ON

THE SCOPE, TENDENCY, AND EDUCATIONAL VALUE

OF THE

NATURAL HISTORY SCIENCES:

BEING

A DISCOURSE DELIVERED IN THE THEATRE

OF THE

ROYAL INSTITUTION OF GREAT BRITAIN,

FRIDAY EVENING, APRIL 20, 1860.

BY

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ON THE SCOPE, TENDENCY, AND EDUCATIONAL VALUE OF THE NATURAL HISTORY SCIENCES.

By T. Spencer Cobbold, M.D., F.L.S.

(Delivered at the Royal Institution of Great Britain, on Friday Evening, April 20th, 1860. Sir Henry Holland, Bart., M.D., LL.D., D.C.L., F.R.S., &c., Physician to the Queen, in the Chair.)

PREFATORY NOTE.

Severe indisposition, subsequent to the delivery of this Discourse, prevented my furnishing an abstract for the "Notices of the Proceedings at the Meetings of the Members of the Royal Institution," as stated in their recent publication, Part X., p. 243: I have therefore, according to promise, caused it to be printed *in extenso*. The interval has enabled me to introduce a few highly-finished Woodcuts, which will serve to explain those portions of the Address specially illustrated by reference to Diagrams suspended in the Theatre, and, at the same time, I trust, render the subject-matter acceptable to a wider public.

T. S. C.

Sir,—I purposely design that the subject proposed for this evening's discourse should be presented to you in the form of an appeal advocating and demonstrating the necessity for a wider diffusion of the Natural History Sciences.

In the earlier days of scientific pursuit, the cultivators of Natural History confined themselves, for the most part, to the

mere collection of cabinet curiosities, whose individual worth was estimated by comparative rarity or singularity of form, whilst the more important facts in regard to the relation of animal, vegetable, and mineral bodies, the one to the other, were entirely overlooked. In recent times, however, the votaries of science, by tracing out the intermutual relations and the reciprocal influences which these bodies directly and indirectly exert upon one another, have fairly realised the existence of a fundamental unity of plan pervading all created nature throughout *time* and *space*. I believe, indeed, with respect to this planet, that it is not too much to affirm, that in all epochs of the earth's history—in whatever phase its cosmical elements have appeared—the laws prevailing hitherto are the same as those in operation at the present day; whilst the singularly varied results which we now witness are regulated by the *degree*, *direction*, and *conditional circumstances* under which those laws are permitted to exercise their sway. To demonstrate the truth of this persuasion in its entirety is not my present concern; yet, I have not hazarded this generalization without careful, prolonged, and independent reflection.

Were it now my intention to develop the legitimacy of this hypothesis, it would be necessary—in order to give full effect to its claims—to furnish illustrations too numerous and varied for a single discourse. I will endeavour, nevertheless, to throw a ray of light on the matter.

As far as the mere toil of observation goes, whether natural or artificial, the Naturalist may be compared to an Astronomer, whose investigations embrace so vast a region, that in proportion as his examinations become minute, so do the limits of his study recede, appearing more and more distant and immeasurable.

Whatever section, or segment of the circle of the known, engages his immediate attention—and the same thing holds good if we suppose him to be acquainted with all the results which the combined experience of his fellow-workers has produced—whatever department of the known, I repeat, is occupied, the regions unexplored must necessarily enclose oceans of truth for ever hidden from his gaze.

Reflecting on such a consideration as this, I can readily imagine that some such a question as the following may occur to you, and I shall suppose that you put it to me thus: "If, as you aver, the known bears so insignificant a proportion to the unknown, might not a more extended acquaintance with those unexplored regions—assuming it possible to acquire this knowledge—produce facts or phenomena the study of which, if submitted to the ordinary inductive tests, would be sufficient to weaken or altogether overthrow your generalization?"

To this I confidently answer,—Certainly not!

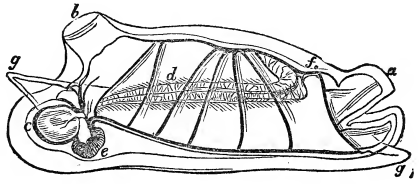
Let us, if you please, look more closely to the position of the Naturalist—or say, rather, the Biologist.

For the sake of illustration, we assume that a particular Fauna or Flora, or a particular group of individualities, or, in the case of the Comparative Anatomist, a particular system of structures (such as the organs of circulation) engages for a time his exclusive attention.

In any of these attitudes the Biologist is precisely in the position of a traveller mapping out the features of an unknown continent. By careful observation, powerfully developed by artificial methods of survey, he makes himself acquainted with all the phenomena presented within the limited area of his wanderings, and, by a comparison based chiefly on analogy, deduces a series of *general propositions* or conclusions in regard to that which lies beyond his reach. Experience has shown that in this way a correct and comprehensive generalization may be established respecting the actual condition of the continent in its entirety, although, of course, the traveller's conceptions of the minor features presented by unexplored districts must necessarily remain imperfect, or altogether fallacious. How is this? Simply, I argue, because, although the laws regulating the phenomena of nature over all parts of the continent are constant and invariable, the *degree*, *direction*, and *conditional circumstances* under which they operate may, and often do, produce such strangely-modified results, that when we descend to particulars we are sure to meet with the most irregular, varied, and unlooked-for phenomena.

Let us now apply this train of reasoning in the case of the Comparative Anatomist, selecting for special illustration Dr J. C. Van Hasselt's discovery of the peculiar mode of blood-circulation which obtains in Salpa (fig. 1)—a genus of tunicated mollusks.

Fig. 1.



The form of *Salpa* known as *S. maxima*, as represented by Milne-Edwards. According to the philosophical explanations of Prof. Huxley, this outline should be reversed, in which case the parts are as follows :—*a*, inferior lip of the anterior respiratory aperture ; *b*, posterior breathing orifice ; *c*, abdomen containing the visceral nucleus ; *d*, branchial lamina or gill ; *e*, heart and dorsal vessel ; *f*, nerve-ganglion, or so-called oculiform point; *g*, *g*, appendages of the test.

The direction of the circulating current alternates, the flux and reflux occurring at regular intervals.

The student of the circulation, who during years of investigation found this life-stream flowing through the ordinary channels in one invariable direction, has suddenly become acquainted with an

animal in which the direction of the life-stream is periodically reversed; and, to continue our *simile*, this new experience is comparable to that of the traveller who has accidentally stumbled upon an unexplored district presenting unique geographical features. Here, then, you perceive, is a natural phenomenon utterly at variance with the investigator's former experience; and this fact, whilst it cogently illustrates, on the one hand, the danger of drawing general conclusions from the study of isolated genera or data furnished within a very limited area, does not, on the other hand, destroy the value of a wider generalisation. The physico-vital laws regulating the flow of blood in *Salpa* are the same as those operating throughout the entire animal series; but the *degree*, *direction*, and *conditional circumstances* under which they act have given rise to phenomena not only unusual, but without parallel in the domain of the Physiologist's experience; and I have thus shown that in one department of Biology, at least, the Naturalist epitomises the practical knowledge of the traveller.

Again, I would ask you to bear in mind that the traveller or geographical geologist deals with phenomena as they occur in *space*. An evening's discourse would fail me to show you by illustration that phenomena in space have their dissimilar counterparts in *time*.

This idea, indeed, has been in some measure substantiated by the late Professor Edward Forbes, in his discourse 'On the Manifestation of Polarity in the Distribution of Organised Beings in Time,' delivered in the theatre of this Institution on the evening of Friday, 28th April, 1854. Nevertheless, calling to our aid the inductions of the Paleontologist, the experimental demonstrations of the Physicist, and the sublimer researches of the Astronomer, we are led to assume, by a species of analogy perfectly legitimate, that the laws operating throughout *space* are the same as those in *time;* and therefore I have submitted to your judgment a broad hypothesis, which, whether roughly or gently handled, is valuable only in so far as it reflects the harmonious outlines of inestimable truth.

Were it desirable, by a further reference to existing facts, to increase the force of our hypothesis, for this purpose *any* of the more remarkable chemico-physico-vital phenomena which ordinarily present themselves to the mind of the Biologist might with almost equal advantage be adduced, and the truth thereby be rendered more conspicuous. Quitting, however, this special application of the subject, I have further to observe, that throughout the entire range of organised existences—whether animal or vegetable—there may be traced a community of plan both in structure and development; and it is whilst engaged in the study of any department of Natural History knowledge, that we are sure to recognise its influence in the aspect of an all-pervading law. In every natural group of individualities, or of separate organs—such as those of special sense, for example,—the working of this law is more or

less conspicuous ; and it is the recognition of its existence despite the modifying power of interfering circumstances, which, to my mind, at least, imparts a perfect charm to study of the sub-sciences of Physiological Botany and Comparative Anatomy, enabling us to interpret accurately the signification of every structural and morphological peculiarity, whether it occur in the human economy, or in the framework of any plant or animal.

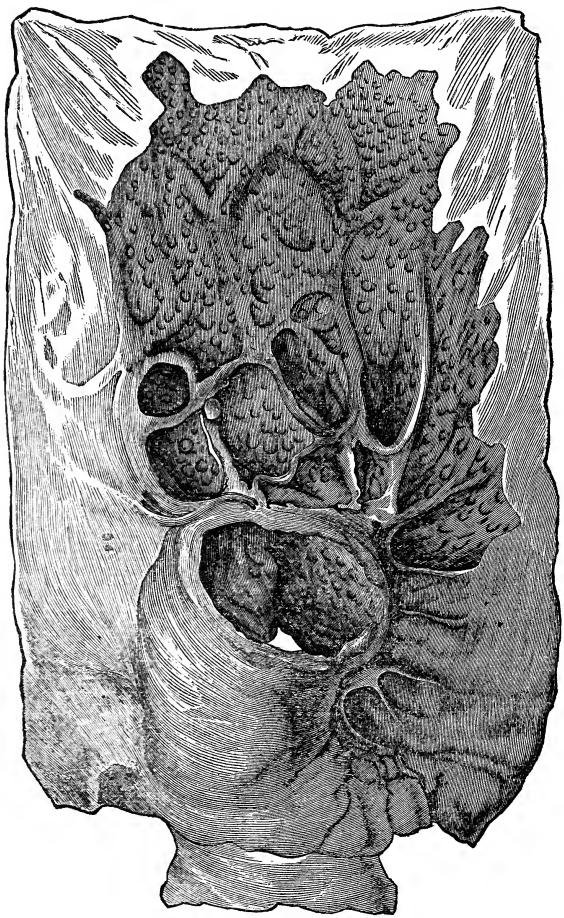
For the partial recognition of the bearings of this law—which Von Baer has defined as the "law of development from the general to the special"—as well as for the full understanding of its character, it is fortunately not necessary that our studies should embrace the whole range of Botanical or Zoological Science,—although, of course, our conceptions of its power and universality are enlarged to a degree precisely corresponding with the range and direction of our pursuits ; and as this community of plan, associated with variety of purpose, is not confined to any particular series of organs or organisms, it consequently follows, that (in order to meet the varied requirements of the several creatures in which special developments occur) we find the same series of homologous structures strangely modified in form and function to suit the foreknown exigencies of every species.

From the tenor of this last observation, it might seem very natural that I should revert to the seemingly opposed theories of Cuvier and Geoffroy St Hilaire ; but the points in their dispute have been so frequently commented on by abler speakers, that I shall only offer a passing remark :—I think we may fall in with the spirit of the Cuvierian hypothesis, and say thus much, at least, viz., that the totality of the phenomena presented by any individual, species, genus, or natural group of beings, indicates a distinct provision for the preservation and perpetuation of the individual, species, &c. ; this provision being limited by the operation of antagonistic forces from within and without, necessary to the welfare of other co-existing species, &c. ; and that the balance of these mutually-opposing influences is in the main progressive, conservative, and perfective. I have no wish now, however, to pursue this question further, otherwise I should be led to take into consideration Mr Darwin's theory in relation to the origin and succession of species. In regard to the hypothesis of Geoffroy St Hilaire, in so far at least as it applies to the development of particular organs, it is clearly manifest that many structures exist without the slightest utilitarian purpose being subserved by their presence ; these are mere type-manifestations or morphological indications of some organ whose assumed completeness may, or may not, be present in some other living or pre-existing allied species.

As an illustration of this, allow me to direct your attention to the occurrence of a singular pouched structure which I have discovered in connection with the ileo-colic valve of the alimentary canal of the Giraffe :

The intestinal glands in ruminants generally (as stated in my article *Ruminantia*, in the Supplement to Dr Todd's Cyclop. of Anat. and Phys.) do not offer any deviation worthy of notice; but here we have a curious exception to the rule affecting the last Peyerian patch which extends considerably beyond the ileo-colic opening. This organ is both striking and complicated, as seen in the accompanying woodcut (fig. 2). It will be observed that there are from fifteen to twenty sacculi, so combined as to form a network of cells, seven of them resembling in some degree the water-reservoirs of the *reticulum*, and having a depth varying from three to four lines: the remainder are more or less incomplete, whilst those farthest from the ileo-colic valve are mere depressions,

Fig. 2.



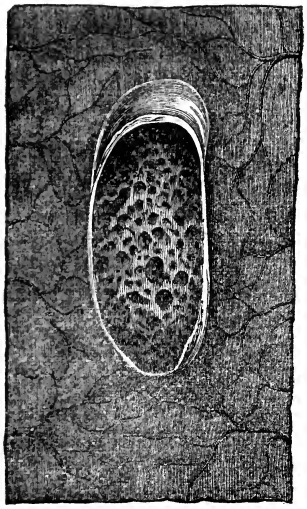
Sacculated Peyerian Gland adjoining the ileo-colic valve. From a Giraffe about two years old. Natural size. (Original.)

the walls of separation being scarcely elevated from the surface. With the exception of two small fossæ seen to left of the orifice, and three larger below towards the cæcal extremity of the gut, the entire mucous membrane, both within and without the pouches, is beset with follicles having precisely the same character as those of the last Peyerian patch within the small intestine. Some few of the sacculi are subdivided by secondary lamellæ ; but, generally speaking, these are not very prominent. The larger folds are extremely thin-walled, transparent, and extensile, so that the amount of secreting tissue becomes much greater than is at first sight apparent ; in one example, to the left of the figure, the orifice of the sacculus is much contracted, while the cavity, on the other hand, is particularly capacious. Altogether, without taking into consideration the laminæ, the follicular structure covers a space equal to about two square inches.

In a young Giraffe more recently dissected, I found this curious development still more complicated. In this case there were at least twenty circumscribed fossæ. Ten exhibited very small outlets, and two or three of the larger and more patent pouches displayed secondary sacs in their interior.*

A few of the Peyerian glands occupying the small intestine also display a tendency to this folding, and afford a consequent increase of the secreting element. This was especially marked in the younger Giraffe just alluded to ; but in the other animal the folds were also present, consisting of semilunar valve-like productions, forming a kind of hood overlapping the duodenal end of each patch. This is well shown in fig. 3, where the concavity of the hood is seen to be capable of admitting the tip of the little finger.

Fig. 3.



One of the ordinary compound or Peyerian Glands of the Giraffe, showing a valvular hood-like fold at the duodenal end. Natural size. (Original.)

* See 'Proceedings of Zoological Society' for February 1860, where full references are given to other original Memoirs in connection with this subject.

From these demonstrations, you will perceive that the Peyerian agminated follicles may be legitimately associated with the highly-developed compound lobulated glands, such as the sublinguals, the parotids, and the tonsils; and the latter, again, may be regarded as morphologically analogous, and also serially homologous with the liver and pancreas. The remarkably capacious outlet of the tonsil in the Giraffe renders this mere comparison still more instructive and significant.

There is yet another aspect in which the structure I have just described may be advantageously considered—a view which I have recently urged in the Anatomical Memoir communicated to the Zoological Society. I allude to it as an illustration of the value of anatomical research in relation to the determination of zoological affinity. The Giraffe is an animal admittedly aberrant and osculant, partaking of characters more or less common to the cervine, antilopine, and cameline ruminants; yet, here we have (in addition to the peculiar horns and partially distinctive cranial, lingual, and external modifications suited to the animal's mode of existence) an entirely unique development connected with the digestive system. When, therefore, it is considered that this marked peculiarity is not known to be shared by the allied families above referred to, and that the complexity of the organ has arrived at a point far beyond the ordinary development of Peyer's glands, I think it but fair that Zoologists should welcome the discovery of a structure which, whilst it lends aid to their definitions, justifies the recognition of the Giraffe as the type of a separate family. This argument loses none of its force from the circumstance that this separation has been advocated on other grounds, such as arise out of the presence of pseudo-keratophorous epiphyses associated with other superficial characters.

In the tracing out of such relations consists the charm of Zoological pursuit, and this is a tendency common to all Natural History Sciences. On independent persuasion, therefore, I respectfully argue that no viscus or system of tissues should be excluded from the characters employed in the determination of zoological affinity—certainly not, at least, when any marked deviation from a classic, ordinal, or generic type is sufficient to impart distinctive cogency to the balance of hypothetical analysis. The comparative perfection of our knowledge of the proper definitive allocation and relative position of organised beings—whether arranged in groups, species, or individualities—doubtless depends on the accuracy and grasp which an extended experience is calculated to supply; but I also submit (and herein, you perceive, lies an argument for the wider diffusion of the Natural History Sciences) that no structural phenomena, great or small, external or internal, scarce or invariable, can be too unimportant to be carelessly eschewed.

With restricted views and artificial classifications, therefore, the Biologist can have no sympathy. The Natural History Sciences must not be allowed each to resemble an eviscerated carcass, but their proportions should be shaped, and their constituent parts

welded together, by data culled from every phase of Biological inquiry. Sometimes the principle of classification may legitimately embrace the consideration of purely chemico-vital manifestations; and in the case of Zoology, we have seen that it may prominently involve a recognition of deep-seated anatomical appearances.

Before leaving this part of our subject, I may observe that the principle of classification is intimately associated with the study of Morphology; but at this stage of the discourse I can do no more than refer to one particular generalisation, which has also an important bearing on the hypothesis first submitted to your notice. It is this, viz., that "the variation of all animal and vegetable forms is subject to a law of geometrical proportion." We cannot now follow up this inquiry; yet I venture to think that, in addition to the curious results obtained by Mr Hay in reference to the application of mathematical principles to the æsthetics of the human figure, and likewise to those obtained by Professors Mosely, M'Cosh, and others, in respect of the forms of shells and plants—in addition, I repeat, to these (associated with other like generalisations, such as the "law of spiral development" and the "law of numerical proportion"), I think it can be shown that similar geometrical laws are applicable to the harmonies noticeable in Zoological affinity, and, possibly also, to the distribution of species. Be that as it may, all nature is but a cycle of harmonies, wheel within wheel; but the relation of the enclosed spheres is so complicated, that to fathom the resources of any group of them requires a combination of powers beyond the reach of any single individual.

Bearing in mind the practical considerations I have in view, permit me in the next place to direct your attention more particularly to the educational value of the Natural History Sciences.

The study of Geology, Zoology, and Botany, collectively or in part, may be rendered more or less subservient in every walk of life; and even to those who pursue these sciences as a source of intellectual gratification they offer peculiar advantages. All of them are fit and easily-accessible sciences for training the mental powers of observation, and, at the same time, if allowed to exercise their full and legitimate sway, they are eminently calculated to advance our social interests. Let me put this more precisely.

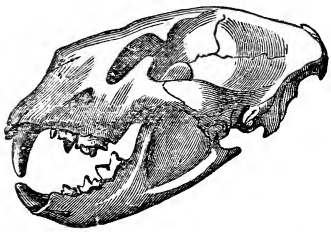
In the daily routine of life, whatever direction our duties may take, or whatever character they may assume, it is admitted by all that nothing is more essential than a well-regulated mind, able to observe, to store up, and to form a correct estimate of the value of facts; and the possession of an intellect of this discerning habit is of immense importance, not only in the acquisition of knowledge, but in the formation of correct opinions. It is granted, indeed, that in so far as the requirements of a man of narrow sympathies are concerned, a fair amount of the so-called common-sense principle may be all that is absolutely necessary for his material advancement; yet, if we desire the higher intellectual

developments of a well-regulated mind—such as the faculty of a retentive memory, a power of detecting the most subtile distinctions between one thing and another, and a thorough comprehension of our social position—we must look to the culture of our mental processes. The absence of a retentive memory is by no means indicative of original stupidity, want of application, or lack of talent; yet those who would become possessors of this valuable product of mental discipline, can only do so by pursuing some subject, the study of which involves a methodical and continuous process of abstract reasoning. Confusion and obliviousness are commonly the result of indiscriminate observation; and the highest degree of cerebral activity will fail to recall facts once familiarly known, unless the storehouse of the mind has been filled in a gradual and tentative manner.

One of the most constant results accruing from the diffusion of the Natural History Sciences is seen in the tendency of such pursuits to overthrow popular prejudices and preconceived opinions. In face of an assembly like the present, it may seem unnecessary to do more than allude to this simple fact; yet, when it is borne in mind that there have been Naturalists, otherwise deservedly eminent, whose habits of thought have led them to entertain unreasonable dogmas, it is clearly the duty of those who wish to take a more consistent view, to point out the impolicy of such a course. By way of illustration, therefore, I respectfully invite you to call to mind the essential characters of a typical Carnivore, and to bear with me whilst I show how entirely at variance with reason are the notions held by many respecting the final intention of the feline structure.

As I have elsewhere observed,* all the osseous elements entering into the solid framework of the feline skeleton (in its highest development) are massive and well proportioned; but it is in the conformation of the skull that we witness an adaptation to the carnivorous habits of the species most conspicuously. In the accompanying representation of the cranium of a tiger (fig. 4), the remarkable shortening of the fascial bones, associated with the powerful grasping teeth, and a surprising transversal breadth of the skull below the orbital and temporal fossæ, are especially significant. The teeth are thirty in number, and of these we find only four true and ten spurious molars, the ultimate grinder on either side of the upper series being tuberculated. This tooth, however, is particularly small, and widened laterally; but, with this exception, all the molars are much compressed

Fig. 4.



Profile View of the Skull of a Tiger.

* In my introductory remarks on the general structure of the Felidæ, in the 'Museum of Natural History,' vol. i., div. 1, Mammalia, p. 109. The *vivâ voce* description was an abridgment of this intercalation.—T. S. C.

from side to side. The crowns are sharp and pointed, the two series, during the action of the jaws, closing in upon each other like the blades of a pair of scissors. Their function is therefore essentially cutting, while that of the huge dagger-like canines, assisted by the incisors, consists in tearing and lacerating—the due performance and integrity of these actions being secured by the strong temporal and nuchal muscle acting upon the occiput and the lower jaw ; and further, to prevent any lateral motion, such as we find in those animals which grind and triturate their food, the condyles or articulating facets of the last-named bone are firmly lodged in the corresponding transversely-elongated glenoid sockets.

Co-ordinating with this prehensile and offensive armature of the jaws, we also find the structural modifications of the feet eminently suggestive. Those of the anterior limbs are pentadactylous, while the posterior feet are tetradactylous ; but the peculiarities which principally distinguish them arise out of the beautiful provision made for the preservation of their formidable retractile claws. The mechanical contrivances here displayed are perfect. Not only are the actions of flexion, extension, pronation, and supination amply provided for—by the peculiar manner in which the bones of the fore-limb are articulated together—but the muscles of this member are so prodigiously developed, that, as is well known, a single blow from the sledge-hammer-like paw of the lion or tiger will fracture the skull of a man, and deal out death to almost any animal that may happen to come within its ponderous swing. In addition to this, we find the claws ordinarily maintained in a state of retraction : this concealed position is accomplished by the agency of three elastic ligaments or bands, which being severally placed above and on either side of the digit, serve to connect the ultimate phalanx to the penultimate segment of the same toe. All injury to the claw is hereby prevented—a circumstance which, associated with the presence of resilient sole-pads of thickened submucous tissue placed under the ball of the toe, also serves to secure the characteristically graceful and noiseless tread of the feline animal. Antagonistic to the elastic binding cords above mentioned, the tendon of a large muscle, called the flexor profundus perforans, is inserted below into the base of the ultimate claw-supporting phalanx. When, therefore, it becomes necessary to display or employ these fearful instruments of destruction, a violent contraction of the muscle in question—which, of course, involves a drawing back of the tendon, and a consequent thrusting forward of the claw—is the principal agency by which this change is effected. There are likewise other small extensor muscles inserted at the upper end of the digit (fig. 5), serving to steady the movement and regulate the degree of protrusion, according to the will of the animal.

Fig. 5.

Dissection of a Lion's Foot, displaying the tendons and ligaments.

It may be further remarked that, although the above constitute the more prominent features in the various structural changes adapted to the wants and habits of the Feline Mammalia, there are others also worthy of being mentioned ; such, for example, as the strong, horny, recurved papillæ of the tongue, formed for rasping the soft flesh from the bones of their slaughtered victims—the comparatively small salivary glands, showing how little mastication is required—the uninterrupted chain of osseous elements extending from the larynx to the head—the flexibility of the vertebral column—the small cæcum—the shortness of the alimentary canal—and, more particularly, the simple cylindrical stomach, which explains that the food is more readily reduced to the condition required for nutriment than obtains in the Herbivora, properly so called.

Contemplating these arrangements, we unequivocally assert that the Carnivore is designed to occupy that particular field in the economy of creation for which its powers are so befittingly adapted; and one would scarcely suppose the legitimacy of this conclusion could be denied. Nevertheless it is. Some have, even recently, undertaken to teach that the organs in question—in which we are wont to recognise evidences of harmony and design—have been diverted from their proper development. They aver that the claws, teeth, and stomach—thus admirably constructed for the seizure, tearing, and digestion of the flesh of other species—so far from exhibiting evidences of benevolence, display rather traces of a different intention; all these organs severally contributing to render the creature ferocious, cruel, and destructive—habits which, in these anti-zoologists' views, the animal ought not to have! Such is an illustration of the melancholy inferences to which unscientific reasonings inevitably lead—a sad mimicry of mediæval times.

For the successful cultivation of the Natural History Sciences, it is above all things necessary that our minds be imbued with a love of truth, in whatever aspect it may present itself. If we perceive that the integrity of organised existences on this planet can only be maintained by the reciprocal action of antagonistic forces, and that the balance of this reciprocity involves and guarantees the welfare of every living entity *having*—in actual possession of—a residence on the habitable globe; if, I repeat, it is clearly evident that any departure from this divinely-appointed law would, on the one hand, only bring about a redundancy, or, on the other, a deterioration; what, I ask, is to be gained by criticising this universal plan—this wise method of government, fixed on principles of justice, equity, and compensation? In the nicely-adjusted balance of probabilities, I recognise abundant good to all living beings, whose immediate wants are thus provided for, and I am content to acknowledge the fitness of the provision which thus regulates the destiny of every species!

The vantage-ground thus imperceptibly acquired induces me, finally, to offer a more direct illustration of the *moral* tendency of the Natural History Sciences. Here, however, I may be brief, as the subject has been treated by other hands.*

It is a true observation, that things familiarly known and understood often fail to leave their due impression on the mind; yet this evanescence is in a great measure counterbalanced in those who court philosophy in common things. Some of the more striking phenomena, however, maintain their teleologic power, in spite of the deteriorating influences of familiarity, or the falsely so-regarded materialistic tendencies of developmental hypotheses.

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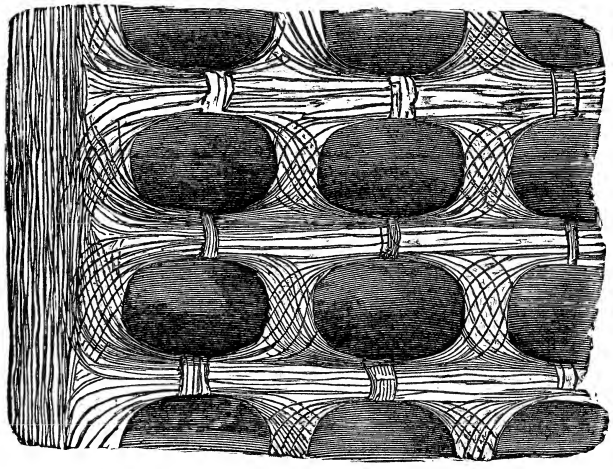
* See Professor Huxley's discourse 'On Natural History, as Knowledge, Discipline, and Power,' delivered at the Royal Institution, Friday evening, February 15th, 1856.

What theories, we ask, shall nullify our independent conceptions of the final cause demonstrable in an examination of the complicated mechanism of the Camel's stomach, associated as it is with other co-ordinating structures almost equally significant? Our reasonings are not fettered by the consideration that the stomachal compartments and their numerous water-cells (fig. 6)

Fig. 6.



Portion of the First Stomach or Paunch of the Dromedary, showing the water-cells.

remain, after all, mere diverticula of the œsophagus. In our view, on the contrary, these morphological variations do but serve to indicate a uniformity of plan, harmoniously blended with the development of other tissues, objects, and circumstances by which the creature is surrounded; and, therefore, whilst we admit, with Lavater, that every organ is "an assemblage of incomprehensible effects," we are at the same time led to recognise the fact, that each bears a strict relation to all exterior organic and inorganic phenomena manifested throughout time and space. Whatever be the history of differentiating specialisations, no matter whether we trace them in connection with the formation of groups, species, varieties, or even particular organs, I am prepared to maintain that such phenomena, if rightly viewed, are calculated to strengthen rather than to lessen our appreciation of the doctrine of final causes!

In regard to the important relations which the Natural History Sciences bear to the resources of art and commerce, these cannot now be entered upon; and this is the less necessary, as one

department of the subject, at least, has recently received able exposition within these walls.*

Brevity in the enunciation of my purpose may have failed to convey to you a due estimate of the scope and tendency of the Natural History Sciences; nevertheless, if the appetite has been augmented, the mind imbued, the desire enlarged, and the will provoked in the direction my arguments have taken, sufficient has, I think, been said to prove the necessity for a wider diffusion of the Natural History Sciences on purely educational and moral grounds. In order, however, that the student may derive durable profit from these studies, *it is absolutely necessary that the tutorial method of communicating knowledge should be combined with the delivery of public lectures.* I believe our Collegiate establishments, so far as the above sciences go, all fail in this particular. When private instruction by demonstration is superadded to public teaching, it is surprising what a relish and facility in acquiring information is thus imparted to the learner. The masses of uncorrelated objects by which the student of organic nature is at first surrounded soon marshal themselves before him like the serried ranks of a well-disciplined host, whilst day by day fresh levies crowd upon the circle of the mind's horizon; yet, notwithstanding this accession of numbers, and the varied uniforms they severally present, it is by-and-by perceived that harmoniety plan pervades their movements, and the meanest unit has its part to play, not only in the *struggle*, but also in the *enjoyment* of its existence.

Of course, in all this teaching, it is assumed that the tutor shall be something more than a mere book-worm—one, in short, who, by practical work in the field, and by careful observation, assisted by all available artificial aids—coupled with a more or less extended acquaintance with the labours of other workers—has it in his power to unveil the beauties of creation as they successively declare themselves to an unprejudiced inquirer.

Under these advantages the study of the Natural History Sciences is productive of the happiest results; the impressions left upon the mind being analogous to those which the ear receives from a well-sustained series of harmonies. Were these experiences, however, shared only by those who are occupied with the warm and cheerful precincts of vitality, the Biologist in any of his callings might afford to despise the researches of the Geologist; but, strange as it may appear to the uninitiated, a similar effect follows the contemplation of the frigid outlines of inert matter.

In a social point of view, I ask, then, finally:

Is it not a privilege to commune with those whose minds are

* In a course of lectures 'On the Relations of the Animal Kingdom to Man,' by Dr Lankester, F.R.S.

imbued with a love of Nature, as she attires herself in the ever-varying attitudes of organised existence? Is is not delightful to come in contact with those whose sympathies extend to objects placed beyond the narrow confines of their daily observation? Is it not congenial to welcome truth in whatever phase she is discoverable in the physico-chemico-vital records of a past and passing world? And is it not profitable, withal, to cherish glimpses of the infinite as we try to draw aside some superficial folds of that dark and many-plaited "veil which separates the seen from the unseen?"

To these interrogatories our learned Institutions will surely answer affirmatively; and I do not suppose the highest of them will object to the following definition of its final aim, as expressed in the language of Vicesimus Knox:—"Mutual improvement, and the investigation of truth; the development of the seeds of genius, and the detection of falsehood; the emancipation of the mind from the fetters of prejudice, and the cultivation of true friendship by social and liberal intercourse!"

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