone of the legs, and in provision for this the hand is in all the mammalia supported by the radius which in the four-footed members of the class is the inner bone.

The second and more obvious though equally fallacious objection is, that of the five digits which terminate the anterior and posterior extremities, the outer ones will then be the thumb and the little toe, and the inner ones the little finger and great toe. Perhaps no correspondence has been more generally admitted, and even taken as a basis for other investigations, than the analogy between the thumb and the great toe, not only because in the commonly accepted condition of the parts they both occur on the inner sides of the hand and foot, but because they are so constantly composed of *two* phalanges, while all the other digits possess *three*.

But even if it were true, which it is not, that this same numerical relation prevailed among the three other classes of the vertebrate sub-kingdom, and there were therefore some grounds for regarding as morphological a rule for which no sufficient teleological cause is yet apparent, we could not reasonably accord to any deviation at the very distal extremities of the limbs, a value sufficient to outweigh the teachings of all parts between them and the morphological centre of the body; and it is better to acknowledge our ignorance of the meaning of one fact than to purposely ignore the existence of others far more numerous and important.

I will here mention the comparisons between the anterior and posterior extremities of vertebrates which, since the time of Winslow, (1775,) have been made by many of the most

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celebrated anatomists, such as Vicq d'Azyr, Sœmmering, Goethe, Meckel, deBlainville, Barclay, Gerdy, Blandin, Bourgery and Cruveilhier, Turenne, Flourens, Owen, and more recently, Mons. Chas. Martins, Professor of Medical Natural History of the Faculty of Medicine of Montpellier, in a paper entitled, " Nouvelle comparaison des membres pelviens et thoraciques chez l'homme et chez les mammifères déduite de la torsion de l'humerus," (Annales des Sciences Naturelles, tome viii. p. 45, 1857.) And again in 1862, in a second paper entitled, " Memoire sur l'ostéologie comparée des articulations du coude et du genou chez les mammifères les oiseaux et les reptiles."

In the former, after discussing and objecting to the views of the other anatomists above named, he says on page 55 : —

" To recapitulate, these comparisons (parallèles) of the superior and inferior extremities of vertebrates may be reduced to three:

1st. The hypothesis of Vicq d'Azyr, who compares the superior member of one side with the inferior member of the other side. (Plate ii, figs. 1 and 3.)

2d. The detailed (détaillé) comparison of Bourgery, who combines the hypothesis of Vicq d'Azyr, with a crossing, in virtue of which the head of the tibia represents the ulna, its lower extremity the radius, while the femoral extremity of the fibula corresponds with the radius, and its tarsal extremity with the ulna.

3d. The explanation of Flourens, where the pelvic member of one side is assimilated with the thoracic member of the same side, the *fore-arm being in a state of pronation.*"

We may easily see, as Mons. Martins has shown, that each of these comparisons is open to serious objections, while their discordance is such that even at this late day those anatomists who do not utterly discredit the existence of any natural relation between the fore and hind limbs " are in doubt between them, without being able to agree upon the most important point, namely, the identification of the two bones of the fore-arm with those of the leg."

It will be noted that through all these comparisons runs the effort to demonstrate a *parallelism* between the anterior and posterior extremities, and not one of the anatomists who advocate them seems to have appreciated the significance of Oken's *a priori* assertion of an *oppositeness* or *symmetry* between the two ends of the vertebrate body, which generalization he simply did not extend to the limbs, the diverging appendages of these two regions.

That this *oppositeness* or *symmetry* does really exist, has I hope been already shown in this paper, and I desire to repeat here that the first suggestion of the idea to me came from my illustrious instructor in anatomy, the Hersey Professor of Anatomy in Harvard University, from whom, much rather than from myself, would I prefer that others should learn what has afforded me so much mental pleasure and profit.[1]

Mons. Martins' view is in his own words, as follows : " The humerus is a bone twisted on its axis 180 degrees. The femur is straight without twisting. The humerus being a twisted femur, if we would compare the two bones, we must first untwist the humerus."

In other words, having made up his mind that the limbs are *parallel,* and finding that they are *not parallel,* he makes them so by a process of untwisting, to which I hope, others will perceive obstacles both mental and physical.

[1] See a short communication by Professor J. Wyman to the Boston Society of Natural History for June 6th, 1860. Proceedings of B. S. N. H., vol. vii., p. 317, " on anterior and posterior symmetry in the limbs of mammals."

He then goes on to say : " The anterior extremity having been thus untwisted, the radius and tibia (which he considers analogous bones), are on the inside, while the ulna and fibula are on the outside ; also the thumb and great toe, and the little finger and little toe, are respectively inside and outside ;" all which correspondences do of course confirm him in his preconceived idea; but since, as has been shown, they are only analogies, not homologies, they do not in the least affect the true view of the case. Anatomy should be studied from the centre outward, as well as from the circumference inward.

Under the head of " Evidence of the torsion of the humerus," Mons. Martins adduces the raised line which passes from the condyle across the front of the bone, and the general direction of the vessels and nerves of the upper arm; not perceiving that both are only physiological provisions, in the one case for the attachment of muscles, and not appearing till needed ; and in the other for the better protection of the vessels and nerves, as is, moreover, equally the case in the lower limb. What can Mons. Martins think of the numerous ridges and apparent contortions presented by all the bones of the great ant-eater (Myrmecophaga jubata) ? It would be difficult to determine how many degrees they should be untwisted to conform to his ideas of their normal condition. Unfortunately, Mons. Martins has not taken warning from his predecessors, and is, like them, haunted with the idea of parallelism, but his view has, in one respect at least, the merit of originality ; for while they humbly took things as they found them, and patched them up as well as they could, he boldly declares that things are not what they seem, or at least seem not what they ought to be, and with his own hands sets them aright. His preëstablished theory is a very Procrustes' bed, to which facts must be adapted, whatever their real import.

Having done this violence, however, his conscience reproaches him, and he thinks to appease outraged Nature by conceding what he is pleased to consider a "metaphysical difficulty," (p. 65.) Here, after admitting that *no such twisting ever takes place,* and that in youth, before the development of the muscles has raised lines on the bones, *no evidence of torsion exists,* he declares that " this torsion of the humerus is not *mechanical,* but only *virtual,* though producing the same effect as if it were real." Also that "natural history is full of such facts." The examples he adduces are undoubtedly such ; but a sounder illustration is to be drawn from the position of the whole anterior extremity ; this is now admitted by all to represent the pair of ribs with their diverging appendages of the occipital cranial vertebra, not only in fishes where the contact is actual, but also in all other vertebrates, man included, as stated above. But the reasons for this conclusion are very weighty, since in addition to the fact that the homologous parts in fishes are actually so attached, there else would be a vertebral segment minus a pair of ribs, and a pair of ribs minus a vertebra ; nor indeed is it certain that even in the higher vertebrates the anterior extremity is not at some time in contact with the cranium, while the other evidence is absolutely conclusive as to the morphological relationship. So that we may say there is a positive necessity for so disposing of these otherwise vagrant vertebral elements. But no such necessity compels us to assume a torsion of the humerus in order to gain a clear and philosophical view of the vertebrate limbs ; and even if in our opinion it did, no such torsion ever takes place, as is acknowledged by Mons. Martins ; so instead of a metaphysical difficulty in the way of his supposed reasonable theory, we find serious, aye, insurmountable, difficulties opposed to a very metaphysical and visionary idea.

Two wrongs do not make a right, and when we are in doubt, it is better to follow Nature strictly and try to discover her way of reconciling apparent discrepancies, than to assume what is not the case in order to conform to a preëstablished theory.

The mechanical conditions necessary for making use of muscular contractility are two points, one generally fixed and the other movable, to which the extremities of the muscle are attached, as in the face, where the muscles may arise from the bone and be inserted directly into the skin, or other part to be moved. In this way, of course, all the power of the muscle is utilized; but for the various requirements as to rapidity of action and beauty of proportion, a part of the power is more often sacrificed by the introduction of two other points, — one fixed, the fulcrum, and one movable, like the part to be moved, but nearer to or farther from the fulcrum, and into which now the muscle is inserted.

This is the more usual method of applying muscular contraction, and converts the various segments of a limb into levers, which are so far strictly mechanical. Thus, in flexion of the fore-arm, the *biceps*, and *brachialis anticus* do not reach directly from their origins on the scapula and humerus to the hand, which is the part to be moved, but two other points are introduced, — one fixed as a fulcrum, the elbow-joint, the other movable at the insertion of the muscles on the fore-arm, thus between the fulcrum and the part to be moved, which represents the weight.

Levers are of three kinds. The first is where the fulcrum lies between the power and the weight; of this kind are all segments of the limbs when acted upon by *extensor* muscles. The third kind is where the power is applied between the fulcrum and the weight, and to this class belong the same segments when acted upon by *flexor* muscles. The second kind of lever is where the weight lies between the power and the fulcrum; of this there are no examples in the body acting by and upon itself, but whenever extension of a limb is employed for raising or supporting the body from the earth, then the different segments from levers of the first become levers of the second kind. Thus, in rising on tiptoe, the weight of the body rests upon the ankle, and so between the ball of the foot, which, resting on the earth, forms the fulcrum, and the heel, to which by the tendo Achillis is applied the power of the *gastrocnemius* and *soleus* muscles. I subjoin line illustrations of these three kinds of levers.
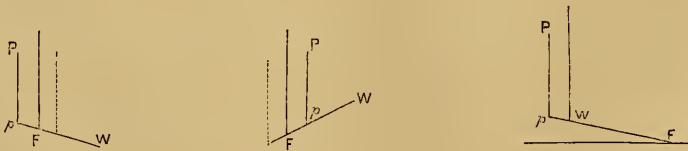
Adduction and abduction are only lateral flexion and extension; circumduction is a compound movement resulting from gradual and successive direct and lateral flexion and extension; even rotation is essentially a peculiar form of the same two movements, for the power is applied at the periphery of the rotated bone or limb, and so at one end of an imaginary diameter line through the centre, which latter represents the fulcrum; the weight may be regarded either as suspended from the half of the line or lever *furthest* from the power, in which case the diameter line would be a lever of the first kind, or as sustained

upon the *nearer* half and thus between the power and the fulcrum, when it would be a lever of the second kind.

Of course, any obliquity in the direction of the muscle or bone, or any variation in the shape of the rotated bone or limb, or the presence of any part as the hand, which may be appended to the extremity, will only appear to complicate the motion without essentially affecting its character.

The general law, according to which the muscles of the mammalian limb seem to be arranged, is in no way startling or peculiar, and the only wonder is that it has never been observed before. No new facts are required for its illustration; human anatomy contains the great bulk of the material, though of course aided by comparative anatomy; and it needs only to see that the facts are not arbitrary, but bear such mutual relation as clearly to admit of one general statement. I will commence with the muscles which act upon the fore-arm, that segment of the anterior extremity in which I first detected the arrangement, and in which it is quite closely adhered to.

There are two *direct* flexor muscles of the fore-arm : one is the *biceps* arising from the scapula and inserted into the radius, the other is the *brachialis anticus* arising from the humerus and inserted into the ulna, though both, of course, are attached to one and the same segment, fore-arm. But this segment may be also flexed *indirectly* by the ulnar and radial extensors of the wrist ; for when a joint is partially or wholly fixed by the simultaneous contraction of antagonist muscles on opposite sides, then the two segments between which the joint intervenes become teleologically as one segment, which is acted upon by all muscles arising from any other segment, and inserted into either of them; each segment being acted upon *directly* by the muscles which are attached to itself, and *indirectly* by those attached to the other. The fore-arm is directly extended by two muscles, one short, the *humeral heads* of the *triceps*, and the other long, the *scapular head* of the same ; the indirect extensors are the ulnar and radial flexors of the wrist, commonly called *extensores carpi ulnaris* and *radialis*.

The humerus is flexed upon the scapula by three muscles, — *directly* by two, one short, *teres major*, arising from the scapula, and one long, arising upon the side of the body, *latissimus dorsi ;* and indirectly by the third, the scapular head of the *triceps* which is also the long direct extensor of the segment next below.

How is it now with the corresponding segments of the posterior extremity ? The leg is flexed at the knee, directly by two sets of muscles, one of which is represented by the *poplitæus* with the short head of the *biceps* when it exists, the former corresponding with the short direct flexor of the fore-arm, *brachialis anticus ;* the other set is composed of the long head of the *biceps* with its accessories, the *semi-tendinosus* and *semi-membranosus*, the former corresponding with the long direct flexor of the fore-arm, *biceps humeri ;* while the *peronæus longus* and *tibialis posticus*, with their accessories; the muscles composing the calf of the leg, and which are long direct extensors of the foot, are, if the ankle-joint is fixed, the indirect flexors of the leg, the segment next above, and correspond thus with the *extensores carpi* and the *palmaris* in the other extremity.

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Here are enough examples to illustrate the general rule which may be stated in several ways, according as we specially regard the muscles themselves, or the bones; and these as segments of *insertion* acted upon, or as segments of *origin* from which the muscles act.

The muscles of the limbs form two groups, *long* and *short ;* the short muscles arising from the *first* segment above that into which they are inserted, and the long from the *second* segment above. A short muscle can act in but one way, but a long one has two actions: one *direct* upon the segment into which it is inserted, the other *indirect* upon the segment which intervenes between its origin and insertion.

Each segment of a limb is flexed or extended by three muscles or groups of muscles; of these, two are inserted into itself, and are therefore called *direct* muscles, flexors or extensors ; one arising from the segment next above the segment to be moved, and hence called the *short* direct, and the other arising from the second segment above, and hence called the *long* direct; the third muscle is termed the *indirect* flexor or extensor, and is the *long direct extensor* or *flexor* respectively of the next segment below, and between whose origin and insertion intervenes the segment under consideration.

Or it may be stated in yet a third way, using the humerus as an example. Each segment not only gives *insertion* to the four muscles which act upon itself, short and long extensors, *deltoid* and *pectoralis major*, and flexors, *teres major* and *latissimus dorsi*, but also affords *origin* to four more, of which two are the short flexor and extensor of the segment next below, *brachialis anticus* and *humeral* heads of *triceps,* and two, the long extensor and flexor of the second segment below, *extensor* and *flexor carpi radialis,* which are also the indirect extensor and flexor, respectively, of the first segment below.

There are several advantages apparent in this arrangement of the muscles of the limbs, and probably many more than have yet occurred to me. The most comprehensive is, that while one half of the muscles, the short, are able to execute but one movement, since but one joint intervenes between their origin and insertion, the other half may act in either of two ways, since two joints intervene between their origin and their insertion. Take for example the *biceps humeri ;* its lower extremity is associated with the short flexor of the fore-arm, *brachialis anticus,* which is thus its *associate* of *insertion,* while its upper extremity is associated with the short extensor of the humerus, *deltoid,* which is thus its associate of *origin ;* in like manner its *antagonist* of *origin* is the short flexor of the humerus, *teres major,* and its antagonist of *insertion,* the short extensor of the fore-arm, *humeral* heads of *triceps.* Now when the elbow, its joint of insertion, is fixed by the simultaneous contraction of its associate of insertion and its short antagonist of insertion, then the *biceps* can act only with the *deltoid,* its associate of *origin ;* but when the shoulder, its joint of origin, is fixed by the simultaneous contraction of its associate of origin and short antagonist of origin, then the *biceps* acts with its associate of *insertion* to flex the fore-arm.

Here is the great advantage in having both long and short muscles ; each long one may act in two ways, and the short ones are then required to counteract one of the actions while the other is performed. Moreover, it often, and in fact usually, happens, that two or more segments of a limb are to be flexed or extended together, and this is provided for by the same arrangement, with the additional fact that the short muscles are generally shorter and thicker than the long. Suppose that two contiguous segments, as arm and fore-arm, are to be extended at the same time. In this case neither of the short flexors, *teres major* and *brachialis anticus,* can act at all, but the long flexor of the lower segment, *biceps,* is enabled to act as the indirect extensor of the upper segment with its short associate of origin, *delloid,* its flexor power being counteracted by its short antagonist of insertion, *humeral*

heads of *triceps*, which, being more powerful, continues to act as an extensor, beside leaving the long extensor, *scapular* head of *triceps* entirely free ; the action of the latter, as an indirect flexor of the humerus, being in like manner more than counteracted by the short extensor of the same, *deltoid*.   But if the same two segments are to be simultaneously flexed, then the short extensors do not act at all, while the extensor power of the long direct flexor, *biceps*, is overbalanced by its short antagonist of origin, *teres major*, and that of the long direct extensor, *scapular* head of *triceps*, by its short antagonist of insertion, *brachialis anticus*, leaving the two long flexors, *latissimus dorsi* and *biceps*, free as flexors of the two segments ; moreover, the long rotators of the fore-arm, *supinator longus* and *pronator teres*, with the long extensor of the wrist, *extensor carpi radialis*, and here by exception, even the long flexor of the third segment below, *flexor communis digitorum sublimis*, now act as indirect flexors of the fore-arm, their direct actions being, if necessary, prevented by their short antagonists, or in the case of the rotators by each other.

Again, as has perhaps been already inferred, the three muscles acting upon any one segment, are, potentially or *morphologically*, of the three degrees of length in *direct* ratio, but of thickness in *inverse* ratio ; and since the power of a muscle is in proportion to its thickness, and the distance through which it can contract, according to the length of its fibres, it follows that a movement is most rapid and forcible at the beginning, when all three muscles act together, and least so at its close when the longer and weaker muscles act alone ; and this agrees with the observations on the variation in the force of contraction of a single muscle, which is found to be most forcible at the beginning, least so at the end.

I have now stated the general law and the general advantages gained thereby as illustrated in those regions where the muscles are most familiar and where the law is quite closely adhered to, yet even here were some departures from it ; and in the remaining portions of the limbs will be found even more variations, according to the number and kind of movements required at the several joints.

There is considerable doubt with regard to the muscles acting upon the scapula, and for two principal reasons, one teleological and the other morphological ; for, beside the complication necessary for the very free movement upon the walls of the thorax, of a part which in many mammalia has no bony connection therewith, there is so much difficulty in comprehending the true relations of some muscles arising from the head and cervical vertebræ, and inserted into the scapula and clavicle, as to afford additional, though for the present vague, evidence concerning that remarkable change, by which the scapular arch has been displaced backward from the occipital cranial vertebra, of which it is in most fishes actually, and in all vertebrates morphologically, the pair of ribs.

The scapula slides upon the sides of the thorax, and is separated from it chiefly by muscles, having in most mammalia no bony connection with the rest of the skeleton ; and the muscles which act directly upon it, are, like those of the face, inserted at once into the part to be moved, without the additional mechanical complication of levers.   It may be elevated and depressed, drawn forward toward the sternum, or backward toward the vertebral column.   Two direct muscles draw the scapula forward ; one, the *pectoralis minor*, inserted into the coracoid process, the other, the *serratus magnus*, attached along the posterior border, both arising from the ribs ; two direct muscles also draw it backward, the *trapezius* outside, inserted upon the clavicle and spine of the scapula, and the *rhomboideus* inside, inserted into the posterior border, and both these arising from the vertebral column.   Here then, as usual, are two flexors and two extensors, but as there is no part beyond the verte-

bral column or sternum on the middle line, all four are teleologically *short* muscles, since but one joint intervenes between their origins and insertions; it seems likely, however, that in a morphological point of view, the outer ones, *trapezius* and *pectoralis minor*, are the long muscles. The scapula is elevated and depressed *directly* by the oblique descending and ascending fibres of the muscles already described or *indirectly* by the long muscles of the humerus *pectoralis major* and *latissimus dorsi*. The true affinities of the *cleido-mastoid* and *levator claviculæ* have not yet been determined; the *omo-hyoid* is probably the representative of an intercostal muscle connecting the ribs of the occipital and parietal vertebræ; the *levator anguli scapulæ* is commonly regarded as a distinct muscle, but from some facts in its comparative anatomy, it appears to me rather as a dismemberment of the *serratus magnus*. All this is rather unsatisfactory, and will, I think, continue so till embryology and comparative anatomy have demonstrated the true relations of these muscles, and the extent to which they vary from the common type of the *intercostales;* for it must be remembered, that the scapula and its posterior representative, the ilium, are not, properly speaking, segments of the limbs, but the dorsal moities or *pleurapophyses* of modified ribs, at the junction of which with the ventral moities or *hæmapophyses*, are given off diverging appendages in the shape of the anterior and posterior extremities.

The *deltoid* is the short extensor of the humerus, arising, as it should, from the scapula; either the long extensor is wanting, or, as is more probable, it is represented by the *pectoralis major*, or one of the several subdivisions of the latter, existing in quadrupeds, where the clavicle is deficient. The long and short flexors of the arm, *latissimus dorsi* and *teres major*, have been already noticed. With regard to the *supra* and *infra spinati*, the *subscapularis* and *teres minor*, I am not yet decided; in man they are chiefly rotators of the limb at the shoulder, but in quadrupeds where the humerus is simply flexed or extended, the three former have more or less power of extension, while the *teres minor* is a flexor. The muscles acting upon the fore-arm have been already described; the *dorso-epitrochlien* of Duvernoy ("Des caracteres anatomiques des grands singes pseudo-anthropomorphes," Archives du Museum, vol. viii.) which exists in the quadrumana and most of the mammalia, has nearly the same relations as the *scapular head* of the *triceps*, being, when inserted upon the olecranon, a direct extensor of the fore-arm as well as an indirect flexor of the humerus, which alone it flexes directly when attached to the internal condyle.

The relations of the *biceps* in the higher mammalia are somewhat complicated by the provisions for rotation between the two bones of the fore-arm, converting that otherwise single segment of the limb into two, whose greater lengths are parallel with, instead of perpendicular to, the axis of motion at the radio-ulnar articulation; and since the *biceps* is attached to the radius, it really extends over three joints, and can act in three ways: at the shoulder in extension of the humerus, at the elbow in flexion of the fore-arm, and at the radio-ulnar articulation in supination or extension of the radius; for, regarding these two bones alone, supination is extension, and pronation is flexion.

It will be seen, however, that the radio-ulnar articulation is not a joint, in the same sense as is the shoulder or the elbow. These latter are constant or nearly so throughout the vertebrate series, and are important anatomical characters; they are strictly *morphological* joints; but the arrangement by which movement is permitted between the two bones of the single segment fore-arm, exists in comparatively few species of mammalia, and these such as in their approach to man, have their fundamental structure most modified in relation to the higher uses they are to perform. The radio-ulnar articulation is properly a *teleological* joint, and as might be expected, its existence does not really interfere with the

of the fingers, unless the proper extensors of the first, second, and fifth digits are remaining portions of it; the only common extensor, like the superficial flexor, having been moved as to its origin, two segments above its normal position, like the short extensor.

In general, the muscles, like the bones of the posterior extremities, repeat in an opposite direction those of the anterior, but the exact correspondences between individual muscles are far more difficult to determine than would be expected, either from the apparently more simple functions of the limbs as such, or from the close antitypy exhibited by their osseous framework. Moreover, extended and minute comparisons of parts have as yet been almost wholly confined to anthropotomy, a branch of comparative anatomy which treats of a structure teleologically most perfect, but morphologically monstrous.

The legs are usually regarded as very simple and regular in their structure, because their only function is that of locomotion; but it is from this very cause that they are more complicated than the corresponding limbs of quadrupeds, for they are also the *only* organs of locomotion, and therefore are required to maintain the equilibrium of the erect body during progression, a duty which in the four-footed members of the class, is shared by the anterior extremities.

By a sort of favoritism shown to the anterior, and physiologically more noble region of the body, when the functions of prehension are transferred from the quadrupedal head to its diverging appendages, the arms, these are in their turn allowed to impose upon their posterior representatives their share in sustaining and propelling the body; but the latter, less highly favored, can merely make an awkward protest when the kangaroo throws upon the base of his huge caudal appendage the task of supporting his body while he kicks out with his hind legs, and when certain monkeys suspend themselves by the other end of their tails so as to leave all their limbs free.

The natural position of the quadruped is sustained in part according to *physical* laws, as is a table upon its four pedestals; but that of man is in direct defiance of these laws, which are ever ready to assert their rights the moment his will ceases to guard against them; and he, the lord of creation, is obliged to take his rest in an attitude other than that in which his superiority is exercised; his elevation is great, but according to the law of the succession of extremes, his fall is proportionately great, when the means of that elevation are withdrawn; he pays as it were, a physiological price for his physiological preëminence.

As in the arms of man were found extra muscles and articulations, with direct reference to the superadded function of rotation, so in the lower limbs there appears to be an increase in the number of muscles, and changes in the relation of those which are morphologically entitled to be present, in view of the fact that by two legs, instead of four, is the body to be propelled and its equilibrium maintained; therefore, they cannot be regarded as presenting the normal condition of parts for correcting our ideas as derived from the arms, since they are quite as fully, though less obviously and directly, under teleological influence.

The real extent of the antitypical relations between the anterior and posterior extremities must be learned from those vertebrates in whom they are actually *fore* and *hind;* and for this, when time and opportunity allow, such works as that of Strauss-Durckheim on "the Anatomy of the Cat;" of Della-Chiaje on that of the Testudo Europæa; and of Meckel on that of the Ornithoryncus, with the more comprehensive work of the latter anatomist, "Traité genérale d'Anatomie comparée," will be invaluable. Prior to these investigations, any such inferences as may now be drawn from the human structure must be regarded as provisional and by no means as conclusive.

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general plan of the muscles any more than if the fore-arm were, in some one species, broken, and thus movable at the middle of its length, some of the muscles being inserted upon the proximal, and others upon the distal moiety. Moreover, the muscles specially connected with this joint, lie all upon the same side of the limb ; namely, with the flexors of the fore-arm and the extensors of the hand, while, if it were a real joint, we should expect to find the supinators or extensors on the same side as the flexors of the fore-arm, and the pronators or flexors on the same side with the extensors of the hand ; but in fact, as before stated, they all lie upon the same side; whereby the long supinator and pronator are both made to assist the flexion of the fore-arm, which is evidently of more importance than its extension. The radio-ulnar articulation is therefore a teleological interpolation, presenting none of the characters of a true joint between the real segments of a limb.

The two opposite movements of pronation and supination are performed by two sets of muscles; those of one set are short, the *pronator quadratus* and *supinator brevis*, arising from the ulna, the first segment above their insertion ; those of the other set are long, the *pronator teres* and *supinator longus*, arising from the humerus or second segment above their insertion ; and here, as with the muscles of the true joints, the short muscles have but one action, to move the radius or counteract each other ; while the long ones either act directly in a similar manner or indirectly flex the fore-arm, the segment which, as to its fixed bone, the ulna, intervenes between their origins on the humerus and their insertions on the radius. The *biceps* is really the most powerful supinator of the radius, and can turn the palm of the hand completely upward ; while the two supinatores can only bring the thumb or radial border of the hand uppermost. There are four muscles acting directly upon the hand, (carpus and metacarpus;) two flexors, radial and ulnar, and two extensors, radial and ulnar ; the ulnar flexor and extensor arise chiefly from the bones of the fore-arm, and are the short muscles, since they come from the first segment above that to be moved, and the two radial are the long muscles arising from the humerus, the second segment above. The long, or radial extensor, is also the indirect flexor of the fore-arm, and perhaps, morphologically, the radial flexor is the indirect extensor of the same intermediate segment, though I am not aware that it ever is so actually ; and on the contrary, when, as in the horse, the humeral condyles are wanting, the extensor arises on the *inner* side, *below* the centre of motion, and would thus act as an *extensor* of the fore-arm, while the flexor arises from the *outer* side *above* the centre of motion, and is therefore physiologically a *flexor* of the same segment.

If we regard the fingers as a single segment, then there is a short and a long flexor, *flexor communis sublimis* and *flexor communis profundus ;* but these would then seem to arise each from one segment above what would be expected ; the former from the humerus, and the latter from the fore-arm ; but the *insertion* of a muscle is of more importance morphologically than its *origin*, which latter is in relation to the required length of the muscle and the proportion of parts, and therefore more liable to vary ; so, taking the less modified foot for comparison, it seems more natural to suppose that the *flexor profundus* is, morphologically, the long flexor, and the *flexor sublimis* the short; its origin having been moved upward two segments on account of the very extensive movements required of the fingers, more extensive in proportion to their size than those of any other part of the body.

With this view, the short flexor of the fingers, like the short flexor and extensor of the toes, is inserted into the second phalanges. That the proper short palmar muscles of the thumb and little finger are not the true representatives of the short flexor is shown by their co-existence in the foot with an unmistakable short flexor. There is no long extensor

It will now be shown to what extent our teleological morphology, as it were, of the long and the short muscles has been traced in the lower limbs of man. The ilium, unlike its longitype, the scapula, is firmly attached to the vertebral column, and does not, even in appearance, constitute a segment of the limb. Physiologically, the short and long direct flexors of the thigh are the *iliacus* and the *psoas magnus*; but the former is without doubt the morphological representative of the *subscapularis*, which is in man an internal rotator, but in most other mammalia an accessory flexor of the humerus; and the real antitype of the *teres major* is the small muscle first described under the name of *scansorius* by Traill, ("Observations on the Anatomy of the Orang-outang (Chimpanzee)" Memoirs of the Werne-rian Natural Historical Society, vol. iii. Feb. 7, 1818;) afterward by Prof. Owen, ("Myology of Simia satyrus," Proceedings of Zoölogical Society of London, January 25 and May 30, 1831,) and lately by me, ("Contributions to Comparative Myology of Chimpanzee," Boston Journal Natural History, page 369, vol. vii.)

The long flexor of the humerus, *latissimus dorsi*, seems to have no posterior representa-tive; the *glutæus maximus* at once suggests the *deltoid*, and may be the morphological as well as the physiological short extensor of the femur; while perhaps that portion of it which arises from the sacrum, represents the long extensor, corresponding with some one of the subdivisions of the *trapezius* of quadrupeds; for it must be remembered that when in them the clavicle is wanting, certain *contiguous* portions of the *trapezius* and *deltoid* become *continuous*.

The *glutæus medius* and *psoas magnus* are suggestive of the *supra* and *infra spinati*, and the *glutæus minimus* of the *teres minor*; the *pectinæus* represents the *pectoralis major*, and the *ad-ductores brevis, longus* and *magnus*, are only excessive developments of what the *coraco-brachialis* is anteriorly; their great size in man being in evident relation, not only to his erect position but also to his firm seat on the noble animal which is to him strength and speed; but in the ape the rami of the ischia and pubes are lengthened downward, and so the adductors arising therefrom act powerfully as extensors of the limb in leaping.

The close antitypy between the direct extensors of the leg and those of the fore-arm has always been remarked, and Cruveilhier even gave to the former the name "*triceps femoralis.*" The *rectus*, like the scapular head of the *triceps humeralis*, is also the indirect flexor of the femur, the segment which intervenes between its origin on the ilium and its insertion upon the inner bone of the leg; the patella, a sesamoid bone developed in the tendon of the extensor, is generally considered to be the longitype of the olecranon proc-ess, both from their ordinary relations to the tendons of the muscles and from the fact that the latter is developed from a distinct osseous centre, and does in man sometimes exist as a separate piece connected to the shaft of the ulna by the continuation of the tendon. The *sartorius* resembles the muscle called "*epitrochlien*" by Duvernoy, and already referred to in this paper; but the former, since there is no long flexor of the femur, takes its origin from the anterior superior spinous process of the ilium.

But if the direct extensors of the leg are morphologically satisfactory, the flexors are quite the reverse, and in them is at once seen the effect of the twofold duties imposed upon the lower limbs; the muscles are too numerous, and most of them are long ones. The *semi-membranosus, semi-tendinosus* and *gracilis* attached to the tibia are apparently all acces-sory to the long head of the *biceps*, which, inserted upon the fibula alone, is probably the real long flexor of the leg, and thus the antitype of the *biceps humeri*, as the short head of the *biceps*, when it exists, is accessory to the *poplitæus* which is the antitype of the *brachialis anticus*, and thus the short flexor of the leg. Ordinarily, all the muscles of the lower

extremity take their fixed point of action at the *distal* instead of the *proximal* ends of the several segments, and the accessory long flexors of the leg are evidently more important as mutually counteracting, and thus as balancing flexors and extensors of the pelvis, than as either direct flexors of the leg or indirect extensors of the thigh.

The direct extensors of the foot are, in man, very large, and two of them, the *gastrocnemius* and the *soleus*, with the enormously developed tarsal bone, upon which they are inserted, seem to bear relation to the above-named physiological necessity; however, they are very good long and short muscles accessory to the *tibialis posticus* and the *peronæus longus*, which seem to be the morphological short and long extensors; and in the Aï, (Bradypus tridactylus,) the latter muscle does actually take part of its origin above the knee-joint.[*]

The short flexor of the foot is the *tibialis anticus*, and the long the *peronæus brevis*, which in man is also made to act as an extensor by its tendon passing behind the outer malleolus, which, however, like the lower extremity of the fibula, is by no means constant in mammalia.

The toes are provided with a short and a long flexor, — *flexor brevis digitorum*, and *flexor longus digitorum*, — and with a short and long extensor with corresponding names; but the morphology of these, and their relations to those of the fingers, will be more easily learned from some animals in which there is more resemblance between the carpus and tarsus without any such prominence of one bone of the latter, as in most mammalia, and especially in man.

The following table may serve as a contribution toward a more complete understanding of the correspondences between the muscles of the anterior and posterior extremities:—

				ANTERIOR.	POSTERIOR.
Humerus and Femur. 1st Segments.	Flexors.	Long.	Ac.	Latissimus dorsi,	?
				Pectoralis major,	Pectinæus,
		Short.	Accessory.	Teres major,	Scansorius,
				Subscapularis,	Iliacus,
				Teres minor,	Glutæus minimus,
				Infra-spinatus,	Glutæus medius,
				Coraco-brachialis,	Adductors,
	Extensors.	Long.		Deltoid (spinal),	Glutæus maximus (sacral),
		Short.		Deltoid (scapular),	Glutæus maximus (iliac),
			Ac.	Supra-spinatus,	Psoas magnus,
Fore-arm and Leg. 2d Segments.	Flexors.	Long.	Accessory.	Biceps,	Biceps (ischiatic head),
				Epitrochlien,	Sartorius,
					Gracilis,
					Semimembranosus,
					Semitendinosus,
		Short.	Accessory.	Brachialis anticus,	Poplitæus,
				Supinator longus,	Biceps (femoral head),
				Pronator radii teres	
				Supinator brevis,	
				Pronator quadratus,	
	Extensors.	Short. Long.		Triceps, (scapular head),	Triceps (rectus or iliac head),
				Triceps, (humeral heads),	Triceps (vasti or femoral heads),

[*]Meckel, " Traité Géneralé d'Anatomie comparée." Tome vi. page 413.

	ANTERIOR.	POSTERIOR.
3d Segments. Hand and Foot. — Flexors — Short. Long.	Flexor carpi radialis longior, ...	Peronæus brevis,
	" " " brevior,........................	Peronæus tertius,
	Flexor carpi ulnaris,.............................	Tibialis anticus,
Extensors — Long. Ac.	Extensor carpi radialis,...........................	Peronæus longus,
	Palmaris longus,..............................	Plantaris,
	....	Gastrocnemius,
	Extensor carpi ulnaris,............................	Tibialis posticus,
Short. Ac.	....	Soleus,
4th Segments. Fingers and Toes. — Flexors — Short. Long.	Flexor profundus digitorum,........................	Flexor brevis digitorum,
	Flexor sublimis digitorum,........................	Flexor longus digitorum,
Ac.	Palmaris brevis,	
Extensors — Long.	Extensor proprius pollicis,........................	Extensor longus digitorum,
	" " indicis, ...	" " "
	" " minimi digiti.....................	Extensor proprius pollicis,
Short.	Extensor longus digitorum,..........	Extensor brevis digitorum.

We have now seen the general plan, or the morphology, according to which the muscles of the mammalian limbs appear to be arranged, and also the general use, or the physiology of that plan; but in no case have we found it so closely adhered to as to exhibit what might be called a typical condition of the parts; everywhere we detect some variation according to the special functions of the muscles. The attachments of a muscle may be changed, as with the short flexors of the fingers; but this is far more common with respect to the *origins* than the *insertions*, if indeed the latter ever are changed; the origin of a muscle may be even duplicated, as in the *biceps humeri*. Quite often there are extra (accessory) muscles, as about the shoulder and hip; and of some of the latter, (*obturatores internus* and *externus*, the *gemelli* and *quadratus lumborum*) I have not yet been able to discover the morphology; occasionally, too, a muscle is deficient, at any rate in ordinary animals, as the longitype of the long flexor of the arm, *latissimus dorsi*.

We may not in every case be able to see the precise value of these variations from the general plan; nor can we even generalize them by asserting that they are more numerous and difficult to understand, at the two extremities of the limbs, as might be expected from the great mobility allowed by the ball-and-socket joints at the one, and the increased number and combined movements of the parts composing the other, and that the muscles are most regular in the intermediate regions of the limbs.

But whether we comprehend them or not, all these variations must have a foundation in use; for all morphology is for the sake of teleology; it is true the relation is also that of cause and effect; but each effect becomes in turn the cause of some use below it, while each cause is the effect of some power above it, till we reach Deity, from whom all things are. In their highest terms morphology and teleology are as Creator and Creation, as God and the Universe: the one can only be manifested through the other, which again is heterogeneous and scattered without the former. It is the universal principle of "concentrated representation;" many particulars uniting under one general, which in turn unites with others under a higher, and so on to Infinity.

Morphology and teleology *appear* as master and servant; but this is only an appearance of the relation when viewed *a posteriori;* and a view *a priori* shows that the reverse exists

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quite as truly. The advantages are mutually conferred, and it is only a division of labor. The commander of a company holds his position both *from* and *for* his men, and only thus can several companies be represented in a regiment, several regiments in a brigade, and so on up to the commander-in-chief, who really represents all beneath him; but what is he without them? Every superior is, or ought to be, more truly the servant of his inferiors, who while they appear to obey him really serve themselves. Broad as is our land, it cannot limit the application of our national motto. " *E pluribus unum*," is not merely a national motto, but the concise expression of an all-pervading law, the basis of the highest natural, human, and Divine order.

It may now be asked, Which is of the greater importance, and deserving of the more attention,—morphology or teleology, the general laws, or the particular facts and uses which they represent? The answer to this question will vary with the three degrees of depth to which our search is carried. At first we exclaim, " The *facts*, of course; they only have an actual existence, and are of any real use; they must be diligently collected and examined; they are strange and beautiful, and our wonder and admiration are constantly aroused." But there is something beyond this. The facts resemble each other, some more, some less, and soon we arrange them in groups, acknowledging, if such grace be given us, that those groups really did exist before we saw them; our minds are occupied with these; we give them names, and delight in contemplating the laws and principles they suggest to us. We find, moreover, that, though *immaterial*, they have a most *substantial mental* existence, and now we accord to this study the higher importance, and, mounted upon our philosophical superstructure, are inclined utterly to ignore the groundwork.

It is as if one had labored long in piling stones together to build a lofty tower, and at last standing upon the single block which forms the summit, forgot all below, acknowledging only himself and the result of his own work. If he stays there, it is clear that he can be of little use to himself or to any one else; he must descend and show to others the way up. And now if he does this,—if he has employed his temporary elevation in looking abroad and beneath as well as above, and, more than all, if he imparts to others the superior information thus acquired, and instructs them that they also may ascend, then he has accomplished far more than if he had remained below surrounded and overwhelmed by the unarranged, and therefore uninstructive abundance, or had stayed at the top, proud and disdainful of those beneath him; and he now perceives that the former position was undesirable and the latter impossible without the other, and accords to each its true value in what he can accomplish with their combined assistance.

These three states of mind are respectively those of the unthinking but observant child, of the reasoning philosophical youth, and of the wise man who, having passed through both these stages, has attained to something better than either,—a power and a disposition to use what he has gained for others.

Three states are mentioned. There is really a fourth, but it is the first in the series, and corresponds to the embryo, which manifests no life, and is as it were the ground in which are implanted the others in their order. It is the stage of inactivity, of preparation, and it is easy to see the analogy between this and the lowest sub-kingdom of animals. The first and the last states seem in a measure to resemble each other on a lower and higher plane, as the vertebrate type stands over the radiate. And as the mature animal and the full-grown tree, in all their strength and beauty, expend their best energies in the elaboration of just such simple eggs and seeds as those from which they sprung, so the latter are the morphological epitomes of what may be, the other teleological expressions of what has been.

Among students of Nature, the three latter states of mind are respectively those of the mere collector or dissector; of the votary of morphology and classification alone; and lastly, of the favored few who happily combine them both, and thus accomplish more than with either one alone; and can we not see that the industry which has succeeded in accumulating such vast numbers of facts is already giving way to philosophical reasonings and a clearer comprehension of the same? The last stage of science is one to be striven for with full belief in its existence in the future.

ADDENDUM. For extended definition and illustration of Teleology, see the chapter on Teleology of the Skeleton of Fishes, in Owen's Comparative Anatomy, Vol. ii.

NOTE. The foregoing paper, in a much less extended form, but containing most of the principal ideas, was originally prepared and presented as a Thesis at my graduation in the Department of Comparative Anatomy and Physiology in the Lawrence Scientific School of Harvard University in July, 1862. Since its revision I have received from Professor James D. Dana copies of the following papers by him : —

1. "On Cephalization." From the "New Englander" for July, 1863.

2. "On Parallel Relations of the Classes of Vertebrates, and on some Characteristics of the Reptilian Birds." From the American Journal of Science and Arts, Vol. xxxvi. Nov. 1863.

3. "The Classification of Animals, based on the Principles of Cephalization." Am. Journ. Science, etc., Vols. xxxvi. Nov. 1863, and xxxvii. Jan. 1864.

4. "On Fossil Insects from the Carboniferous Formation in Illinois." Am. Journ. Science, etc., Vol. xxxvii. Jan. 1864.

Also, from Norton Folsom, M. D., Surgeon of the 45th Regiment U. S. colored troops, the manuscript notes of an Essay by him "on Anatomical Symmetry," read at the Commencement of the Massachusetts Medical College, in July, 1863.

All these papers I have read with great interest and pleasure, not only for their intrinsic scientific value, but also because in some portions of them were contained confirmations of the ideas expressed in this paper, which confirmations are the more gratifying as coming from such masters in the science as Wyman and Dana, from the former of whom, Dr. Folsom writes, many of the ideas in his essay were derived.

I write this in order that the coincidences between the views in the papers above mentioned and my own may not be held to lessen the originality of what was written some months before those papers were read by me.

BURT G. WILDER,

Surgeon 55th Mass. Vol. Infantry.

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