THE TESTIMONY OF THE TEETH TO MAN'S PLACE IN NATURE

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THE TESTIMONY OF THE TEETH TO MAN'S PLACE IN NATURE

WITH OTHER ESSAYS ON THE DOCTRINE OF EVOLUTION

BY

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PREFACE.

SOME apology may be due to the public by the author for presenting them with what may seem an inconsequential series of essays. He hopes, however, that he may have some readers to whom they will not appear so disjointed as their titles suggest.

Being much interested in Natural History, Metaphysics, and Theology, he has from time to time worked up questions which presented themselves, and delivered most of these essays as lectures or papers at the Plymouth Literary and Scientific Institution, or the Odontological Society of Great Britain, by whose kind permission they are now reprinted. Some have appeared in the *Zoologist* and other periodicals. The first chapter, the ninth, the eleventh, and the twelfth, have never been previously published, and all the chapters have been rewritten and corrected up to date.

The essays themselves are of very various pretensions. Some only aim at suggesting thoughts as an amateur, which may find sympathy in the minds of those who have arrived at the same standpoint. Chapters IV., V., VI., VIII., IX., and X. are, however, the author believes, technically reliable.

In connection with the Darwinian controversy he directed his attention to human teeth, of which he had professionally plenty of cases for comparison. It might have happened that he had found the Darwinian hypothesis quite erroneous in this respect. There might have been no more likeness between the teeth of a man and a monkey than between a man and a cat or dog; but this was not so. The variations noticed in human teeth might have proved infinitesimal, or only connected with disease, and having no relation to the supposed derivation; but this was not so. On the contrary, every point on the evolutionary hypothesis was verified completely.

The difficulty of making the evolutionary hypothesis harmonize with the Bible has been strongly felt by the author. On further consideration of the subject, however, it appeared to him that the controversy arose from their being so very much alike in their statements; that taking into consideration the exceedingly different conditions under which they were written, they may be said rather to support each other than the reverse. No doubt the evolutionary theory may make homiletics a little more difficult, but I do not see in it any tendency to alter our spiritual or moral standards.

I am indebted to Mr. R. N. Worth, our Plymouth historian, for the illustration of the Batten skull, and to my publishers for the loan of the illustrations of human and gorilla skeletons. The rest of the illustrations were all drawn under my own supervision.

F. H. BALKWILL.

Plymouth.

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CHAPTER I.

ON PERCEPTION.

Slight summary of theories of perception—Plato, Aristotle, Descartes, Locke, Hume, Malebranche, Kant, Berkely, Reid, Browne, Gall, Spurzheim, Combe—Definition of Perception, Classification of states of consciousness, Hobbes—Definitions of will, anxiety, effort, difficulty, fatigue, success, failure, conception, sensation, time, space, motion, substance, perception, evidence, attention, words, purpose, truth—The external world—The perceptions through the senses and combination of muscular actions—Possibility of error.

VARIOUS theories have from time to time been started to account for our acquaintance with the external world, of which the following are some of the most notable opinions on the subject.

"Plato illustrates our manner of perceiving the objects of sense in this manner: He supposes a dark subterraneous cave in which men lie bound in such a manner that they can direct their eyes only to one part of the cave, on which shadows of external objects are thrown as they pass between the light, let in at the mouth of the cave, and the viewed wall." (Reid on Perception, vol. i., p. 63.)

Aristotle and the Peripatetics called the images presented to our senses "sensible species" or "forms," those presented to the memory or imagination were called "phantasms," whilst those presented to the intellect were called "intelligible species." Here we have a very good classification of what in later times, especially since Descartes, were termed "*ideas*."

The theory which the ancients seem to have held in connection with this system of *species* was, that films or images of their different qualities were continually given off by external objects, which were received by the senses and caused the species to arise in us.

Descartes threw over the theory of films and species, which seems to have degenerated into a very mystical disjointed jargon; and beginning with his own existence as the first incontrovertible fact, proposed, from his own thoughts, to infer an external world, instead of taking the external world for granted and then trying to account for his acquaintance with it. His followers, like the Peripatetics, divided the phenomena of perception into three heads; only instead of species they were called ideas, viz., those of sensation, imagination, and pure intellection.

Descartes' views were eagerly adopted, and the belief in innate ideas of God, right and wrong, cause and effect, and other general ideas, assumed the authority of scientific sanction.

Locke opposed the theory of innate moral or intellectual ideas such as those previously mentioned; but though he pointed out what physical philosophy has lately claimed to have discovered experimentally, viz., that substance could only be evidenced to the sense by different modes of motion or force, he still seems to have admitted that elementary sensation, such as blueness, sweetness, warmth, etc., were innate ideas suggested through the senses by the various motions of light, heat, and friction.

Hume pointed out the law of association of ideas. After any two ideas have been associated together, either by time, locality, resemblance, contrast or any other relation, the introduction of one subsequently was likely to give rise to the other also. This law of the association of ideas, as we shall see when discussing the theory of evolution, will probably prove to be of solid scientific value.

Father Malebranche supposed that there *was* an external world, as we were told so by the revelation of the Bible, but tried to demonstrate that we could have no immediate knowledge of it; that our perceptions were ideas communicated to our minds by contact with the Divine mind, Who, as He created everything, must have the ideas of everything in His mind, and communicates them to us on the occasion of their necessity. He proposed the theory that we formed our own ideas, but rejects it as improbable; it is, however, I think, worthy of more attention.

Kant pointed out that if there were an external world, our ideas of it, when right, would be of a different value to what they would be when wrong, and classifies the mind in these two states under separate names. Where the evidence is not conclusive nor the object corresponding to the idea formed, he calls "opinion." Where the evidence is not conclusive, but the idea does correspond to the object, he calls "belief." Where the evidence *is* conclusive and the idea, of course, in correspondence with the object, this he calls "certainty." Without considering the correctness of his nomenclature, the observation is a valuable one, and we may frequently remark the difference in value of the state of mind relative to an object being correct or not, although arrived at from the same evidence.

A sees B pass him at a little distance, and remarks to his companion, C, "There goes L." "No," replies C, "L is out of town." "I am sure it was L," replies A, "I saw his face." They give chase and overtake B. "Well," says A, "I thought it was L. I thought I saw his face clearly enough." Or, on the other hand, it really turns out to be L, and A would probably congratulate himself by saying, "Ah! I *knew* I could not be mistaken," stamping the fact of his knowledge by how it turned out, not by the strength of his impression.

We constantly find this distinction practically made and allowed; where no practical result depends upon the correctness of a person's opinion or belief, he is only expected to show that he had as good or better evidence for holding that, than any other view; but when a result depends upon an external fact being rightly appreciated, he is often condemned by the result, not by the evidence he can produce in excuse for his judgment.

Bishop Berkely showed that our perception of visible distance was not from perceiving the angle which straight lines make with each other when drawn from the eye to the extremities of the object, but was the result of experience, not of any necessary, but of the *usual* accompaniments of distance, as comparisons with known intervening objects, dimness and diminution of apparent size.

The size or intensity of a perception, he measured by taking the smallest possible sensation as unit and multiplying it. "Whether or no *matter* be infinitely divisible," says he, "may be questioned; but there can be no manner of doubt that the sensations of the mind are not so."

The smallest possible sensation he calls "points of perception." I think Locke had also indicated something of the same sort.

Berkely contended that, as there was no resemblance between the ideas communicated to us from any object by touch and sight—between the appearance of an object near and far off and under the microscope—there was no evidence of any external world; that these perceptions were the words by which the Supreme Ruler communicated to our minds what to do, and what to prepare for, and that when we ceased to perceive a thing it ceased to exist. He advanced this view as an argument against Atheism.

It is rather surprising that we should have the same theory advanced in the present day by Comte, to deny that we have any right to try to account for phenomena by attributing substance to them.

"There is nothing in nature but mind and ideas," says Berkely. "Nay," says Mr. Hume, "there is nothing in nature but ideas only; for what we call mind is nothing but a train of ideas, connected by certain relations between themselves."

Dr. Andrew Reid was tired of trying to reconcile the ideas in the mind with their object, and cut the Gordian knot by supposing we did actually perceive the object itself, "for," says he, "when I think of Alexander the Great, I must have the *idea* of Alexander in my mind and think of the real Alexander as well; but I only think of one Alexander, therefore I immediately think of the real Alexander without any intermediate idea at all." With much merit Reid applies to his theory the method of supposing it to be correct, and then trying how it would work in fact, and explains by it the laws of perspective. Unfortunately we cannot so easily explain the phenomena of perception; this theory leaves error unaccounted for; if there had been no real Alexander, we might have thought about him all the same. The merit of Reid's observation lay in pointing out that we refer sensations received from what we believe to be an external object, there, where we believe the object to be.

Dr. Thomas Browne showed Reid's mistake, and laid great stress upon the *feeling* that accompanied any phenomenon being the means of discerning its relation to ourselves and other phenomena. Memory he describes as "certain feelings arising in the mind, with the feeling that they have been there before."

Gall, Spurzheim, Combe and the phrenologists attempted to prove that the whole range of human action is the result of separate organs of the brain specially adapted to each class of ideas; so that external objects only excite ideas in that mind which has a particular organ adapted for its reception.

Although their system can hardly rank as a theory of perception, still in their works are found some first-rate studies and exercises on individual peculiarities of perception, showing that objects, which are as clear as the sun at noonday to some minds, are entirely unperceived by others.

Let us try and come to some understanding of the meaning in which we are to take this word perception, before trying to account for our possession of the faculty of which it is the name.

If I look at a statue of Apollo, I say, I perceive it. Now if I shut my eyes, I shall have an idea of it in my mind, and with that idea I have also the conviction that there is still the real Apollo there where I see it when my eyes are open; but still I do not say I *perceive* it; perhaps the most intelligible way of expressing this will be to say that I have a conception of it. But whilst I look at it, I am conscious that the variously shaded figure which meets my eyes is not the conception of it which I have when they are shut, nor very much like it, although I may have an impression that one is derived from the other. As well as the figure on the eye I conceive of another side to it, which would present another shaded figure to the eye, if I went round it; I conceive of some weight and hardness in it; if I saw it falling upon me, I should not enter upon any very abstruse reasoning before moving out of the way. The variations of shading make me conceive that if

I alter my position so as to bring these parts into profile, they will manifest certain relative modifications of outline. Although I can see the whole of the statue through the pupil of the eye, and therefore on the surface of a circle of less than a quarter of an inch in diameter, yet from the knowledge of its distance from me, and certain sensations of perspective, I conceive of it as being some seven or eight feet high. Therefore, as well as the abiding conception I have of the statue when I perceive it, I have a certain indication of its relative position to myself coming through the eye and altering with every alteration of this position. This, which can be excluded by obstructing the organ of sense which receives it, we will call sensation; and as both sensation and conception are necessary to perception, our definition may stand thus :—

Our conception of the external world immediately accompanying sensation.

It may be objected that this definition leaves out those perceptions of our own states, which Locke classifies under the head of reflections; but I think we may willingly leave them out as likely to confuse us, and not legitimately belonging to our subject.

It is not very difficult to classify the whole of our consciousness under three heads.

We can will. That is, imagine some end to be attained, desire to attain it, and act for its attainment.

We can feel. That is, experience pain or pleasure, happiness or misery, joy or grief.

We can perceive. That is, become conscious of external things, facts, etc.

Let us consider if the origin of feeling and perception can be traced to the will.

With regard to feeling, it seems pretty clear that the presence of external objects gives us pleasure or pain. The presence of a friend gives us pleasure, of fire to our fingers, pain and so on. All objects would be equally indifferent to us unless we had had some previous preparation relative to them, and as we could have no preparation before we existed *it is evident that we could have no ideas of pleasure or pain relative to external objects at the commencement of existence.* Now, we may notice in ourselves and others every day that the will is often set upon otherwise indifferent objects, and then the simple fact of obtaining them gives pleasure, or of losing them gives pain. Thus, then, it is not difficult to derive feelings of pleasure or pain as legitimately flowing from the will. And, moreover, it strikes us as an intelligible and sufficient cause, appreciable to our understandings.

To *imagine*, is a necessary ingredient to the will, as is well pointed out in the following quotation from Hobbes.

"And because *going*, *speaking*, and the like voluntary motions, depend always upon precedent thought of whither, which way and what, it is evident that imagination is the first internal beginning of all voluntary motion." (Hobbes' Leviathan, vol. iii., p. 38.)

Having the power to will something I will take it for granted that we do so, that is desire, and try to fulfil our desires; in other words we act. But as there are external objects and forces surrounding us of which we are entirely ignorant (perception not being yet allowed), we will inevitably come into collision with them, that is, will find our will resisted. This will give us pain; we therefore act in another direction to avoid this pain and meet with fresh obstruction, perhaps differing in some manner relatively to our actions to the former obstacle, until at last we begin to imagine the causes of these obstructions, in order to avoid or make use of them.

Having imagined a cause to certain resistances, we shall act accordingly; when we are right we shall succeed, and the conviction that our ideas are correct will arise; whereas, when wrong, we shall fail, and then try and form fresh ideas by acting about the obstacle until we have got all its relations. Thus, I think we may account for conception; the imagination formed upon past action. But soon we are aware that some of these external objects are available to assist us in attaining our desires, the presence of these no longer gives pain but pleasure; and then again we find them hindering our designs, so that the same ideas being sometimes associated with pain, sometimes with pleasure, at last in themselves become indifferent though equally distinct, and hence we get simple sensation.

Hobbes has the following remarkable paragraph which very nearly expresses this view of the subject. "Concerning the thoughts of man, I will consider them first singly and afterwards in train or dependence upon one another; singly, they are every one a representation or appearance of some quality or other accident of a body without us; which is commonly called an object, which object worketh on the eyes and ears and other parts of a man's body; and by diversity of working produceth diversity of appearances." (Leviathan, vol. iii., chap. 1.)

"The cause of sense, if the external body or object, which presseth the organs proper to each sense either immediately as in taste or touch, or mediately as in seeing, hearing, and smelling, which pressure by the mediation of the nerves and other strings and membranes of the body, continued inward to the brain and heart, causeth there a resistance or counter-pressure, or endeavour of the heart to deliver itself, which endeavour, because outward, seemeth to be some matter without, and this seeming or fancy is that which men call sense, all which qualities called sensible are, in the object that causeth them, but so many several motions of the matter by which it presseth our organs diversely." Again, he says, "And, although unstudied men do not conceive any motion at all to be there where the thing moved is invisible, or the space it is moved in is for the shortness of it invisible, yet that doth not hinder but that such motions are. For let a space be never so little, that which is moved over a greater space whereof that little space is part, must first be moved over that. These small beginnings of motion, within the body of man before they appear in walking, speaking, striking and other visible actions, are commonly called endeavour." (Leviathan, vol. iii., p. 38.) Hobbes considered life but a quality of matter, and therefore describes all human action and passion as merely the relations existing between this live matter and the external world; if he had but given the initial motion with the power to choose in what direction it would move to the will, I should have had nothing to do but to have accepted his definitions and worked them out; but if the order of motion be exactly reversed, it will fairly represent the theory advocated.

When we have got so far as to receive conceptions of our own body and the rest of the external world immediately accompanying sensation, in other words, perceive, we shall perceive that all external objects stand in some relation to our actions, either to facilitate or oppose their attainment, and it is by no means derogatory to the initial freedom of that will to say that once determined it will become a law that we must desire all those relationships which are subservient to the original volition, and the absence of those averse to it.

Now, according to our premises, the satisfaction of our will gave a feeling of pleasure. Therefore, with the perception of the relationship to our desires of any external object a feeling of pleasure or the reverse would arise.

To this feeling of the relationship of anything to the desire, I can find no very well authenticated name. It is rather more, I think, than the "general feeling of relationship" of Browne, and more peculiarly individual than the "Divine idea" of Fichte. It is possibly that known by poets under the name of spirit; as the spirit of the woods, mountains, mammon, etc. But there is a popular word which is often used with this meaning in a superficial manner, and as it is the best I can find at hand I shall make use of it. It is *Purpose*, and its definition will be as follows:—"That feeling of relationship to our actions which accompanies the perception of any external object." For convenience, the word will be used objectively as well as subjectively. Objectively it will be the relationship of any object to our actions.

The following are a few general definitions of words used in this sense:—

To imagine an end to be attained, to desire that end and to try to attain it—is—TO WILL. To meet with resistance is *Sensation*, with uncertainty of success – Anxiety.

To try to overcome the resistance is *Effort*. Continued uncertainty of success is—*Difficulty*.

With continued effort—*Fatigue*.

Success—is *Joy*, *Pleasure*, *Happiness*, etc.

Failure—is *Pain*, *Grief*, *Unhappiness*, etc.

To form ideas of the external world from resistance is—*Conception*.

The same objects of conception being found sometimes in aid of, sometimes against the will give—simple *Sensation*.

A change in the relations of the same object gives the idea of—*Time*.

More than one object at the same time gives the idea of—*Space*.

Motion gives at once the idea of Time and Space.

A consciousness of identity existing with change of states, of will, sensation and feeling—gives an idea of—*substance.*

The recurrence of a sensation gives the conception already formed of the substance supposed to give it —AND IS PERCEPTION.

When the conception of the external world is sufficiently correct to maintain a consistent, continuous form, so that the general outlines need not be often altered, *memory* begins.

Passed sensations, whose ideas are relied on, when used to make fresh conceptions, are—*evidences.*

On the look out for fresh evidences to complete a required idea, is *attention.*

External objects, when used to make the desires of one mind known to another, are called *words.*

The feeling of relationship to our will, and therefore, in the second place to our actions, of any object, or combination of objects, or state of things, is *purpose.*

The correct purpose of anything—THE TRUTH.

But if there be no special sense to the nerves of each organ, it may be asked why we have the different organs. To this, the following reply may be made:—

It cannot be denied that the external world differs, as much as it appears to the senses to differ; and not only so, but the means by which it is manifested to us must equally differ, for there could be no difference of perception where there was no difference in the evidence. Hence it will be seen that our bodies are continually surrounded and assailed by all those forces or manifestations, which we call light, heat, sound, scent, taste, touch, &c. If all these were received by one organ of sense, we may well understand how next to impossible it would be to get any clear ideas out of such a confused chaos of sensation ; but by having several organs, so constructed that each one shuts out all the motions or impacts, with the exception of those giving a particular class of evidence, and arranging these for the best advantage to the sense, we may arrive at all the beautiful harmony and yet distinctness of the senses as we now find them. And we shall have, as it were, a natural analytical machine which classifies, and sets in order food for our minds without any effort of our own.

The idea of the different organs of sense will rather be, that they are sieves or gauges of divers sizes which reject all matters except those of a particular fineness; and that our conceptions of wherein one class of sensation differs from another, will lie in the difference of purpose of one class from that of another.

Tactile and muscular pressure are commonly regarded as alone sensible to resistance, because of the greater visible bulk and displacement which accompany their sensations, and of the much greater expenditure of force which these consume. The speedy exhaustion of the nervous centres by muscular action, is the cause of muscular effort being so much more speedily followed by weariness than other perceptive effort ; but the same organ, nerve, conveys the powers of resistance to the muscles as conveys the power of touch to the fingers, or sight to the eye, and recommunicates the kind of resistance met with to the sensorium.

In touch we are made aware, by filaments of nerves disposed over our bodies, of any displacement which their parts suffer by contact with external bodies.

When we conceive of any injury by these means occurring to our frame, by which we are to attain all our ends in the world, of course it gives us pain. Pain seems best associated in *purpose* as "a sense of injury," which, being very defined in all its relations, is acute, and being material in its origin, is commonly known as physical pain. Thus, a small accession of heat, which, being but a form of force, in some way rather promotes the easy working of the machinery, gives us the pleasurable sensation called warmth; a larger amount disintegrates the matter of our bodies and throws it out of gear, and we have a painful burn.

The conceptions we have from muscular action have generally been associated with those of touch, because touch is necessary to muscular action, and conveniently provided to its use; but they are in reality the most widely separated of any of the senses. Mere touch is perhaps the simplest of all the senses, whereas by our muscular action our highest intellectual requirements are attained.

The letters of the alphabet are only twenty-six in number, and yet how apparently infinite are their combinations. The muscles of the body number some hundreds, so that it is not suprising if the conceptions acquired by different combinations of their action should be also infinite.

But so evident is the connection between our muscular actions and the conceptions to be derived from them, that I think I need no further refer to it.

The next sense, in order of fineness, will probably be taste.

Here, as well as tactile sensations, and muscular action, feeling the forms or consistencies of bodies, the organ is so arranged as to take in the differences of liquids and so judge of solids as they dissolve. It is placed so as to judge of the suitableness of those substances from which, from time to time, the body receives fresh supplies of substance and force, and what wonder if it arrives at peculiarly agreeable or disagreeable feeling in accompaniment of its sensations?

The surface of the tongue is covered by minute papillæ of very different forms, in which fine filaments of the nerves are differently disposed; and there is no more difficulty in supposing that this mere mechanical difference should give difference of sensation, and each sort of papilla be enabled to comprehend something that the other could not, than there is in supposing that the same sensation of touch gives a different perception, whether we touch a tumbler with the elbow or grasp it with the hand.

Our conception by smelling is probably of some sensible object floating in the air, or the quality of gaseous bodies. We pass these over our tongues, but no difference of sensation is caused; but we often find that certain sensible qualities floating in the air are the forerunners of food, and hence a savoury smell will probably be one of the first pleasures of this sense.

The organ of smell is certainly sensible to solids and liquids, but they are so inimical to its well-being, that we soon learn to avoid paying attention to them through this channel; hence sensations of this sort do not much enter into our conceptions of scents. Sometimes in early attempts at bathing, we may smell salt water, but this is an exception—perhaps rarely becomes a habit; and on our first acquaintance with snuff, we shall probably reject it as unsuited to the general purpose of the organ.

The nose is a chamber which is crossed in many directions by thin plates of convoluted bones, over which is spread a membrane in which lie the fibrils of the olfactory nerve. Through this chamber we have the power of passing at will a current of air or gas; when we do so, the whole of the displayed filaments are cognizant of the same sensations at once; there are no sudden successions of vibrations which force their way in, whether we will or not, as in sound; there are no parts partially affected as in sight. So that grant but nerves delicately organized enough to perceive the differences which can float in gaseous bodies, and the organ as we find it in its mechanical arrangements, and I do not see how we want any ideas of special sensation to account for notions of smell.

Hearing disputes the palm of rank in the intellectual scale with sight, because by means of it, in connection with the muscular actions of the vocal organs, we can so readily convey our purposes to each other. It is also perhaps the one in which it is easiest to disassociate the sensation from its cause, and to show that there is nothing at all resembling the sensation of sound external to the ear (save in how far is preserved to it the order and degree in which the motions fall).

These motions of the air pass off from their cause, so far as surrounding objects will permit them, in globular ripples at about the rate of 1120 feet per second; and as they are pretty regular in their comparative relations to their causes, and are capable of infinite modification, they are a palpable means for affording us evidence of all the resisted motions going on for a good distance round us. They are made available in the following manner:—At the end of a funnel which somewhat concentrates the force of the vibrations, they strike upon the surface of a flexible diaphragm, which, being thus moved, communicates the motion to a series of small bones, and they, in their turn, convey the message to the true ear. The last bone of the chain is called "stapes" or "stirrup," which fits exactly into an aperture in the bony part of the second chamber of very complicated and curious shape, of which the object is not, I believe, very well known; this is filled with a fluid in which the fine filaments of the auditory nerve float, and which receives sensations from concussions of the liquid, in at any rate the same order and relative degrees of intensity as has occurred externally.

Is there any wonder that the conception of sound differs from that of smell and taste? It ceases with the cessation of the interrupted motion, and therefore we cannot attach to it the idea of being a quality of any external body. Motion here, is scarcely possible without friction, so that in a general way one of its chief purposes is to warn us of passing events in aid of our eyes, and also by many complex processes, in combination with all our other faculties, to enable us to learn of each other, in some dim manner, what feelings, sensations, perceptions and purposes we are experiencing, when in bodily presence one of another.

Now, far greater in number, importance and worth, are our desires regarding each other, than concerning the rest of the external world; so, associations of pleasures of a higher class may fairly be expected to accompany the exercise of this organ than either that of touch, taste or smell.

Just such superiority, in fact, as we find claimed by lovers of music for its pleasures over those of the three former senses.

Lastly sight, of all the organs of sense, grandest and most truthful! It seems profanity to suggest that there is only a difference in degree of velocity, size, form, &c., between the sensations of colour and that of a cricket ball striking the body; and yet I suppose I shall not have the physical philosophers against me, if I assume that light is but a mode of force or motion.

But whether it be a mode *of* motion, or a substance *in* motion, there is no doubt that we see by means of the light coming from the object, and producing an impression upon the retina of the eye; not from our seeing through the light to where the object is.

However we may move round an object, so long as the rays of light can reach our eyes in a clear straight line, we see it; therefore there must be rays of light proceeding from the object in all directions, in fact forming the same globular ripples as those forming sound, and it evidently depends upon the external mechanical arrangement of the organs, that our sensations of light are not similar to those of smell or sound, except perhaps in the fineness or acuteness of them. For if the rays of light were allowed to fall immediately upon a net-work of nerves delicate enough to be affected by them, it is evident that the whole of the displayed nerves would be affected by every object within their scope, and the only difference which each new object would make to the field of vision, would be a general alteration of tint.

But the direction of the ripples of light are all changed by falling upon and passing through the varied surfaces of the lens in front of the retina, in such a manner that the radii of the ripples of light converge after passing through the lens, so that their point of meeting again shall be just upon the retina, which of course will give a different point for every external object to which straight lines can be drawn from the eye. Now, as the axis of these doubly converging rays will be a straight line from the point of sensation on the retina, the following will be an illustration of the relationship to external things which the visual picture represents.

Ornamental mosaic work, of tables, work-boxes, &c., is made by taking a number of thin strips of differently coloured woods and gluing them together in such order as to form a beam, the transverse section of which, at any part, will show the required pattern ; thin slices are then cut off one end, to be used as required. Such a mosaic work of colours will explain our conception of sight, with the exception, that the bars of colour must be supposed to be radiating, instead of parallel and ever changing with our changing positions.

What we see is the opaque cut end of the beam, and all our conceptions of the different lengths of the rods at the other end are the result of other combinations and previous experience. Thus, as Bishop Berkely very truly remarks, the visual image is not really like anything that exists, or is like very few things. It is, perhaps, something like a painting or photograph on a flat surface ; but it expresses our position in relation to things externally, and *vice versâ*, and we form conceptions of those things just so far as all the actions of our other powers enable us to ; in other words, we get with the sensation of the coloured image a *feeling* of its purpose.

The artist sees a glorious sunset, with freedom of space, wildness, power, and a lovely assemblage of harmony and contrasts of colour, giving him a motive or purpose for a painting, where the fisherman only sees a storm coming.

Light is composed of impulses or waves so minute, that 20,000,000 would measure but one inch; these fall upon the eye with intense velocity. The intensest sensation we receive from them is produced by gazing at the sun, but as this causes with it some feeling of pain by being injurious to the organ, we may take the purest white we can gaze upon without such pain as the purest, simple sensation of light. If we come upon a well-defined surface giving off this motion, we shall see a white figure, and if a defined space in the centre of this is devoid of motion, we shall see a black figure there! If we get an intimate mixture of these figures so small that they are separately indistinguishable, we shall get shades of black or white, whichever predominates. Now suppose we get figures equally brilliant to these shaded ones, but composed of different modifications of motion—giving equal degrees of contrasts among themselves, but at the same time giving no difference of sensation to any other organ of sense, what better idea can we form for these than colour? Sensation being, as it were, the substance of the will itself, which may be, and probably is, different in every man, although, relatively modified by external facts, the same in every one. Thus A's sensations of red, blue and yellow, may differ from B's, but they will differ from each other as much in B as in A.

Having acquired the use of our senses, we shall rapidly acquire other conceptions. We shall see a form always accompany us, which, whilst other forms are continually changing place, is more constant; we shall find that changes in the visible relationship of other objects to this form affect our other senses, whence we shall soon get a determined idea of our own body as such. We shall probably conceive all substances to be as like ourself, in essence as they are in motion; we see the child hurt by the table call it "naughty table," and strike it.

It is not necessary that there should be any great logical acumen, or much cogitation, to account for the great precision and accuracy to which common-sense perceptions attain. The law which regulates their growth, I believe to be very similar to Darwin's theory of the origin of species.

It is a common observation of any new or untried theory that as much may be said against as for it. The same may be said of almost any logical theory, but when it comes to be acted upon, there will be the tendency, in facts, to establish the correct and dissolve away the false. In the struggle for existence the weak ideas go to the wall.

It may be objected that we are not conscious of any effort or action in perception; but one reason of this is because we commonly think of muscular motion as action, as it is so visible, and uses up our stock of physical force so quickly, thereby causing that anxiety for the means to carry out our designs called fatigue; another reason is because our use of the muscles has a greater variety of choice and irregularity of action, so that they are more readily analyzed as voluntary efforts. Nevertheless, there is a continuous stream of force passing to all the organs of sense along the nerves from the sensorium, and if this is interrupted in any organ, sensation there at once stops. We may cease that continual acting upon the most internal parts of our sensitive system which we call attention, if this is only partial, from being strongly occupied elsewhere, we shall not perceive anything through the neglected sense, and the person is said to be absorbed ; if from desire for rest, we gradually withdraw our attention from all the senses, we are said to sleep.

It may be objected that we attribute the sensation to be there, where we conceive the object to be; but in the first place it is clear that it is not because we perceive it there; because if we touch anything with a long rod it will appear to us that we perceive it with the end of the rod, whereas, evidently we have no sensation in the end of the rod, it is only that the contrecoup of the rod in the hand gives us the idea of the object at the other end.

In the second place, as sensation is the first experience and the conception of an external cause comes after, the difficulty is rather to disassociate them than to account for their association.

Where this is easily done we do it, as for instance, when we do not attribute pain as a quality of the edge of a dagger, because they are not often associated, or are easily separated ; but we do associate our sensation of green with that quality in grass which causes it, because we can through our senses form no other idea of it.

In the third place, as it is only by our sensations that we can get any notion of comparative locality, there is no more difficulty in attributing the colour of pink to those walls, where I conceive its cause to be, than there is of attributing locality to myself at a distance from it.

A similar reply may be made to those who query, how are we to know that our life is not all a dream without any external world at all? The very actions and experiences which make us assume that a dream is *not* reality, are what have given us our belief in reality, and therefore to deny that they are sufficient authority for our belief is in fact to attack the belief itself.

On the other hand, if this theory of perception is applied, I think we shall find it rationally explain any problem properly comprehended under it.

According to it there must be many erroneous conceptions of men, which rank to them with all the authority of true perceptions. And do we not see whole nations have acted, and do continually act in complete error and confidence, in a manner inexplicable, unless they attributed their conceptions to external real things perceived by them?

In conclusion to sum up the whole argument. If we have no means of telling whether our conceptions of external objects are similar to the objects themselves, except by the evidence that acting amongst them gives, I think we shall not be very presumptuous if we assume that it was by acting amongst them that we got these conceptions, if we can find ground for believing that we have this power of conception. Is there a power in us to imagine, desire, and act, or are we only as lumps of wax, beautifully tempered, it is true, but only capable of receiving impression.

For myself, I confess, I cannot avoid the consciousness that I can act—that is, cause change in external objects with intention to do so—I can *choose* which of two courses of action I will pursue. That is, make a choice, an influence which did not before exist, nor was caused.

I can form an *intention*—an idea of something to be done in the future, and therefore not *impressed* upon me by any external object.

I can remember the past, which does not exist, and therefore again form an idea not impressed by any external object.

And last, though not least, I can make a mistake, and thus undoubtedly form an idea not impressed upon me by any external object.

This essay is no doubt very crude, and some of its positions hardly now tenable; but one of the points raised seems to demand attention, namely, that there can be no instincts or ideas implanted in any living being *before* it existed, they must therefore have come afterwards.

I have allowed it to stand without entirely recasting, as some of the metaphysical points discussed in it I have been accused of not having considered.

CHAPTER II.

HUMAN AND BRUTE INTELLIGENCE.

Reasons why writers on "Instinct and Reason" generally contrast, instead of compare, human and brute intelligence—Development of intelligence following lines of inheritance—Increment in man following the use of implements, articulate language and reflection—Physiological laws more nearly allied to habits of action than Chemistry or Physics—Co-ordination of perceptive and active organs—Sympathy of association—Variation of business in man parallel to variation of species in brutes.

HAVING arrived at the conclusion in the previous chapter, that our perceptions, as we now find them, must have been acquired after the commencement of our existence, whenever that was, let us compare our faculties with those of the lower animals and see if this consideration throws any light on the subject.

Previous to the popularity of the doctrine of evolution writers on mental science have been careful to exclude the mental or moral faculties of the lower animals from the limits of their subject before entering upon the examination of those of man; or if they have compared human with brute intelligence, it has been in its most violent contrasts, with the object of establishing essential differences.

This may have arisen partly from a feeling which considers it derogatory to man's moral dignity to trace any kinship, however remote, between him and his humbler fellow-creatures; and from a suspicion that to allow of any such comparison is inconsistent with the belief, that he has a soul capable of an immortality not to be attained by brutes; but also, and I think principally, from ignorance.

In consequence, however, of the knowledge which has been accumulated and systematized by modern naturalists, and more particularly in consequence of "Darwin's theory" having suggested an hereditary connection between them, there is a wave of thought now passing over us which makes the tracing and comparing of the affinities between the intelligence of man and the brutes inevitable. Such a comparison cannot fail to give some aid towards the comprehension of each, even if we are not yet able to lay down exactly wherein lies the great difference between them.

The more highly organized the animal, the greater its intelligence; so that the development of this faculty may be expected to keep pace in parallel steps with the evolution of physical organization.

The embryonic stages in the growth of many animals show marked resemblances to species lower in the scale, as has been pointed out in support of a hereditary connection. In the same way, when we analyze the human intelligence in order to conceive its simplest state and growth, we find a parallel resemblance to the evolution of intelligence as conditioned by the organization of the lower animals, which may be roughly tabulated thus :—

Simple volition accompanied by action and preceded by an imagined purpose.

This action being resisted by the external world, ideas are formed of this resistance, in order to overcome it.

Action repeated meets with resistance as before. The idea previously formed, to account for this resistance, suggests itself, and a perception is made.

It becomes more easy to repeat the same action than to try fresh ones to which unforeseen resistances occur ; hence habit is made.

Habit, or the will, or perhaps habit and the will, modifies the body for the better performance of certain actions ; hence organization.

Offspring inherit this organization. Their intelligence is conditioned to flow more readily in the same actions as that of their parents ; hence instincts or other hereditary mental faculties.

Thus far human and brute intelligence seem to run parallel. Then come the following conditions, wherein man's intelligence seems to have got quite beyond that of the brute :—

The increase of power by the use of implements.

The communication of information and the lessons of experience by articulate language.

The consideration of his own mental state with a view to improving it ; hence reflection.

Animals can be arranged, according to their structures and most essential characters, so as to form a more or less perfect genealogical tree. This suggests one of two conclusions: either the arrangement represents the successive steps of idea or invention by which they were created, or that all the different species have in reality the consanguinity which this classification appears to indicate.

One of the simplest forms of animal life presents itself as a little jelly-like mass, which, to quote Professor Huxley, "possesses all the essential qualities and characters of vitality; it is produced from a body like itself; it is capable of assimilating nourishment, and of exerting movements." It has no definite organs or parts; when it moves it pushes out any part of its body which is convenient. When it wishes to assimilate food, it can hardly be said to eat; it places itself over or against the food, which then passes directly into it through any part.

For such animals to be able to maintain their existence, the surrounding conditions of life—that is, a supply of food and the absence of a liability to mechanical or chemical injury—must be of the most favourable kind. Consequently we find that one of the first things done by animals of this type is to cover their delicate bodies with a tiny calcareous shell.

We have here, in one of the simplest forms of physical life, voluntary action, with power of changing the form of its body, power of adding to that body from other substances so as to grow by taking food, and a power of separating from itself a part which shall commence a new life with similar powers.

Such animals form the models of the ultimate parts from which all the tissues of all animals are developed.

Physiological laws, then, instead of having chemical or mechanical laws as their highest principles, can be best explained as habits of action. Each tissue and organ of the body is the record of voluntary action passed into habit and perpetuated into instinct by the "survival of the fittest," or some other law of suitability to the surrounding conditions of life. Every animal has therefore within it all the instincts of which its organs or tissues are evidence.

Here the question of individuality thrusts itself upon us. Is it the same life that continues on from parent to offspring? How do all these aggregations of separate animals lose their individuality and humbly class themselves as cells with fixed duties?

Does intelligence pass down from father to son? Have we dim memories of what our parents did? or does each individual begin his own experience and develop his own intelligence with such aid as the arrangement of his inherited organization may give him?

In many of the lower forms, the individuality of community only seems to have been arrived at. A sponge, for instance, is built up of a great number of small particles into canals and chambers, each of which particles "is provided with a cilium," to quote Professor Huxley again, "and as all these cilia work in one direction they sweep water out in that direction. The currents of water sweep along such matters as are suspended in them, and these are appropriated by the sponge particles lining the passages, in just the same way as any one of the Rhizopoda appropriate the particles of food it finds in water to itself. So that we must not compare this system of apertures and canals to so many mouths and intestines; but the sponge represents a kind of subaqueous city, where the people are arranged about the streets and roads in such a manner that each can easily appropriate his food from the water as it passes along."

In animals higher in the scale of life, when a nervous system has been evolved, this republican form of individuality soon ceases to exist. In communities of animals which have one economy, such as exists in a hive of bees, the individuality of the separate members is sufficiently evident. Thus, one solution of the difficulty which presents itself is, that through the nervous system a central government is established to the individuality of which all the rest of the organization of cells is subservient.

All action is not the result of intelligence. The heart beats, the watch ticks, without our considering either as signs of intelligence, because they continue their actions regardless of external circumstances which do not immediately affect them. If we saw them forecast and alter their actions to suit coming events, we should attribute the quality to them. If we conceive of a being understanding the working of a piece of machinery, we should allow intelligence to it.

To understand is in reality to translate the principles involved into the principles of the actions of the understanding one. So far, intelligence will stand for a power of a being to see the relation of external things to its own powers and purposes. Again, the formation of an intention or purpose would show intelligence. Or the consideration of its own purposes in relation to its circumstances, choice of some to encourage in preference to others, or formation of fresh ones, would manifest intelligence. Is intelligence, then, the power of creating idea—the imagination ?

We concede to the man who does difficult and responsible things, requiring at the same time great imaginative power, more intelligence than to him who, whilst giving evidence of equal power of creating ideas, is not capable of producing *successful* actions of equal difficulty. Is it not, then, the power to perceive truth ? and, as practically manifested, the power to perceive the relation of external things to a purpose, and *vice versâ ?*

Is this power of perceiving truth a substance or an attribute ? Intelligence perhaps could not exist without action, action without willing and feeling, yet our own consciousness bears us witness that these states are distinct ; hence we believe that they are but states of substance.

We are conscious we are the same individuals we ever were, whilst the substance of our bodies is being constantly changed by material loss and addition ; hence we get one distinct notion of a difference between mind and body, namely, that one is always the same and indivisible, whilst the other is easily divided and always changing.[1]

Our appeal to consciousness gives us the same answer; we can conceive that a mind cannot grow by little bits of substance being added to it, whether these possess intelligence or not; though this does not dispose of the question as to whether mind itself is not an attribute of life.

Intelligence is, then, the power of the mind to see the relation of external things to its own purposes, and *vice versâ*: but it cannot see or know anything beyond its own experience; it cannot grow, save by the efforts and experience of the mind to which it belongs.

I think if we take a clear view of these two conclusions—

The mind cannot be divided;[1]

Its intelligence can only grow by its own efforts and experience;

and add to them another—

The mind cannot be prepared before it begins to exist (is created);

we shall get rid of a great many indistinct notions which make many of the actions of animals appear inexplicable, and the direction in which we should seek their solution will be considerably restricted.

The conditions under which intelligence acts divide into two heads:—

First, the organization of the animal to which the intelligence belongs; its body, with which it is

[1] This position seems no longer tenable.

always associated in time and place (so far as we are speaking of it), over the actions of which it has great power. This body is its instrument in carrying out its ends, and requires constant attention to keep in good repair and readiness for use.

Second, the external world—liable to change in time and space—in which it must seek to satisfy its desires. If the animal can only perform few actions, the conditions necessary to its existence must be easily fulfilled. If, on the contrary, the conditions of life are varied and scattered, they require more considerable perceptive powers and complicated actions in order to enable an animal to avail itself of them; then, according to any theory of evolution, the organization of the animal will have been gradually fitted to meet those requirements, a more highly developed species will be the result, giving conditions for developing a higher degree of intelligence. It might be impossible for it to know how to perform such complicated action without considerable experience, and we find that where a high degree of intelligence is attained a more or less lengthened period of parental care is given. The necessity for parental care no doubt has a powerful reactionary influence in stimulating the intelligence of the parent, and may prove the elementary condition for developing sympathy into affection.

But there is a consideration which will show us that evolution, if a fact, must implant in every animal a tendency to perform the actions most conducive to its existence as a species.

The most simple animal has to use its intelligence on what perceptions it can make. It finds some things suitable for food or covering, which it appropriates; some unsuitable, which it rejects. This relationship of the object to the uses of the animal I propose to call *its purpose*, using the word for the object or combination of conditions, as well as for the volition of the animal to or from them.

All animals, except the lowest, possess special organs, those of sense enabling them to perform those acts by which they recognize general qualities of objects, as well as special organs of physical movement. When a *perception* of anything takes place, a conception is made, including all the sensations received from that object, together with whatever *purpose* or relationship to itself the animal may imagine it to have.

Now, if all that part of the organization by which information only is obtained has been gradually evolved from species to species as we ascend in the scale, the external conditions which brought them into existence must, at the same time, have entirely co-ordinated them, with the other active parts of the body, in accordance with the purposes of the species.

Whatever perceptions its organization conditions the intelligence of any animal to make, will be accompanied by a co-ordination of its other active powers corresponding to the usual purposes of that species.

There must always be in a species the organization to maintain its existence, get its food, propagate offspring, etc.; and the perceptive faculties which enable it to perceive the opportunity or right time to do this will be co-ordinated with the active powers for doing it. By this co-ordination the volition easily performs its purpose; and when conditions containing a purpose are perceived by an animal, the subjective purpose combining the necessary actions naturally flows forth.

In animals of high organization we should expect a proportionate number of subordinate purposes co-ordinated by superior purposes, which were commanded finally by the individual intelligence which directed the voluntary actions.

This co-ordination is established by means of the nervous system of which a general notion may be conveyed by comparing it to a telegraphic system permeating the body, in which the nerves represent the wires, and the grey matter of ganglia, or brain, the offices where messages are received and sent out. Intelligence is required to read the *purpose* of the message received, and to form the purpose which directs the actions ordered. For example, a fish pursues a smaller one in order to devour it. It does not use its intelligence to act all the complicated sets of muscles necessary in following the turns and twists of its prey; it merely forms a purpose from the information received from its eyes, and this purpose uses the already co-ordinated powers in pursuit. On a near approach, however, the fish sees something which makes it suspect its expected prize is a snare. It perceives an opposite purpose from almost the same visual sensations, and flies from it, the same co-ordination of muscles taking place under command of the contrary purpose.

Intelligence can only grow by its own efforts and experience; but a great deal of information or help may be had by the association of animals having similar wants. Sexual association must have immense influence in this direction. In animals of associated or gregarious lives it begets a sympathy of action which opens up a wide field for the transmission of motives or purposes thus becoming common to a species, which it might not be possible to transmit by the co-ordination of inheritable organization alone.

Amongst men, fashions, habits, and feelings are thus perpetuated; such as are necessary or "fittest" surviving, whilst those less perfectly adapted to life drop out. A law, with regard to motives, habits, etc., may be laid down almost identical in statement to Darwin's theory of the "Origin of Species." Habits of action, we know, can be thus transmitted by association, as when an English child brought up in France speaks French.

The power of the sympathy of association may be noticed in looking at a flock of sanderlings, which wheel and turn as if under the influence of one spirit. May not the migrations of many animals be thus explained?

Man supplements the powers of his body by the use of implements, and so varies his purposes or co-ordinated actions as to give a choice as to what sort of business of life he will pursue.

The choice of business to man may be compared to that of variation of species, and at once throws open conditions of action and reaction, to the development of his intelligence, of immense importance.

CHAPTER III.

COMPARISON OF METAPHYSICAL AND PHYSIOLOGICAL METHODS OF EXAMINING THE MIND.

Phrenology based on observation—Sir W. Hamilton exposes error in Phrenology—Metaphysics hopeless in physiology or pathology—Confucius on knowledge and heartsease—Knowledge of connection between Nervous System and intelligence only commencing—Law of reflex action—Nervous centre of speech in brain proved by diseased cases—Socrates, Shakespeare—Physiological Mental Science Materialistic—Sir W. Hamilton on absolute knowledge—Illustration from sound—Defence of spirituality placed upon procession of life from ovum.

THERE is perhaps no science which has undergone so complete a revolution of late years as that of metaphysics.

At one time considered the queen of sciences, its methods were almost entirely dependent on introspection of the consciousness. This position was attacked about the end of last century by Gall and Spurzheim's so-called science of phrenology, which at once became popular.

The cause of this popularity is not far to seek. Phrenology was founded to some extent on observation; so that there was considerable vitality in its nomenclature. It recognized and accommodated itself to an infinity of different modifications of personal character, a position which was abhorrent to the scholastic metaphysicians, who sought to maintain the doctrine of the absolute unity of the mind, and hence an essential identity in the fundamental state of consciousness.

Phrenology also professed to be so applicable that an adept could give the approximate mental character of any subject by examining the shape of his skull. It thus became at once interesting to a great many persons, thanks to a laudable curiosity which is not entirely vanity; though it is doubtful if the old philosophical admonition, "Know thyself," was intended to be fulfilled in this manner.

The metaphysicians felt the attack; and later, Sir William Hamilton, from 1836 to 1845, made numerous observations on human brains and skulls, and also those of some lower animals, with the view of exposing the fallacy of phrenology. He was completely successful in showing that the phrenologists were wrong in the functions they assigned to the cerebellum, and the mental faculties assigned to organs of the brain lying behind the eyebrows; and yet it may be questioned if he had not already given up the cause of pure metaphysics as a lost battle, by bringing it to the practical test of observing the facts of action in connection with the functions of the brain. He may be said to have been the last of the scholastic metaphysicians of pure consciousness of any note.

Since that time the physiologists and pathologists have been winning points all along the line, and raising questions as to the unity or solidarity of the consciousness, and its separableness from matter, which the old metaphysical method has been found inefficient to answer.

This new departure in the science has proved of immense use in improved treatment of mental disease. In the last century the treatment of the insane seems to have been shameful. According to a work on "The History of the Insane in the British Isles," by Dr. Hack Tuke, chains, flogging, and exposure to the climate without clothes, were by no means the worst of the common treatment. That this arose entirely from the scientific opinion of the unity of the mind, I should be loth to maintain: it is as difficult to imagine that it was pure inhumanity, though, to a certain extent, the logical outcome of a belief in the unity of the mind; for if the mind were an elementary substance, essentially distinct from matter, the delusions of insanity could only be understood as obstinacy, wilful error, wickedness, or possession by the devil. Such an explanation raised combative feelings in the caretaker, which resulted in harsh and punitive treatment. But, whatever the connection may have been, it is certain that with advance in knowledge of the connection between the nervous system and the mind, there has been an ameliorative and more humane treatment of the insane.

As was well said by an ancient eastern philosopher —Confucius, I think—"Let knowledge be increased. When knowledge is increased, the way is made easy. When the way is made easy, the heart is enlarged. When the heart is enlarged, the country is at peace."

It is not to be supposed that phrenology is to bear all the honour of this change of front. The general advance of the correlative sciences, as well as the use of the microscope, alone made it possible.

"Still," to quote Ladd, "it is a surprise from which investigation can never recover, to find that the connection between our sensations, mental images, and volitions, and the peculiar material constitution and functions of the cerebral mass of nervous matter, should be so intimate as it undoubtedly is."

The *doctrine of evolution* also had a helping hand in drawing attention to the relative facts of mind and nervous system; for if the mind, as we find it in human beings, was placed ready-made in the body, with all its emotions and capacities for action and reaction, a solution of the manner of their connection seems at once hopeless, but if, on the other hand, mind and body have grown up together through a struggle of ages from the most elementary form, their intimate connection would be natural, and their relations capable of being traced. Those who pursue this inquiry in comparative physiology say they find facts in accordance with this conception.

Without recapitulating the order and increment of complexity, it may be stated that the fundamental parts of all nervous systems seem to be central cellular or granular masses, called ganglia, supposed to be capable of sensation, forming ideas, purposes, &c., from which nerves run to the extremities and other parts of the body. The nerves are classed under two heads : around one are formed the active organs as muscles and glands; around the other are grouped the perceptive organs, as eyes, ears, &c. The generally received opinion is, that stimuli from the external world, impinging on the perceptive organs, cause these to transmit a message to the central ganglia, where an idea is formed from the message, judgment given on the relative import of the information received, and a suitable combination of active organs stimulated through the other or efferent nerves, to make what efforts the exigencies of the case require. In man the principal of these ganglia are the *spinal cord*, the *medulla onlongata*, the *cerebellum* and the *cerebrum*, as well as a great many smaller ones scattered about the body.

This circle of action, i.e., first impact of external stimulus on the organ of sense, transmission of intelligence to central ganglion, and transmission thence of co-ordinated action, is called the law of "reflex action."

Such of these actions as must, from the necessity of things, have been continually or commonly recurring, seem to have become automatic, i.e., proceed from the external stimulus without any further consciousness or judgment being used. For instance, Ferrier found that "a fish deprived of the brain maintains its normal equilibrium in the water, and uses its tail and fins in swimming with as great precision and co-ordination as before. It is, however, continually on the move. Left to itself in the water it swims in a straight line, and unlike other fishes, which stop to smell or nibble at this or that, it keeps on its course as if impelled by an irresistible impulse, and is only stopped by the sides of the vessel, or worn out by fatigue." (Functions of the brain, by *Ferrier*, p. 35.) The sensation of the water on the skin supplied the stimulus which resulted in the continued swimming.

It will be seen that the question of the unity of consciousness is here raised. The fish had lost in its brain the higher conscious or judging-power instructed by the various organs of sense, and therefore these no longer influenced the spinal cord; but the query remains, whether the spinal cord itself is conscious in its co-ordination of the swimming muscles. If merely automatic, it is still usually under the power of the higher nervous centres, as its actions are modified when in connection with them by their particular direction. Another question arising here is, whether the action of the spinal cord, if merely automatic and unconscious, was so always? or was it initiated in consciousness, and has it, after ages of use, passed out of consciousness?

The law of reflex action is a very general one, and a great many actions which we are perhaps accustomed to regard as voluntary or intelligent, are really produced by reflex action on a previously prepared nervous connection. Take, for instance, the act of reading. By slow and continual efforts we have established a nervous connection between the visual shapes of printed or written words, their sound to the ear, their oral utterance, and the usual meaning or relation which they have to our every-day actions. When we read, our action is almost entirely reflex; the sight of the words excites the corresponding idea or purpose in the sensorium of the brain, which combines and sends out the very complicated muscular actions which produce the articulate voice. In the case of blind people, who can read by feeling with the fingers, the initiation of the connection may have been by writing. We have thus seven or more different sets of reflex actions over words.

1. In three ways by hearing. We can hear a word—say the word *run*. This can be reflected through the mouth by our repeating the word, or through the hand by our writing it, or through our legs by running.

2. In three ways by seeing. We read the word *run*, which, exciting the central motor centre, can issue forth by vocal utterance, by the hand in copying the word, by the legs in running.

3. By feeling. As a blind man reading, which usually only issues out in action as reading.

There is the still wider and probably older set of reflex actions connected with words, where the various conditions under which we are placed produce thoughts or states of mind which we wish to communicate to others. In this there has to be a deal more intelligent effort used to find the right words; but the history of persons possessed of great gifts in this respect, points to the fact that there has arisen in the human sensorium certain connections between particular states of thought or feeling and words, so that the appropriate expression naturally occurs.

Persons under great excitement or peculiar conditions, utter often peculiar and unconventional phrases, which, however, at once strike the hearer as appropriate or natural, showing some previous connection between the feelings or thoughts and the words.

It is the word which excites the appropriate action in its complexity, the consciousness or will only giving it permission to go forth. This will perhaps be made plainer if I give in illustration the cases of Aphasia, or loss of speech; and Agraphia, or loss of power of writing, from disease of the speech centre in the brain. To quote Ferrier: "Examples of all these different conditions are to be met with in those afflicted with Aphasia. Some can neither speak nor write; some can write, but cannot speak; some can write their names, but nothing else. All can comprehend spoken language, many can comprehend written language; others not at all, or only imperfectly."

To quote Ladd: "Aphasia is far more frequently due to changes in the left, than in the right side of the skull. Out of 260 cases, Dr. Seguin found the lesion in 243 on the left side, and only 17 on the right." This is no doubt due to the fact that the right hand is usually used in writing, as motor stimuli would cross over from the left to the right side, according to a well-known law or fact. He goes on to say, "Remarkable cases of left-handed people, who have become aphasic through lesions of the right hemisphere, are actually recorded." It must be remembered that intelligence in other respects is apparently unimpaired; the articulating muscles of mouth and voice are not paralyzed, and can be used in other acts, as also the writing muscles of the hand and arm can be used voluntarily and intelligently.

The illustration occurs to us that the diseased nervous system is somewhat like a very complex railway junction, connecting a great many different lines, but some catastrophe has broken up all the rails, turning-tables, and shunting levers, into a confused marsh of soft clay and broken iron; so that when the trains come in from their separate courses they are lost, and can no more issue on the right routes.

But what would Socrates have said to this—"I am he who is talking to you, not that which you will soon see buried." Yet in this case we see that the "he who talks to you" is gone; and yet, at any rate, part of the intelligent being remains with his body, which is not about to be buried.

Shakespeare seems to have perceived the fact of there being subordinate motor centres. You may remember the scene in Macbeth, where he is waiting for the time to arrive when he shall murder Duncan. The motive centre forms the idea of a dagger, which is about to be used; but as the action cannot yet issue forth by the hands and arms, the intense excitement actually forces the idea down the optic nerves on to the retina, so that Macbeth fancies he sees a dagger in the air before him, and commences his soliloquy:—

"Is this a dagger which I see before me?" &c. Also in Julius Cæsar, where Brutus is contemplating the assassination of Cæsar:—

> "Between the acting of a dreadful thing
> And the first motion, all the interim is
> Like a phantasma, or a hideous dream;
> The genius and the mortal instruments
> Are then in council; and the state of man,
> Like to a little kingdom, suffers then
> The nature of an insurrection."

But does not this lead us to materialism? I do not think that necessarily it does; but still I am afraid that the arguments as against materialism, drawn from introspective considerations of the consciousness, in attempts to isolate it from matter by attributes of unity, inextensibility and solidarity, must be considered at present, at any rate, as having the weight of evidence against them. One great gain has certainly been attained in its being made clear that training is of much greater value than scolding in producing right action.

It used to be a philosophical apothegm, if not originally an oracle, that the highest knowledge was "to know that we knew nothing," which may have had three meanings. 1. That as a maxim of humility it was a good and wise position to take. 2. That the common-sense or knowledge of mankind, although a sort of knowledge, was usually so powerful that it was only the highest intellects that were capable of examining its nature, and who then found it so aberrant and unaccountable, that all they could say about it was that they only knew that they knew nothing. 3. That at the time of its utterance it was perceived how much there was to be known, but how little they then knew.

This maxim has been beaten out perhaps in almost every direction to absurdity. Some philosophers have denied that mind existed; some, as Berkeley and the idealists, that matter existed; whilst Hume, who was more consistent, denied the existence of either, and affirmed that only a sequence of sensations existed. Even Sir W. Hamilton considered that we had no absolute knowledge.

He says, "I virtually assert we know nothing absolute—nothing existing absolutely; that is, in and for itself, and without relation to us and our faculties. I shall illustrate this by its application. Our knowledge is either of matter or mind. Now what is matter? Matter, or body, is to us the name either of something known or of something unknown. . . . . In short, it is a common name for a certain series of appearances manifested in co-existence.

"But as these phenomena appear only in conjunction, we are compelled to think them conjoined in something. But this something, absolutely and in itself, is to us as *zero*. It is only in its qualities or effects that it is cognizable. That which manifests its qualities is called the substance. To this substance of the phenomena of extension, solidity, etc., the term matter or material substance is given, and is therefore, as distinguished from these relative qualities, unknown and inconceivable.

"The same is true as regards mind. In so far as mind is the common name for the states of knowing, feeling, willing, desiring, etc., of which we are conscious, it is only a name for a certain series of connected phenomena, and, consequently expresses only what is known. But in so far as it denotes that subject or substance in which these phenomena inhere, it expresses what in its absolute existence is unknown."

But is not this overstating the case? That our senses often give us false impressions is true, and that their information is very partial and often insignificant, must be allowed.

Take the illustration most commonly given, that of sound. If we hear the blow of a hammer on an anvil, it appears to us that the sound is produced there where the hammer touches the iron. If we hear it at a greater distance we hear the sound some time after we see the blow fall, and it appears then to us that the sound has traversed the space straight to us from the blow. But when we find that all persons standing a distance in a circle round the anvil hear the sound after the blow is struck, but at the same time as one another, we get the idea that the sound has travelled from the centre like a circular ripple on a pond when a stone is thrown in; and when we find that the same holds good in all directions of space, we get the idea that the sound has progressed like a rapidly expanding bubble. Still we conceive it as sound proceeding in this form. But when we are shown that sound is only a sensation produced in the ear, not at all like what produced it, we gain the further conception of this bubble being only a film of compressed air or motion communicated to the particles of air without there being any sound at all outside our ear. The question arises, what has become of our absolute knowledge? We thought we were absolutely certain "we heard a sound."

If anything exists and has relations, including actions and reactions, what do we mean by having absolute knowledge concerning it? Is it not absolute knowledge if we know that it does exist, and has such and such relations, actions, and reactions? What more can there be to know about it?

To say, therefore, that we do not know anything absolutely about the substance of matter or mind seems to me in reality only to amount to saying that we cannot know all their relations, actions and reactions; which may or may not be true.

Now we know that matter exists by the sensations it produces in us, which is one of its relationships; and we also know that its actions must differ relatively, as there are relative differences in these sensations. For instance, the sound in our ear may be said to be unlike the blow of the hammer on the anvil, yet in the same relation as those blows fall will be the sounds in our ears; as they are heavy or light, slow or quick, so will the sounds be in our ears. So that I think we may still say correctly that we are absolutely certain we heard the blows, although we certainly do not know all the relations, actions and reactions set agoing by these blows.

The argument for the materialist, therefore, lies something like this: It is not a good argument to say that the mind is not a quality of the body because it does not feel a bit like the body looks, as that is merely saying that it does not feel, when you are in it yourself, like it appears to the organs of sight when in another person, or like certain portions of the anatomy appear when dead.

It seems to me that so far the materialist has the best of the argument, and that we shall have to shift the field of battle to the primordial cell from which all life comes, for if it can be shown that of two cells originally precisely the same, as far as material qualities are concerned, one proceeds to become a tomtit and the other a turkey, it will go hard with the materialist to deny something within that cell beyond its material qualities.

The one must be a tomtit organization the other a turkey organization — in embryo

CHAPTER IV.

ON SOME OF THE CORRELATIONS BETWEEN TEETH AND OTHER ORGANS IN MAMMALS.

Adaptation of teeth to requirements of animal—Indication that this points to use of flint implements, as reducing size of human canines—Cuvier, Owen—Echidna, ornithorynchus, Sloths, Armadillos, anteaters, no front teeth, huge claws—Kangaroos' teeth, action of—Guinea-pigs' teeth, action of—Hedgehogs' teeth, action of—Narwhals' tusk, development of rhinoceros, no teeth as weapons, horn instead—Hippopotamus' teeth as weapons, no horn—Ruminants rarely canines, horns instead—Teeth of ruminants, action of hogs with teeth for weapons, no horns—In most mammals lower canines close in front of upper.

THIS chapter consists, for the most part, of a paper originally read before the Odontological Society in 1869. It is given here as bearing on the question of the adaptation of the organs of an animal to its requirements; also because of a statement of an apparent correlation existing between organs which are used as weapons.

Front teeth being absent, immense claws furnish weapons or tools. Canine teeth disappearing, horns appear.

This is not a universal law, as some extraordinary fossils have been described by Professor O. C. Marsh in America, "Dinocerata," with trenchant canines and apparently horns as well. However, these animals are very aberrant forms, and looking at drawings of the skull I feel impressed with the idea of the supposed horn cores rather supporting hard callosities of the skin than actual fighting horns; in fact, the idea suggested is that the animals used their heads in moving piles of fallen timber, either to get at prey or some particular food, or perhaps form retreats in which to shelter. But be this as it may, the correlation existing between the various organs of offence and defence, showing that as one weapon increases in efficiency another dwindles or disappears, has a bearing in the evolution of man.

If a man be descended from an ape, which seems almost certain, it would appear that the adoption of actual weapons, as stones or clubs, would have a correlative action in reducing his canine teeth.

The immense difference in size between human canine teeth and those of any of the large apes being a very conspicuous and one of the main distinctions between their dentitions. What follows, with the exception of two lines at the end of chapter, was written before 1869 for the Ovonological Society.

In studying the mechanical arrangements of the teeth in man, I found it necessary to dip into the comparative anatomy of teeth. Here, the dynamical provisions, and the correlation which exists between the teeth and several other of the natural external organs of animals is very evident and beautiful. I have thought it best to avoid scientific names of the different species, trusting that those who would have preferred the more precise way will be willing to receive as an apology that the subject is rather one of mechanics than of natural history.

The conditions of animal life which are universal, and at the same time most subject to variation and exigence are, shelter from the weather, defence from foes, and a continual supply of food. Wherever we meet with a combination of these conditions, an animal may be expected, which will fulfil in its concrete organization the requirements thereof, to fill the place. These necessities are sometimes partially arranged for in the beast itself; some animals are sheltered by warm coatings of fat or fur, whilst others dig burrows, hide in holes of trees or clefts of rocks, or build warm nests. As a means of defence, some bristle with spines, some trust to their speed, some use their horns, whilst others seek their burrows, or fly up cliffs inaccessible to their pursuers. Where food varies with the seasons, we find some animals remove their habitations to where they can get the same or similar food, whilst others are so constituted that they can subsist on a change of diet. Of these conditions, the supply of food is pre-eminent; hence, the kind of food made use of has a strong bias in determining the character of the organs of the animal.

Teeth, principally of use in taking and preparing aliment, are likewise often used as instruments of defence and of preparing shelter; they have, therefore, always been of high importance to the comparative anatomist in classifying the brute section of nature.

Cuvier makes principal use of them and the feet, the two most active organs; whilst Owen, on the contrary, though led by these to some extent, gives a higher place to the brain, the most subjective of organs.

The classification of Owen will be followed in this paper, as the affinities of the species seem placed in better order, though I cannot help thinking that the principle upon which it is said to be based is less intelligible than Cuvier's.

Teeth are placed in mammalia at the entrance of the alimentary canal, between the lips and tongue; they are implanted in the upper and lower jaws, in a manner and with an action with which we are so familiar that they are both difficult and unnecessary to describe.

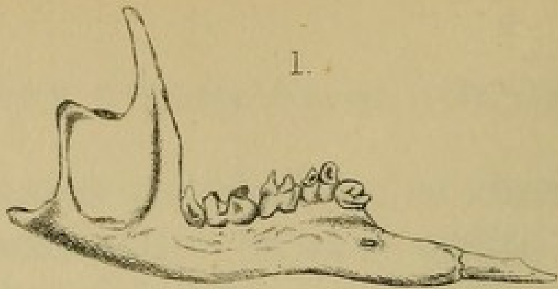
The details of the maxillary apparatus may be divided into two heads—firstly, the forms of the teeth, and secondly, the arrangement by which they are used. The former may be arranged roughly into cutting, piercing, and chewing; the latter into bones to carry, and muscles to give force to the former.

The muscles may be divided into those for opening the jaws, and those for biting, crushing, and grinding.

In the skull of a fossil tortoise (the dicynodon), we find the three forms of teeth in their simplest conditions.

The temporal muscle is the biting muscle, reaching from the upper back part of the skull through the zygomatic arch. It is inserted into the coronoid

1.

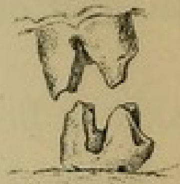


Kangaroo lower jaw.

b.

Lower molar, birds eye view to shew longitidinal ridge between transverse blades.

c

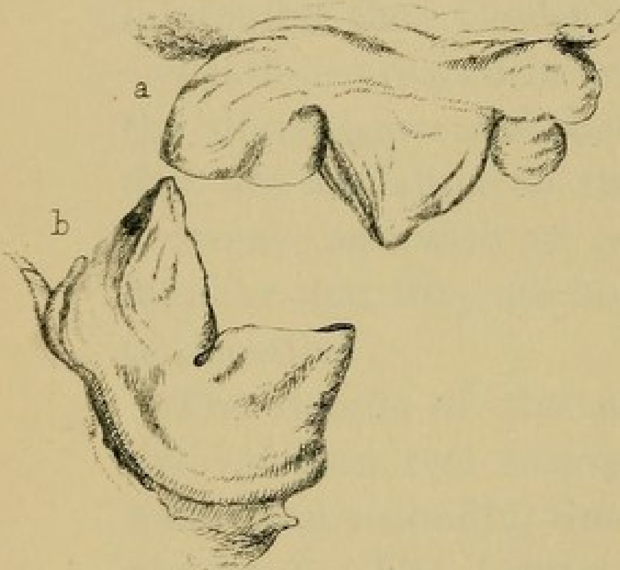


Upper and lower molars side view to shew relative position in chewing.

2.

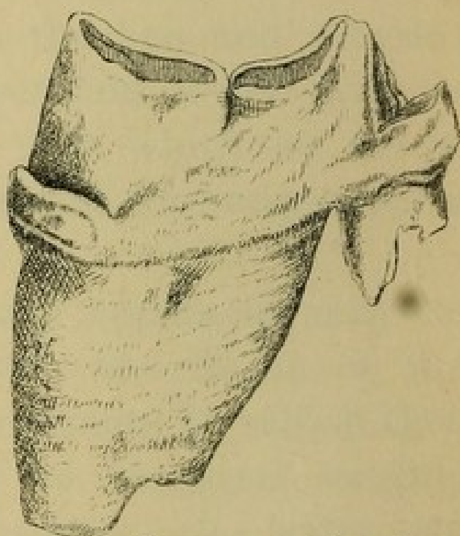
a

b



a. *Upper premolar of Leopard in relative position to* b. *lower molar previous to biting to shew shear-like action.*

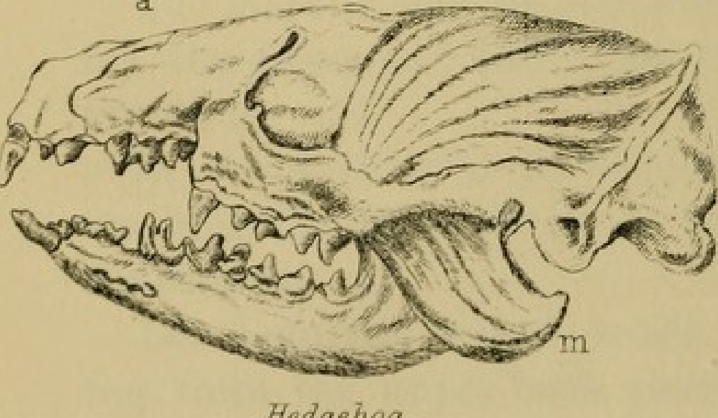
3



Lower molar Hyana to shew basal ridge, compare with hedgehog's at 4.b. *and leopard's at* 2.b.

4.

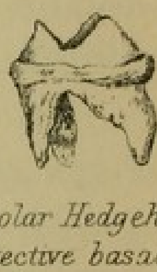
a



m

Hedgehog.

b



Lower molar Hedgehog to shew protective basal ridge of enamel.

process of the lower jaw, so near to the hinge of the joint that it makes of the lower jaw a feeble lever of the third power, being far too weak to do much work in crushing or masticating the food; but what it loses in power it makes up for by the quickness with which it can throw the front teeth through a large space, giving to all predatorial animals that sudden snap by which they seize an agile living prey. Hence we find it largely developed in all such beasts—badgers, hyænas, cats, bears, wolves, seals, hedgehogs (Plate I., fig. 4), bats, some monkeys, etc.; whereas, in the herbivorous—sheep, horses, etc., it is exceedingly small.

In some rodents, however, as the guinea-pig (to which I shall allude further on), it is tolerably developed, and, from a peculiar form of the coronoid process, is of use in drawing the jaw backwards rather than upwards.

In chewing, the crushing power exerted only for a short comparative distance requires greater force; hence we find the masseter and internal pteregoid muscles, which are more advantageously placed, to render it large in herbivorous animals, but particularly so where the food is very hard, as in the horse, beaver, etc.

Wherever there is required a slow but powerful upward thrust of the lower incisors, as in pigs (rooting), many rodents (gnawing, etc.), these muscles, or at any rate the masseter, have their efficiency increased for this purpose by having the posterior angle of the jaw largely developed backwards (see hedgehog, Plate I., fig. 4, m).

Cementum, dentine, and enamel, are found in most teeth, but in some the enamel is wanting, as in the tusks of the elephant; in others the cementum is absent, as in the incisors of rodents; but dentine is common to all.

The office of dentine is to give strength to the tooth. The enamel forms a protective cap to the tooth, sustaining wear much better than the dentine, though too brittle to form the body; also it often serves to keep a certain form constant, by arrangements in which the dentine and cementum surrounding it, being softer, are constantly worn away to a lower level.

The cementum, more highly organized than either of the foregoing, seems to form a connective tissue with the vascular system. At other times it takes its place as a yet softer substance than dentine, in maintaining an efficient form to the tooth.

In mammalia the lower jaw alone moves; and it has been observed by Owen that the condyle is always convex, whereas in cold-blooded reptiles and hot-blooded birds the articulating surface of the lower jaw is concave, receiving a projection from the skull, on which it moves. To account for this fact, I will hazard the following conjecture:—

In mammals there is always some variety of motion required from the jaws in preparing food; being warm-blooded, the quick consumption of their system requires it, hence the condyle must have some scope of action. In such a case, it is best economy for the most movable of the contiguous surfaces to play within the other, in the same way that a pestle moves in a mortar—the power is applied to the convex part, the pestle, not the mortar.

In neither birds nor reptiles does this chewing take place. In birds, that the head may be light and not over-balance them in flight, the masticating apparatus, the gizzard, is removed into the body.

Reptiles, being cold-blooded, probably do not require to masticate their food, but swallow it as nearly whole as possible. Thus there is no variety of movement, the jaws simply open and shut, added to which (in all the specimens I have been able to observe), the lower jaw is more massive than that part of the skull with which it articulates.

At the bottom of our classification stands the echidna, a spiny ant-eater, which possesses no teeth, but has the deficiency supplied by immense claws, which serve him at the same time to obtain access to his food, and to escape from his foes. The latter he can do so effectually (according to Waterhouse), that one disturbed by some travellers in Van Diemen's Land, sunk itself perpendicularly into the earth, keeping its spiny back only accessible to the intruders. In consequence of this faculty it has not the power of rolling itself into so complete a ball as our common hedgehog, which, not possessing much, if any, burrowing powers, requires this means of making a similar coat defensive.

The ornithorynchus has weak, horny molars, and no front teeth, but in compensation, the most perfectly webbed feet of any mammal, enabling it to pursue its food—aquatic insects and mudworms ; it has likewise powerful burrowing claws, which it is able to use by folding back the web, which, whilst swimming, completely blinds them.

We may notice that wherever the front teeth above and below are wanting, an extraordinary development of claws supplies their place.

The genera marked by this omission were united in one order by Cuvier—that of *Edentata*—and the affinity seems very close, for all the other genera—sloths, armadilloes, and different ant-eaters—have immense claws.

In the sloths these claws serve to suspend the animal from the lower sides of branches, whilst it feeds on their leaves secure from enemies. One species, indeed, possesses canines, but it only has two claws on each limb, whilst its less fortunate relatives possess three.

The armadilloes, besides burrowing, are defended by a scaly coat of mail. Their grinding teeth are of a very simple description, and they seem to live on insects, decomposing carcases, and vegetables. So formidable are their burrowing powers that (according to D'Azara) inhabitants of the parts frequented by them are obliged to protect their dead by driving boards deep into the ground round their graveyards.

The true ant-eaters possess no teeth, nor can I learn that they burrow; their enormous claws seem sufficient protection. Their mode of defence is to await the adversary sitting up, seize him in their forepaws and press their claws into him. In "The Naturalist of the Amazons," the author gives a graphic engraving of one of these animals punishing a dog of his own in this manner.

Of the marsupial carnivora, dasyures and thylacines, there does nor seem much to notice which we shall not find more typically developed among the placentals. Not having the speed of the dog, or the retractile claws of the cat, they content themselves with less active or feebler prey, and the molars possess an inner cusp, which is probably of use in holding in place the cylindrical bones of small animals, whilst they are crushed by the opposing tooth, as these isolated talons are found less and less numerous in flesh-eating animals in direct ratio with the comparative size of the prey to the animal, until we find in the feline species there is only one in the large upper premolar.

Of the phalangers and opossums I cannot find much information, nor do they present very manifest characteristics.

Occupying a similar position amongst marsupials to that taken by ruminants in the placentals, are kangaroos. They possess, however, very different teeth. Having upper as well as lower front teeth, the latter being found in the higher form of animals alone, they are enabled to crop harder and dryer herbage, and their molars are superlatively formed for clipping into short lengths such food as dry grass or hay; they are composed of a series of transverse short blades (Plate I., fig. 1, a), in which the lower close just behind the upper like the blades of a pair of scissors (Plate I., fig. 1, c), with the exception that the edges close parallel to each other instead of at an angle. That the food should be seized and cut when the jaw moves from side to side, instead of falling away on either side, it is necessary that the blades should be a little hollowed on their edge; to accomplish this, a slight longitudinal ridge rises between the blades, which is just reached by the edge of the opposer when the mouth is shut (Plate I., fig. 1, b), this wears the middle part to a lower level than the corners, and keeps the required form. The blades, wearing against each other, keep themselves sharp; altogether it is a very efficient chaff-cutter.

The front paws of the kangaroo are so short that its head is nearly horizontal when grazing; in relation to which position the lower incisors are horizontally placed, and the upper perpendicularly, so that the grass rising into its mouth is divided by these teeth at an equal angle, the lower being probably thrust forward by the pteregoid muscles, instead of being shut in the ordinary manner; for in addition to the relative inclination of the lower incisors, there is a peculiar hollowing of the inside back part of the lower jaw, corresponding to the position of these muscles, but not having succeeded in getting a fresh head for dissection, I am unable to describe it.

Burrowing animals are very liable to meet with roots in their way, and those who are not possessed of powerful claws to enable them to force, as the armadilloes or moles, are provided with sharp teeth to gnaw a passage; these would be liable to great wear, and we have the endless chisel-shaped incisors of the rodents. They form part of a circle of prismatic section, the anterior surface strongly guarded by enamel. The end, which is implanted in the jaw, is open, and filled by the formative pulp, as in all continuous-growing teeth, which supplies the continual wear. The dentine, from its softer consistence, wearing to a lower level than the enamel in front, maintains the tooth sharp. To bring this construction to its highest efficiency, it is necessary that there should be no lateral motion, which would throw the edges of the front teeth across each other, and destroy that evenness of wear essential to sharpness. In the wombat, a burrowing marsupial rodent, this is not provided for; the front teeth are so placed that they wear themselves flat upon each other, and a sharp edge is obtained by allowing the teeth to follow the curve of a large, instead of a small circle —a manifest disadvantage.

Amongst the true rodents this is not the case, and they file up their food by a backward and forward motion, to which end we find the condyle of the lower jaw laterally compressed, and working in a longitudinal furrow in the skull.

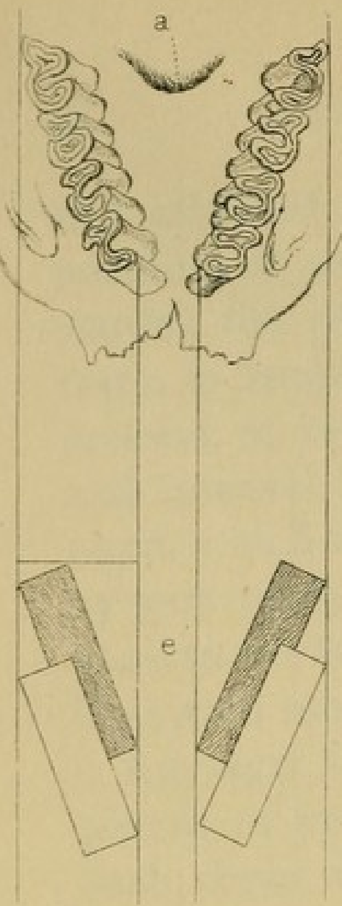
Many of the patterns of molar teeth in rodents are very beautiful, their form being mostly maintained by various dispositions of dentine and enamel. The softer dentine, continually wearing to a lower level, always keep them sharp.

The common guinea-pig presents some interesting features of this order. In gnawing, a large swift bite is not required, but a slow, powerful one, so we find the coronoid process of the lower jaw but rudimentary, and the temporal muscle elongated and attached to the bone, anterior to the usual position, so as to enable it to draw the jaw backwards; the posterior angle of the jaw, on the contrary, is lengthened backwards into a considerable process, so as to give greater scope to the masseter, and internal pteregoid muscles in throwing it forward, which is yet further enhanced in the masseter by part of this muscle being produced through the bone to the front of the face, and thus a forward and backward motion is obtained.

Amongst those animals whose condyles do not permit of much lateral motion, the leverage of any such force upon the front of the mouth would throw too great a strain upon them. This is guarded against in the carnivora by the lower canines being set so as to lock in front of the upper; but, the little animal under consideration not having any canines, the molars are so arranged that the faces of the lower ones slope inwards at an angle of about 45 degrees, whilst those of the upper slope outwards to correspond (see Plate II., fig. 1, b).

Those animals, on the other hand, which grind their food by lateral motion, are enabled by this motion to bring the surfaces of the teeth out of opposition, so that they can receive and carry back, into a position where it can be crushed, food from the cavity of the mouth.

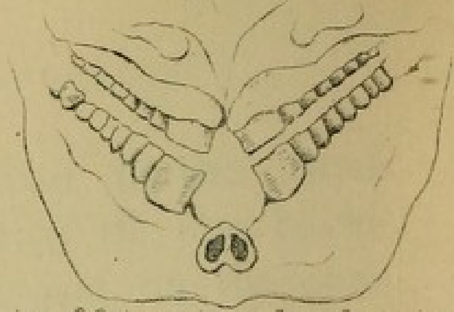
In the guinea-pig, to meet this requirement, the teeth are approximated at an acute angle, anteriorly, so that in the mere backward and forward motion before mentioned, the surfaces are brought from opposition (Plate II., fig. 1, a, e). But that the



a, *Guinea pigs upper molars viewed from below to show inclination of the general line of teeth on each side to the other on horizontal plane*

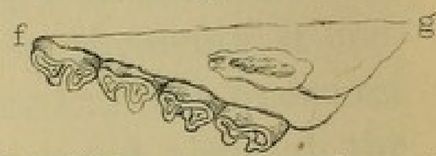
e, *Rectangles representing the relative positions of upper & lower teeth when the lower are moved forward shewing how much of the upper (shaded) would be then uncovered.* —

b



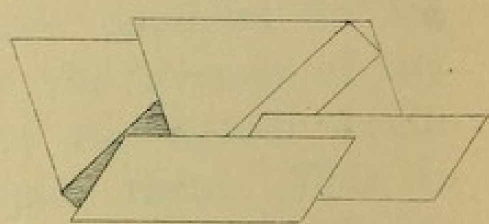
Front view of Guinea pigs molars the incisors being removed, chewing inclination of surfaces to each other on vertical plane. —

c



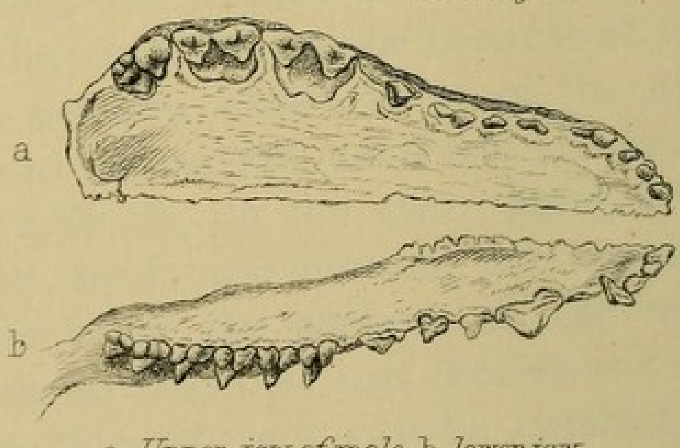
Side view of Guinea pigs upper molars to shew inclination of general line of grinding surfaces to line of motion f. g. —

d

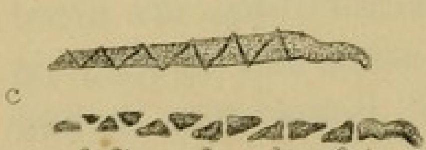


d, *Rectangles representing upper & lower molars as at* e *placed diagonally on the sides of two troughs, which can slide horizontal one within the other, being the real relative position of the grinding surfaces of teeth, of the Guinea pig.* —

2

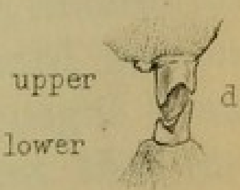


a, *Upper jaw of mole* b, *lower jaw.*



c. *Worm shewing the line and number of pieces in which it would be cut by a bite from mole.*

d. *Section of worm in position between teeth before being bitten.* —



surfaces should incline to the vertical plane, whilst the lines of the teeth inclined on the horizontal plane, and, at the same time, that there should be a free horizontal motion, requires yet another modification, for on this simple construction it is evidently impossible.

Let us suppose two troughs, each composed of two rectangular planes, meeting in the same angle on their longest sides. These troughs would fit each other, and would slide freely backwards and forwards. Now we will make a band on each side of one of these troughs, straight from the angle at the bottom of the trough in front, up to the corner at the edge of the trough above behind, and similar bands on the other, so that the bands on the one trough exactly superpose those on the other. We shall thus have two converging bands on each surface which incline towards each other when seen either in front or from above, and which are at the same time capable of a forward and backward motion in the horizontal direction. Now, if we outline upon these bands the shape of the guinea-pig's upper and lower molars respectively, we shall have their precise relative position, thus accounting for the fact that the tops of the molars are much lower, relative to the line of their horizontal motion, in front than behind (see Plate II., fig. 1, c, d).

The hedgehog is a familiar example of insectivora; possessed of only rudimentary canines, and, not having either teeth or claws suitable for burrowing, he is defended from his foes by his prickly coat, into which he has the power of contracting himself. With projecting lower incisors for grubbing up stones, etc., in pursuit of insects, he, in like manner with the guinea-pig, has the angle of the lower jaw produced backwards, to enhance the power of the masseter muscle, to give a forward and upward thrust (Plate I., fig. 4, m). Insects having systems supported generally by an external framework, and being often cylindrical in shape, the teeth of insectivora bristle with sharp cusps, which at the same time keep the prey from slipping away, and crush in its covering. Some insects, beetles, etc., upon which the hedgehog feeds, possess thorny coverings, sharp claws, etc., to prevent which wounding the gums, the teeth are surrounded by a protective guard of enamel, which stands out round the base of the crowns (Plate I., fig. 4, b).

We meet with similar provision in the hyæna. This animal, not possessing sharp retractile claws of the cat tribe, nor the elongated muzzle and speed of the dog, is at a disadvantage, and is often driven to feed on the leavings of these species, to avail himself of which he is possessed of muscles capable of cracking bones which have been left; and its teeth, similar to cats' in other respects, are analogous to those of the hedgehog in possessing the protective basal ridge of enamel, which in this case serves to ward off splinters of bone (Plate I., fig. 3).

To return to the insectivora. The mole does not possess the gnawing front teeth of the rodent, as it requires teeth by which it can seize and drag out worms—its principal prey—as they quickly shrink into their holes; it is furnished, in compensation, with immensely powerful fore-paws, by which to force its way past obstructions, as is familiar to most of us; but it is the arrangement of the molars which are especially interesting from a mechanical point of view. Animal food does not seem to require much crushing, but rather comminution; and the molar teeth of the mole are so formed as to mince up their food into numerous triangular morsels at each bite. This is effected in the following manner:—

Imagine two cutting edges, one above and one below, on each side of the mouth, so arranged as to pass each other, and cut like the blades of a pair of scissors; it is evident that these would only make one division of the worm at a time on each side, and if it fell on the lower blade longitudinally (the most convenient position) it would probably be allowed to fall on one side, or at most would be only split in two; if now, we *zigzag* these blades, keeping the same reciprocal cutting relation between the upper and the lower, whilst there will be width of edge for the worm to lie upon, it will also be cut into as many pieces as there are angles in the *zigzag*, that is, supposing the worm not to be wider than the mean width of the tooth. But there would still be a tendency to slip on one side, therefore, a longitudinal notch is cut the whole length of the *zigzag*, both above and below. An end view of the row of teeth, with the worm in position, would give the appearance of a circle embraced between two angular forks (see Plate II., fig. 2, d).

This curious pair of *zigzag* scissors is constructed in the following manner: each of the three molars in the upper and lower row is composed of two triangular prisms, placed so that their bases form a continuous line, the angle standing outside in the lower jaw, and inside in the upper, and so arranged that the angles of the one fit exactly between the angles of the other (see Plate II., fig. 2, a, b). As these prisms are solid, to give the edge spoken of above, a notch is cut out of each base, the angle of which slants up to the angle of the prism, and both the other sides are noticed by the longitudinal cut before spoken of. As there are three molars, a thin worm, such as the wire-worm, would thus be cut up into twelve little pieces at each bite, or there would be six pieces taken out of the side of a larger one (see Plate II., fig. 2, c).

The lowest genera in the next sub-class, that with convoluted brains, is that of the whalebone whales, which, however, possess no true teeth, their want being compensated to the animal by the whalebone filter, which has been repeatedly described.

Among the toothed whales which follow, the narwhal has an extraordinary development of one of the teeth homologous to the central incisor. This is prolonged to the front of the mouth, nearly in a line with the long axis of its body, to the extent of six or eight feet; it is straight, and of the form of a gradually tapering, slender cone. This species inhabits the bays in the Arctic Circle, where, in the winter, ice is often rapidly formed on the surface; and it is supposed that the function of this spear-like tooth is to pierce an air-hole through the ice, in case of emergency.

This suggestion is strengthened by the following analogy :—The walrus, living in the same neighbourhood, is provided with two large tusks, projecting downwards from the front of the mouth, to assist it in raising its massive body on to the ice. These teeth, which are canines, he dashes into the ice, as far forwards as he can reach, and then, by means of powerful neck muscles, draws himself up to repeat the process. Dentine, as dentists very well know, has a tendency to split down the long axis of the tooth, like wood, and the violent concussions to which the walrus subjects his canines would be likely to split them, if solid, of the ordinary tooth substance; but when the tooth is about half formed in thickness, from the outside inwards, the formative pulp changes the character of the calcified mass, and the dentine forms in nodules, a little like granite in structure, though maintaining the same density and firmness as before. This unsplitable central column succours the outside layer of dentine, though to the latter the tooth owes its longitudinal strength and immunity from transverse fracture. The narwhal's tusk, it is true, has not this central granular column, but it has a feature which, as it would accomplish the same end, indicates a similar function; it is spiral in itself, that is, twisted like a rope, not like a corkscrew, and thus any tendency to split is avoided, as transmitted force would be divided, and, proceeding in opposite directions, would nullify itself. This spiral growth also insures the straight development of the tooth, any irregularity, being soon transferred to the opposite side, corrects itself. The same method of preserving unsplitability could not be used in the case of the walrus, whose tusks, being employed as hooks, require a slight curve.

Some doubt (based on the microscopic structure) has been expressed by Mr. Spence Bate, as to whether the tusk of the narwhal does really turn as it grows, and as it is not very easy to put the question to the test by catching a young narwhal and marking the tusk at different stages of growth, I shall give the following theoretical reasons for believing that such is the case.

In the first place, it is perfectly straight and projects almost horizontally from the snout of the animal. Now, from what we know of the effects of gradual steady pressure on the shape of growing teeth, we may believe that, if it merely grew straightforward, the force alone of gravity would give it a downward bend, for the weight of the tooth is very considerable long before it has attained its full development.

In the second place, the dentinal pulp only grows forward from the base; there is no interstitial growth of the dentine, so that there would be no motion during formation between the pulp and this tissue; therefore, although the fibres might arrange themselves in spiral succession, there would be no microscopical evidence of it; they would still run in straight lines in the radii of the transverse section, just as we see bristles in the common spirally-twisted bottle brush. On the other hand, as it is externally marked with a spiral twist, if this grew straight forward from the basal pulp, it is evident that the external form of this must keep constantly revolving, whilst its substance, in this relation, remained motionless. This alternative appears to me much more improbable than the other. The opinion that the tooth does revolve in growth is yet further strengthened by reference to the formation of the cementum. The capsule which forms this substance does not follow the growth of the tooth like the dentinal pulp, but remains in a band round the outside of the base, laying the cementum on the dentine as it passes, and therefore the layer close to the dentine will be laid when that part is on the internal edge of the formative band, whilst the last layer will come from the external edge; and we might expect to find some traces of this lateral motion left in a vertical section, just such indeed as we do find. Taking all these indications into consideration, I cannot but believe that the narwhal's tooth does revolve during its growth.

There is another mechanical advantage in the construction of this tooth pointed out by Owen. In order to lighten it somewhat, the pulp remains uncalcified, to the amount of about one-third of its thickness throughout the front part of the tooth, but narrows in, so as to leave that part implanted in the socket nearly solid.

Passing over the manatee and dugong, of which little seems to be known, we next, among recent mammals, arrive at the elephant. This animal presents us with some features in its dentition analogous to that of rodents; its tusks, like their front teeth, have persistent formative pulp, and continue to grow during the life of the animal.

It may be a question whether a change of climate did not deprive the northern circles of woods, before it exterminated the members of this genus within its confines, as the great tusks of the northern mammoth are often recurved to a considerable extent, just as we might imagine those of the elephant would grow, if deprived of the wear and tear of use. If this be a correct guess, it would be a rather curious illustration of how far adaptation can go, as there is good evidence that the mammoth of Siberia, in its latest stage of existence, was abundantly covered with hair. In this case the cold, which had rendered its tusks useless, had failed to remove them when only an incumbrance, but had, at the same time, stimulated the adaptive faculties of the animal into greatly increasing the warmth of its covering by a warm coating of hair.

The molars of elephants still strengthen the idea of relation to rodents, being very similar to those of the capybara, the largest existing representative of this order. They are composed of a number of transverse layers of dentine, enamel, and cementum, which, by their irregular attrition, give the top of the tooth always the surface of a very rough file. There is a difference in the disposition of these tissues in the African and Indian elephant, of which I will hazard a guess in explanation.

The enamel of the African elephant is arranged so as to enclose diamond-shaped spaces of a softer tissue ; the diamonds are placed, touching each other by their obtuse angles, all along the centre of the top, the length of the diamond corresponding to the width of the tooth. In the Asiatic species, the surface of the grinder presents a nearly parallel series of transverse lines of enamel, the comparative result of the two methods being that the African tooth is a much coarser rasp than the Asiatic. The female of the former species has nearly as large tusks as the male, whilst in Asia she is either totally devoid of them, or they are exceedingly small. Now the principal use of the tusks is to prise up trees, in order to browse on the branches; hence it would appear that the female of the Asiatic elephant, being unable to provide herself with such large branches as the African from her want of tusks, does not require so rough a molar for their mastication, and for this reason the teeth have been modified in the whole species.

Among the odd-toed mammals, the rhinoceros, an almost exclusive grass-eater, is very poorly furnished, for his size, with front tusks, in comparison with his rivals in bulk, the elephant and hippopotamus, having only insignificant incisors, to compensate for which deficiency he carries on his nose a powerful horn, to use either as a weapon, or for forcing his way through impediments in the undergrowth of the thick forests he inhabits.

The solid-hoofed genera—horse, ass, zebra, etc.—seem to be the type of speed among herbivorous quadrupeds, and their superiority in this respect over the ruminants (which, embracing the antelopes, deer, etc., possess many very swift species) seems to turn on the fact of their having upper front teeth as well as lower. In consequence of this, they are enabled to take harder and more nourishing food, such as ripe corn, beans, etc., to the grinding of which their molars are specially adapted. This more concentrated food furnishes them, in smaller bulk, with that force which is the reservoir of their speed. Being thus able at any time to set a pursuer at defiance, they do not require to eat their food in haste and retire to obscure retreats for protection. Their hoofs are therefore formed for rapid progression on the unvaried plains where they browse. Here, in the midst of their sustenance, they can afford time to chew it properly as it is eaten, and therefore have no need for chewing the cud afterwards.

In the various accounts of foreign sports, such as Gordon Cumming, etc., one reads of most of the antelopes, deer, buffaloes, etc., being run into by the mounted hunter, but of zebras or quaggas, never; whilst it is reported that the Arabs, in order to capture the wild ass, are obliged to place relays of fresh horses along the route of its expected flight.

True, ruminants embrace many widely spread and numerous species. Vast herds of antelopes in Africa, which, browsing on the open plains, retreat to the hills, woods, or marshes, to chew the cud, living less amongst woods than the deer tribe, are furnished with superior weapons of defence, in the shape of long, sharp, powerful horns without prongs, which they use with such effect, that Gordon Cumming relates of a wounded oryx held at bay by his dogs, that, ere he could come up, four powerful hounds were placed *hors de combat*, the antelope stabbing right and left but twice.

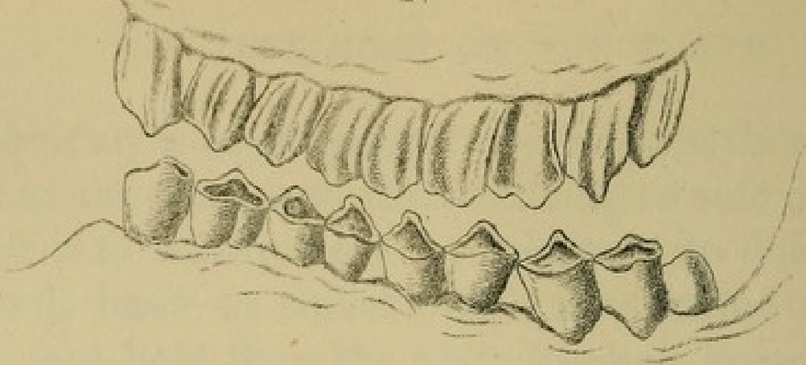
Closely allied to this genus are the deer, which, being more sheltered in woods, their usual habitat, do not require, perhaps, so deadly a weapon of defence, but combine with it a means, in the shape of diverging prongs, of quickly lifting up, in order to pass under any obstruction of branches, etc. Sheep and goats select mountains for their fastnesses, and their horns are generally so turned at the end as to protect the head, and receive the brunt of falls over rocks, etc.

Oxen depend upon their powerful horns, and the mutual protection of association for defence; and often seek a succulent pasture, combined with shelter, amongst the reeds of marshes and river banks.

As I have before stated, this family have no front teeth; and only a few—the camels, llamas, and musk-deer—possess canines. It is worth remarking that these are not supplied with horns. Possessing no front teeth, they cannot take such concentrated food as the horse tribe, and are, therefore, not so capable of saving themselves by flight, partly because from the nature of their food they require a greater quantity, which interferes, to some extent, with the compactness of their build; and partly, probably, from the inferior force-producing nature of that food. They are, therefore, provided in their economy with an arrangement by which they are enabled to crop quickly a large quantity of food, without chewing it at the time, and then, retiring to safe quarters, submit it to mastication at leisure. In doing this, they will have to travel over more varied and unstable foot-hold than the plain-keeping horses; and, in order the better to do so, their hoofs are cloven, which gives them greater holding power. In the before-mentioned books of field-sports it is common to meet with instances where the hunter on horseback lost his game by its taking to hilly ground, where his horse, which had been previously gaining upon it, was entirely thrown out.

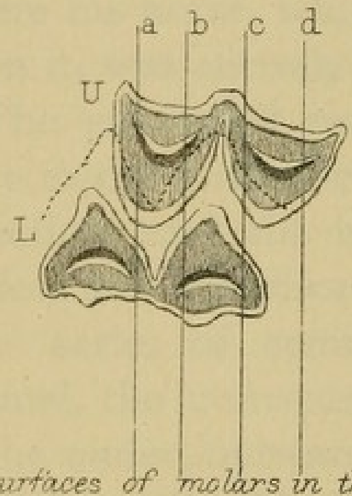
The entangled mass of grass which ruminants have to chew requires to be cut and crushed in every direction, and the means adopted for this is very perfect and complicated. The molars are arranged in a series of semi-lunar plates of dentine and enamel, the convexity in the upper being inwards, in the under, outwards, so that in chewing the action is reciprocal. The tops of the teeth present two platforms at different levels, which reciprocate between the upper and lower jaws when they meet; that is, the innermost platform of the upper tooth falls upon the outer-most platform of the lower; whilst the outer-most of the upper and the innermost of the lower fall free of any opposition (see Plate III., fig. 3). The walls, which form the step from the higher to the lower level, in the upper and lower teeth respectively, pass each other with a scissors-like action, by which a mass of food is first divided and then enclosed between them, until the

1.

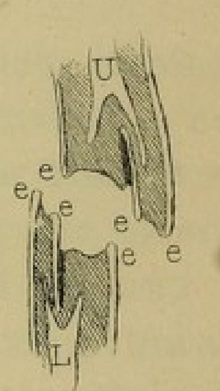


1. *Side view of molars of Sheep, to shew zig zag line of wear.*

2.



3.



2. *Grinding surfaces of molars in their relative lateral position, shewing that all the tooth substance between the lines* a.b. *in the upper would wear against the small quantity between* a.b. *in the lower whilst the large mass between* b.c. *in the lower would wear against the small mass between* b.c. *in the upper thus producing the zig zag wear of Fig. 1. The dotted line represents the actual position of the lower on the upper and shews how the Fig. 4 is obtained.*

3. *Section of upper and lower molars of sheep, to shew their relative position just previous to biting food, also how the disposition of enamel keeps one platform higher than the other.*

4

4. *Shews the zig zag row of lanceolate shapes, which would represent the crushed grass, punched out by the sheep, at each bite, on each side.*

lower-level platforms meet, and crush it. I am afraid this description is not very clear; but any one who will take a sheep's skull in his hand, I think will readily understand it.

The maintenance of this form to the tooth is regulated by the shape of the teeth and the disposition of the dentine and enamel. For example: in the transverse vertical section of the upper molar of a sheep, first comes a strong layer of enamel, then a thicker one of dentine, another of enamel, then a deep slit dividing the wall of the external platform from the internal one; next, a very slight film of enamel, another layer of dentine, and, lastly, an outside of enamel again. The consequence of this disposition is that the dentine which is protected next the indentation by only a rudimentary film of enamel, wears to a much lower level than the other, and the required step is produced on this side of the lower platform, whilst the enamel on its other side, which would otherwise keep it high there, is worn down by being opposed to a much greater body of enamel in the tooth which meets it; that is to say, the broad platform, which is the higher one in each tooth, wearing the convex platform, which is the lower one (Plate III., figs. 2 and 3). But, if these platforms were mere plain longitudinal steps, it is clear that the enclosed food, finding no escape, would offer too great resistance to be crushed. But by disposing them in a series of angles, only part will meet at a time which will facilitate the action. To produce this form, the teeth are so placed that the middle of the solid part of the teeth in one jaw falls exactly between the semi-lunar convexities in the other (Plate III., fig. 2), where it, of course, meets with less tooth substance to wear; the reciprocal effect of which is that a side view of the teeth presents the appearance of two zigzag lines, the angles of the one corresponding to the depressions of the other (Plate III., fig. 1). By this arrangement, also, so much of the flat surfaces do not meet each other; the semi-lunar margins alternating when they meet, cut out and crush a series of zigzag lanceolate forms, thus dividing the blades of grass in every direction, however they may lie (Plate III., fig. 4).

The even-hoofed mammals, which do not chew the cud, are yet slower again than the ruminants, but are generally fiercer in disposition, having large developments of their canines, which, like the incisors of rodents, are always growing.

The hippopotamus inhabits rivers, and feeds much on the roots of aquatic plants, and is well provided, in the incisors and canines, with picks to root them up, and shears to clip off the more stubborn.

The hog tribe are also probably root-eaters, principally having protruding lower incisors with which to grub them up. They defend themselves vigorously with their long powerful canine tusks.

The fin-going animals, the seals, live on fish, and their molars mostly present a series of tridents, with which they can hold firm their slippery prey when seized, whilst they have well-developed canines as a means of defence.

Toe-walkers comprehend the most agile of the carnivora. Of these, the cats, possessing retractile claws, are unable to run down their prey, but spring upon it from a place of concealment; these sharp claws enable them to hold it whilst they destroy life with their formidable canines. They are among the largest of the genus, and the lion and tiger, by their weight, are able to drag down such large game as buffaloes, and the larger antelopes and deer. The mane of the lion is a valuable protection from the rude shocks which would be met with if he sprang upon one of these animals in a rocky place, and both rolled over rogether. With small incisors for scraping the bones, they have large trenchant canines, the lower passing in front of, and within the upper, thereby preventing any danger of dislocation to the jaw in the struggles of the prey. This disposition of the canines is all but universal, and, I believe, with the same object, viz., to secure the lower jaw from closing out of its place, and so getting the cusps of the teeth entangled, or straining the articulation of the jaw.

The molars in the fore part of the mouth in cats, are mostly composed of one strong laterally-compressed cone, guarded before and behind by a small tubercle, which protects the gum; their function seems to be to assist the canines in holding the captive, and to joint the larger bones. Behind these, above and below, comes a single large tooth on each side, which is so indicative of the flesh-eater, that Cuvier named it the carnassial tooth. They have two strong cutting edges, which meet and pass each other like the blades of a pair of shears. If the edge were straight, as observed with regard to the kangaroo, there would be a tendency in any unyielding substance to slide forward, therefore the edge forms a waved notch, so that on closing the jaw it encloses the substance first, and then cuts it (Plate I., fig. 2). In order to preserve this form, as the teeth wear away, they slope at an acute angle from the side which rubs against the opposer, which latter side is perpendicular.

Dogs, having no retractile claws to help in seizing and holding their prey, have their muzzles elongated, which gives room behind for more molars, one of which is tubercular and possesses a large masticating surface; whether this has any relation to his endurance in running, or not, I can only surmise.

Cuvier speaks of the carnassial tooth of cats as particularly adapted for cutting up flesh, but I imagine that they tear off as large pieces of flesh as can be swallowed, which receives no further chewing, and that the essential function of these teeth is rather to divide the tough tendons which attach the muscles to the bones.

Amongst the lemurs, the galeopithecus, or flying lemur of the Indian islands, presents a unique dentition. It is destitute of upper front teeth, while those in the lower front jaw are deeply indented, like the teeth of a comb; and as its back teeth are of a well-marked insectivorous type, it is possible that a solution of their function consists in their use in searching the backs of other animals for parasites or larvæ.

The teeth of monkeys are generally frugivorous in their character, but they vary so much, and in many cases so nearly approach the human type, that I will refer to them *again* in a future paper.

CHAPTER V.

A DIFFICULTY FOR DARWINISTS.

Mivart's statement of difficulty—Convenient definition of word species — Isolation of marsupials — Different theories of classification, best represented as genealogical tree—Comparison between marsupial thylacine and dog—Huxley's view of probable derivation of dog from thylacine—Teeth of wrasse, parrot fish and rodents—Comparison of growth of bone to clusters of foraminiferæ—Question of difficulty of physiological construction and maintenance of teeth in living body.

THE third chapter of Mivart's "Genesis of Species" states a difficulty to the acceptance of Darwin's theory of the origin of species thus:—"On this theory the chances are almost infinitely great against the independent accidental occurrences and preservation of two similar series of minute variations resulting in the independent development of two closely similar forms." Amongst other illustrations of his theory, he mentions that Professor Huxley had called his attention to the very striking resemblance between certain teeth of the dog and the thylacine. Having had this difficulty very strongly forced upon my own mind in studying mammalian teeth, I will try and state it more fully than is done by Mivart.

There are certain highly specialized and complicated organs found upon different animals, which are so similar that, upon Darwin's theory, they ought to be hereditarily descended from or related to each other, and yet, by the same theory, it seems almost possible to prove that such could not be the case. Now, if this proof does hold good, some very considerable modifications of the theory will be necessary.

It is a fact familiar to every child that there are many kinds of animals differing from one another in their general characters, and that some of these animals are more alike than others, so that a rough, common-sense classification soon takes place in the mind of every individual, by which all the animals they are most familiar with, are probably arranged according to the peculiar conditions of that individual. A settler in a new and wild country might have two sub-kingdoms, viz., wild and domestic, of which the wild might be divided thus :—

Dangerous to human life ;
Noxious, but not dangerous ;
Injurious to crops ;
Useful for food ;
Furnishing useful furs or skins ;

and so forth. It would soon be observed that there were many animals so similar in appearance that they might easily be mistaken for each other, and that these similar animals had a similarity of habits, that their offspring resembled them, and that there was a community of blood-relationship between them. Thus a rough idea of species is arrived at ;

but when scientific men have tried to define the limits of these different species there has arisen the greatest difficulty, each definition generally depending upon what the arranger really believed to be the origin of species, and therefore impossible to be used in discussing that origin without begging the whole question.

Now as a merely useful word, and not a dogmatic one, I think "species" may be used in two ways: the first, I suppose, would be the logical one, that it was the lowest or simplest unit of generalization—i.e. that all animals so nearly alike that they cannot be conveniently divided into smaller groups should belong to the same species. The second requires a little elucidation: all animals between whom there is consanguinity are not exactly alike, although more or less similar, and minor differences amongst animals having such community are sometimes capable of generalization; still, this blood-relationship seeems to be the central fact around which all affinities of form, habit, or character, group themselves, and there is no dispute that where a certain amount of divergence in these affinities or resemblances is found, there is no longer any possibility of fertile interbreeding.

A definition framed on this fact will suit very well for the purposes of this discussion, and is included in the first explanation. Taking as the simplest unit of generalization those animals amongst whom there is the possibility of interbreeding belong to the same species, and where there is no such possibility to different species.

This is not given as a correct definition of the term "species," when used zoologically. But as orthodox naturalists, Darwinists, and common-sense observers are all agreed in the fact that there is such a limit, it is accepted as convenient.

The number of species of animals in the world is immense, and it might occur on first thoughts that however these different forms of life originated, they must be capable of some classification by their resemblances; but a very slight acquaintance with the science of zoology forces upon us a conviction that a classification is possible expressing more than this.

Numbers of these species consist of animals of great complexity of organization, and the resemblances and affinities of construction of many of the organs belonging to animals of different species are so interlinked and graduated as to suggest irresistibly some mysterious continuity between them. The permanence of animal life is provided for amongst each species by the reproduction of young, which generally develop into animals like their parents, although in some of the lower forms it takes two or three generations for the return to the same form. All animals can be so arranged, according to their organic structures, and most essential characters, as to form a sort of genealogical tree.

Three theories are tolerably widely accepted to account for the classification by scale of development and affinity of construction of which animals are capable; one is, that they were created in general harmony of idea, to educate the soul of man; another, that of Darwin, supposes that there were but few of the simplest forms, that all the rest have been developed by a severe competition amongst these forms, which, in reproduction, continually varied slightly; that in this severe struggle for existence, the best forms survived, and gradually the higher types of life were thus developed, without any further interference of any other power. The third view is held by those who are not satisfied with the first mentioned opinion, inasmuch perhaps as the width of creation, coming so little within the view of the majority of mankind, it seems rather a presumptuous and inadequate idea to suppose that this infinity of gradation was made for the education of men, so few of whom could ever see its meaning. These persons also doubt the power of the second principle to be capable of surmounting all the difficulties of organic construction, or of producing the originality, beauty or sensibility which is actually found in the organic world; they are rather inclined to believe that they behold the real steps of evolution, invention, and creation, by which not only is man to be educated, but by which he was invented and created (if these two words should not stand for the same act).

According to this last theory, whether there has been, or has not been a material continuity between the lower and higher types, might be open to discussion; the main difference between it and Darwin's theory is, that it maintains that a material continuity is not necessary, and that the mere laws of necessity (granted a low type of life) and the general conditions of the world are not sufficient to account for that classification of the organic world, which is possible, but that an ideal bond of unity of design is plainly indicated. Whereas Darwin maintains that the bond of unity has been material continuity, produced entirely by the action of the general laws of this planet upon an original simple form of life. Here are Mr. Darwin's views in his own words :—

"As each species tends by its geometrical ratio of reproduction to increase inordinately in number, and as the modified descendants of each species will be enabled to increase by so much the more as they become diversified in habits and structure, so as to be enabled to seize on many and widely different places in the economy of Nature, there will be a constant tendency in natural selection to preserve the most divergent offspring of any one species. Hence, during a long-continued course of modification, the slight differences characteristic of varieties of the same species tend to be augmented into the greater differences characteristic of species of the same genus. New and improved varieties will inevitably supplant and exterminate the older, less improved and intermediate varieties, and thus species are rendered to a large extent defined and distinct objects. Dominant species belonging to the larger groups tend to give birth to new and dominant forms, so that each large group tends to become still larger, and at the same time more divergent in character. But as all groups cannot thus succeed in increasing in size, for the world would not hold them, the more dominant groups beat the less dominant. This tendency in the large groups to go on increasing in size and diverging in character, together with the almost inevitable contingency of much extinction, explains the arrangement of all the forms of life, in groups subordinate to groups, all within a few great classes which we now see everywhere around us, and which has prevailed throughout all time. This grand fact of the grouping of all organic beings seems to me utterly inexplicable on the theory of creation."

Now if this grouping has been the result of hereditary connection, how does Darwin account for similar or homologous organs having an independent source?

This is the case in point. The marsupial mammalia form a natural order. No naturalists have ever attempted to separate them in classification, and the fact of their being almost exclusively found in Australia and adjacent islands (only one genus, that of the true opossums, being found elsewhere, in North and South America), gives us all the more confidence in regarding them as such. At the same time this isolation tells very well in favour of Mr. Darwin's theory. The marsupial is a very early type of mammal, and was at one time much more widely distributed than at present. Prof. Owen figures the lower jaw of a small insect-eating marsupial taken from the Stonesfield oolite in Oxfordshire, England. Now, if the placental type, which is a higher and prevailing one, had arisen from one species of marsupials, it would, if the advance was of sufficient importance, have gradually supplanted the lower type, wherever it came into competition with it; and we have only to allow that this struggle did not first occur in Australia, and that all communication with the rest of the world was cut off before the predominating race could reach Australia, and we should expect to find, according to Mr. Darwin, exactly what we do find: all the animals there retaining a distinct classification grouped around the old marsupial type.

The sheet-anchor of Darwinism is, that the adaptations of organs to the needs of the animal are not produced by external circumstances, but that out of the infinite slight variations which arise the one which gives its possessor the advantage in the "struggle for existence" prevails, the less excellent dies out.

Out of the infinite possibilities for improvement which surround any animal, it would be extremely improbable that the same should be arrived at by different species, and *a fortiori* when this improvement consists of organs exceedingly complicated and apparently difficult of development.

Let any one consider the wing of a bird, a fly or a bat, and he will understand what I mean; if we only knew of one organ of flight we might be led to suppose that it was the only mechanical contrivance possible to this end, and yet we see in these instances, how entirely distinct are the means to the same action.

How rational and in accordance with *a priori* reasonings it seems to be, that bones should be within the body to support the soft parts and give them by leverage the means of determined motion; and yet when we compare invertebrate with vertebrate animals it shows us that we may allow infinite scope for variety of construction. Mr. Darwin has referred to the growth and affinities of language in illustration of the growth and affinities of species; it will bring it home to us, and may be not much overstraining the case, if I say that to expect to find the same organization developed from similar external conditions, on Mr. Darwin's hypothesis, will be a parallel case to expecting to find the same language evolved from two originally distinct people who had no communication, because their external conditions were similar. Imagine the European discoverers of Japan finding the natives speaking a European language, or one so near it as readily to be understood by them. Would they not find it very difficult to believe in an independent origin for that language? Just so, then, we ought to find an absence of placental animals in Australia, if it was separated from the rest of the world before that type was introduced. So far the illustration is entirely against us.

But let us look at this order of marsupial mammalia a little more closely, and see of what divisions it is composed. We have the familiar kangaroos, which take the place in the Australian fauna that the lighter ruminants—antelopes, goats, sheep, and deer—do in the larger continents, browsing on the herbage of the plains or amongst the rocks during the dusk, and lying hid in the light day-time. Here is the same place in nature filled by how different and original a type. Then we have the wombat; this animal is to all intents and purposes a rodent; its four front teeth possess a persistent pulp and continually grow forwards on the arc of a circle as they wear away, with a strong plate of enamel arming their front surfaces, so as to keep this sharp by the greater wear of the softer tissues. Behind, the body of the tooth, consisting of dentine, is surrounded on its surface by a layer of cementum or bone substance. These incisors are separated from the grinders by a wide space unoccupied by any teeth. The same arrangement may be seen by any one who will take the trouble to examine the skull of a rat or guinea-pig; a rabbit or hare differs in having four instead of two upper front teeth. But it is possible that the placental type may, in the first instance, have branched off from a marsupial rodent. Mr. Darwin himself draws attention to the affinity exhibited by the viscacha, a rodent of South America, something like a hare in general appearance.

We may imagine a genealogical tree of the principal divisions of mammalia, hypothetically connecting the marsupial and placental divisions by the rodents, through this affinity of the wombat for them. According to natural selection, as I understand it, we should expect to find such a connecting link, and this evidence at any rate is not antagonistic to the theory.

But what is to be said about the thylacinus, the hyena or tiger of the settlers in Van Dieman's Land, a predacious marsupial, the size of a large dog, whose skull is so very similar to that of a dog that it would need a good naturalist to distinguish it from a dog's if he found it lying about on an English common.

The dog has six insignificant incisors above and below; thylacinus eight above and six below. The dog has two large curved conical canines above and below; thylacinus precisely similar ones; the lower canines, in both cases, close in front of the upper, although the lower incisors close behind the upper. Next behind the canines in both animals a row of spear-headed teeth are placed to help to hold a struggling prey. The molars of the marsupial, six in each jaw, are formed for cutting flesh and breaking small bones; two of the teeth in each jaw of the dog are similarly formed; four posterior ones above and below being tubercular grinders, more adapted for crushing than cutting. The homologies of their respective dental formula are :—

THYLACINUS.

	Incisor.	Canine.	Premolars.	Molars.	
Above ...	8	2	6	8 = 24	= 46.
Below ...	6	2	6	8 = 22	

DOG.

	Incisor.	Canine.	Premolars.	Molars.	
Above ...	6	2	8	4 = 20	= 42.
Below ...	6	2	8	6 = 22	

Anyone who will compare the skulls of the badger or seal with that of the dog cannot fail to be struck with the much greater dissimilarity they exhibit than do the two skulls we have been considering; yet both these animals are indubitably classed with the dog in the same order of carnivora, far removed from the marsupials. Some naturalists, led no doubt by this fact, classed marsupials as a sub-order of carnivora, but in that case we should only reverse the difficulty by having to account for the homologies of the wombat with the higher rodents.

There is a solution which may perhaps be offered, that the higher rodents and carnivora arose on parallel lines from the marsupial rodents and carnivora ; but in that case it will give the same difficulty in another form, for it will admit that the placental type had arisen from at least two separate origins, which, according to our previous argument, is infinitely improbable.

The more I ponder the subject the more I am convinced that the difficulty is no mere quibble. To look at the three skulls of a thylacinus, a dog and a seal, and to consider that by any possible genealogy the dog is more nearly related to the seal than to the thylacinus, and in fact that before the relationship between the dog and the marsupial can be traced every sign of a carnivorous animal must have been lost and reproduced, presses it strongly upon my mind that there is some force at work unaccounted for by the theory of the evolution of species in their struggle for existence.

I find the following remarks bearing on this subject by Oscar Schmidt in his work on "Mammalia in relation to Primeval times" (page 269). "Huxley states, in several hundred species of dogs he found fibrous formations which are said to correspond with the marsupial bones, the distinguishing feature of the marsupial group. If this observation becomes an established fact, the direct descent of dogs from marsupials would seem in the highest degree probable."

This, of course, opens out the question of all the higher mammalia descending from dogs, the higher rodents and insectivora being re-evolved; otherwise we must suppose that, on advancing lines, the three orders gradually abandoned pouch-bearing and adopted placentation and longer gestation on parallel lines.

Let us review the complexity and apparent difficulty of the evolution of teeth in such definite form and arrangement as those I have been describing. I say *apparent* difficulty, because in making researches the student can hardly fail to be impressed with a feeling as if ages upon ages had been spent, and myriads of forms evolved for every little step in advance.

I will try and give a general outline of what seems to have been the path of the evolution of teeth, as a great deal of the strength of my argument is based upon the very high type of organization which they evince.

We do not find that teeth maintain any important place in the animal economy until we arrive at the sub-kingdom, Vertebrata. There are a few curious examples among the lower forms, as in Echinus, the leech, and amongst mollusks; but it is amongst animals possessing a bony skeleton that teeth are met with in endless variety of form, structure and arrangement. Amongst the lowest vertebrates (fishes) we find, as we should expect, the lowest types of teeth, some of which seem to consist of a tissue scarcely varying from bone in structure, so that it may be well to say a few words about bone itself as illustrative of our subject.

The essential requisites of bone seem to be, that it shall possess a certain amount of mechanical strength and hardness, in order to support the soft parts and provide them with rigid bars to be used as levers; also that it shall be capable of such change of shape, as the general growth of the animal requires, that this last process may take place. Bone is occupied throughout its substance by small hollow spaces, technically termed lacunæ, which communicate with each other and with the nearest vascular surface by means of very fine tubes termed canaliculi; these lacunæ and their canaliculi are occupied by soft living cells which seem to possess the power of building up or taking down whatever is required.

Little animalcules (foraminiferæ) have the power of secreting small shells around them, leaving fine holes all over the shells through which to pass fine processes of their bodies, which only consist of a little jelly-like protein.

We may look upon each of these cells occupying the lacunæ of bone as so many foraminiferæ which have lost their individuality, and have had implanted in them a sort of instinct, or habit, of building up around them, or pulling down, or merely keeping in repair, just what is required by the physiological well-being of the animal; like a colony of bees, always hard at work attending to their duty. In order to provide them with requisite food, bone of any thickness is traversed by vascular canals, called Haversian canals, which give fresh bone its pink colour, and the blood vessels within which, bring the food and take away the *débris* as required. Around these canals the cells group themselves, communicating with them by the canaliculi.

The problem to be solved in the construction of teeth is rather different from that of bone. Here part of the organ has to resist more or less severe direct mechanical friction, has to be exposed, and at the same time maintain a strong connection with the living and sensitive body. One of the first distinctions between tooth-substance and bone seems to be in the elimination of the requisites for pulling down and re-building. No normal tooth, that I am aware of, alters its shape after formation. The calcigerous or bone-forming cells retire to the circumference of the space around each vascular canal, and dwindle in size until they disappear, or they retire into the vascular canal and remain there as a persistent soft pulp. The fine canaliculi, around which the salts of lime which harden the tooth were deposited, remain. Professor Owen mentions having observed the tooth of a fish composed only of this structure, which he calls vaso-dentine (See Owen's "Odontography" or C. Tomes' "Dental Anatomy"); an advance upon this vaso-dentine is made by the whole exposed part of the tooth being protected by a layer of the calcified tissue traversed by canaliculi, but possessing neither lacunæ nor vascular canals. This is a very common form amongst fishes.

In the common wrasse or connor of our shores we find this harder external layer developed inwards, to the extinction of all the vaso-dentine. The tooth is entirely composed of hard, very finely tubular dentine, but this construction seems to interfere with the vital connection of the tooth with the living jaw, as there is a provision for a constant succession of teeth from below.

In fishes generally, there seem to be few examples of teeth implanted by fangs in a socket, and no great permanency of connection between the teeth and their possessors; there is generally provision for a constant succession from behind forwards, as in the sharks and rays, or from below upwards, as in the wrasse, already mentioned, or the angler, where new teeth rise up between the old ones, which fall away. The law seems to be that of irrelative repetition. There is no instance amongst fishes of such a continuously growing tooth as we find in the wombat, which if it were a probable structure to occur from separate origins we might expect, since there is much greater variety of form and number of species among fishes than mammals. The dental apparatus of the parrot-fish is one of the nearest resemblance to the teeth of rodents in function that I can find; that of the lepidosiren looks something like in section, but I do not know sufficient of the habits of this animal to say anything of the functions of its curious-looking jaw. Amongst reptiles the same law of constant succession of teeth holds good, which looks as if there was the same difficulty of retaining the teeth permanently; but when we arrive at mammalia we find at most only one change of teeth, and this apparently in order to accommodate the adult animal with a larger set than would have been convenient for its young state.

The peculiarities of structure which perform this apparently difficult feat are these: the part of the tooth most exposed to wear is protected by enamel, which is extremely hard, and, so far as we know, entirely devoid of life; below this, and immediately surrounding the single vascular permanent originally formative pulp, is the body of the tooth, formed of dentine, which is traversed by an immense number of fine tubes passing from the pulp to the circumference; these tubes being occupied by fine processes of the formative cells, which, as we have before seen in the development of teeth amongst fishes, have retreated into the vascular pulp. Around the outside of such part of the dentine as is not covered by enamel there is a layer of bone substance containing plenty of calcigerous cells; this layer is called the cementum. This cementum surrounds the fang in those teeth which are thus attached to the jaw, and no doubt, by its highly vital character, plays an important part in maintaining the life of the tooth, and by its plastic nature perhaps helps to accommodate the fitting of fang and socket together.

Teeth such as those found in the dog, thylacine, wombat and rodent, are organs of an exceedingly high order of organic construction, and there is an exceedingly close resemblance between them respectively, i.e. between thylacines and dogs, between wombats and some rodents.

CHAPTER VI.

AN UNNAMED FACTOR IN ORGANIC CONSTRUCTION.

Objection to evolution as inimical to morality must be invalid if theory is true—Cumulative evidence—Exclusion of question of origin of life—Habitation—Convergent lines of development—Internal factor recognizes improvement in organ and reproduces it teleologically—Evolution of canine tooth, or ruminant grinders—Growth of tissues an instinct —Goethe—Socrates—Herbert Spencer.

MANY educated persons fear that Darwin's theory of evolution will have a depressing effect upon moral excellence. With this conclusion I do not feel that I can agree, as I think that the present state of knowledge establishes evolution as a science on as sound a foundation as that of geography or astronomy.

The evidence in favour of evolution is afforded by the independent concurrent testimony of the sciences of astronomy, geology, geography and biology, the latter including paleontology, anatomy, physiology, embryology and histology, each science being the product of the accumulation of an immense number of facts by a great number of workers; the records being of the remotest antiquity, the evidence such as is admitted *by all men, everywhere, and at all times*.

The facts of all these sciences arranged independently, and the accumulation of a multitude of labourers, all point in the direction of the evolution or progression of life.

It must be remembered that the old prophets and philosophers had not the knowledge which we now possess, which makes it seem impossible to many to think connectedly on the plan of the Universe and their own relations in it on any theory which does not admit evolution or progression as an established law.

That life can spontaneously appear where there is no life, is an essentially different proposition to that which asserts that a simple form of life may progress to a higher state. I do not know of any evidence establishing the former proposition as a fact. But, whether a fact or not, in all logical fairness it should be eliminated from the discussion of the laws of evolution. For life, however simple, to start up where there is no life, is no evolution, but either a direct creation, in the dogmatic meaning of the word, or an inconceivable explosion.

Evolution, so restricted, is a doctrine which is circumstantially, if not directly, proved by the *concurrent* testimony of too many sciences to be gainsaid. It must be remembered that we have only lately had the immense store of facts accumulated by the spiritual descendants of older observers at the present day, that our predecessors longed for more knowledge, that some of them seem almost to have foreshadowed many of the facts now well-established, that their cry was how little they knew—how much there was to be known.

Another restriction may be required on a point in the theory of evolution which has seized upon the popular imagination. I do not think it is necessary, to a theory of evolution, to hold that there has been an unbroken hereditary genealogy between the lowest and highest form of life, or, to come to the point of popular interest, that man is descended from an ape. (I now think it all but proved, and no doubt true: 1891.)

Whether there has been one break of genealogical descent in the *tree of life*, on the evolutionists' plan, or many, or none, it does not appear that we have sufficient scientific evidence to lead us to a conclusion. Here, therefore, our proper position is to hold our judgment in suspense until more evidence is advanced, or is exhaustively proved to be not forthcoming.

It may be competent to us to speculate as to which way the evidence seems to point, so as to direct our search for fresh facts either for or against our suppositions; but I hold that it is as vicious to jump to conclusions beyond the evidence before us, as it is to shut our eyes to facts because they may seem to point to conclusions which do not harmonize with our previous conceptions. In taking truth for our guide we must not try to dictate where she shall lead us—in putting our "hand to the plough, we must not look back."

In geography it is well understood that all the land on the globe has a solid connection either above or under the ocean, but still each island and continent requires survey to inform us of its special shape and connections above water; so in the science of evolution, as applied to animal life, we feel assured that there is some connection linking the whole, yet still we require that each species or genus shall be distinctly surveyed to note its connections, and where facts are not forthcoming, must be content to hold our judgment.

Mr. Darwin believes that from a low or simple form of life, all the more complex and higher types have been evolved, by the necessities of the struggle for existence, and the consequent survival of the fittest or higher type; the changes taking place by *irrelative spontaneous variations* modelled and directed by the external conditions in which the animal is placed, without the interference of intelligence, except so far as it is allowed in the provision of external conditions, so arranged as to conduce to such progressive development.

External conditions are, no doubt, of immense importance in modelling and determining the form of different species. It is difficult to get them definitely described, for—as has been pointed out, and notably so by Darwin—they are often of an exceedingly complicated and involved nature. A great part of these conditions is formed by the habits or productions of other animals or plants, forming series of vortices of complex interdependencies of necessarily synchronous development, which remind us of the "house that Jack built." These conditions are assumed in the life histories of animals, they have not yet, I think, been very clearly treated by any one, but must assume more and more importance as the battle of the theory of evolution is fought out. They are the moulds in which species are cast, the possibilities without which they could not exist, and not being capable of tangible or visible representation, are apt to be lost sight of. The scholar will perhaps tell us that these conditions were known to old philosophy by the name of "mothers." Cuvier and later naturalists have generally spoken of them as the "conditions of life." "The environment" seems to be a later term. Are not these terms too vague and inflexible?

There seems some evidence that species are formed and varied by their *habits*; the word *habitation* then suggests itself as exactly appropriate, and at the same time is a more convenient word. It is familiar, and has the stamp of antiquity upon it, with almost, if not precisely, a similar signification (Isaiah xxxiv. 13), "And it shall be a habitation of dragons and a court for owls"; or where the word house or mansion is used in almost a synonymous sense (as in Job xxxix. 6-7), "Of the wild ass whose house I have made the wilderness." As applied to man, the term would include not only his dwelling place, but all his surroundings, by which he subsisted or which gave him position. What made a man's rank, title, business, profession, living, handicraft, work, could all be more easily included under the term *habitation* than environment.

But do not the facts of modern research show that more than the influence of the various *habitations* on the globe must be taken into consideration to account for the various forms of animals? An energy must be allowed to the physiological growing powers of life, including a faculty more nearly resembling intelligence than it has been the custom hitherto to assign to these functions. An energy throwing out growths or variations in search of the required necessary improvement which is to preserve the continuation of the species, or a modification of it in the *way of life;* also a comprehensive unity of mind prompting the individual towards the right path.

It has been objected against the doctrine of evolution, that if the theory were true we should find similar species evolved on parallel lines, instead of constantly diverging ones.

In the previous chapter I tried to prove this very position, as I pointed out that the higher mammals must have arisen from at least two branches of the marsupials, viz., the carnivorous and rodent; and I find that Professor Huxley and many other naturalists are of opinion that "several distinct groups of placental mammals, differing in the beginning, arose from several distinct groups of marsupials." Whether it be possible to separate the placental mammalia into different groups, I do not pretend to offer an opinion, but as far as the evidence at present stands, it seems to manifest the presence of unity of purpose acting beyond the individuality of the particular animal or species.

The purpose of the present chapter is to present some evidence of a factor within the body of the individual creature, forming the organs with unity of purpose and a consciousness of what is being done in other parts of the same body, which it is difficult, if not impossible, to reconcile with the theory that it is the result of "irrelative spontaneity," however controlled and directed by its "habitation" in the "struggle for existence." Should this conjecture be correct, it may tend to show that intelligence is more latent or unconscious in its workings than is commonly supposed; as Goethe said, "We are unconscious when we are doing right, it is only when we do wrong we begin to feel."

The nature of the evidence will be taken from the analogies and homologies of teeth, which are organs extremely high in the scale of specialization. Instead, however, of comparing the development of teeth in different animals, the argument will rest upon the development, differentiation, and approximation of form and function in teeth in the same individual; the point desired to be proved being: that, granting some theory of evolution to be an established fact, still we must allow to the energetic principle we call life some power beyond that of "spontaneous irrelative variation" to account for the *repetition* of highly organized similar constructions in the same mouth.

A tooth stands extremely high in the scale of organized tissues; to keep so dense and hard a substance alive seems to have been a physiological problem of great difficulty. Teeth are dermal appendages, like the nails and hair, and therefore are not part of the internal skeleton, as has been clearly stated by the younger Tomes, notwithstanding which we find them, with few exceptions, arranged homologically with regard to the bones, and symmetrically with regard to a bi-lateral division.

Amongst fishes, for example, where all the bones of the mouth, and some in the throat, may carry teeth, often in great numbers, which are continually falling off and being renewed, we do not always find a precise bi-lateral symmetry either of form or arrangement. Yet even here the law is observed to such an extent that without further evidence we should feel obliged to inquire what had caused such a parallel evolution of teeth on two sides of the mouth. For although the teeth amongst fishes do not present the high development or such definition of sculptured complexity as those of mammals, yet the diversity of form amongst them is almost infinite, and even that between teeth in the same mouth often very great. For example, in the Port Jackson shark the front teeth are like prickles, the back teeth like a tesselated pavement. The same may be said of the common wrasse of our shores, or the wolf-fish, whose front teeth are like grappling irons, the back ones like paving stones. These teeth are approximately symmetrical and homologous in arrangement. But by the doctrine of evolution these teeth have all been developed from the same elementary form of spine or prickle, such as we find covering some of the rays and sharks. Without going further, I think we might work out an argument on this evidence to show that a unity is required to effect this beyond the power of external conditions alone—something having an attribute very much akin to intelligence, as if the whole were conscious of the growth of its several parts, and ready to avail itself of any improvement any part had attained, and adopted the same in other parts similarly circumstanced.

The force of the evidence in favour of this unnamed factor being cumulative, let us take the evolution of the *canine tooth* as we find it in predatory animals, as a unit or standard, so as to compare the amount of time or the number of successive stages which this tooth has passed through before it reached the perfect definition which we find it in amongst the carnivorous animals. We will allow that this tooth has been evolved by mere *irrelative variation*, *controlled by external conditions;* I do not say that it has been so evolved, but being tolerably simple in form, few in number in the same mouth, and clearly defined in place and function, we will suppose that it has been so formed for the sake of the argument, as the interference of any other factor must have tended to shorten the time of its evolution. Taking the time therefore required by the evolution of the canine tooth as a standard, if we find a much more complicated tooth and series of such teeth produced in much less time, and passing through much fewer gradations, we shall begin strongly to suspect that there has been some other factor at work than that of "irrelative variation, controlled by habitation."

The more intelligence we find in the life histories of animals, the more highly organized do we find their bodies, taken as a whole, or in each particular organ or systems of organs. Thus keeping pace with the general organization and intelligence, we find particular organs more highly organized and effective, and the more perfected any special differentiation is, with the greater tenacity it is retained; that is, it can be traced through a greater number of genera.

To begin with the lowest type, amongst fishes the commonest form is two long rows of teeth of an acutely conical shape, nearly equal length, slightly curved backward, and distributed around the margin of the jaws. These are very suitable for seizing and holding a flying prey. In the crocodiles, amongst reptiles, the snout is greatly prolonged, probably giving greater facility in the capture of their food. Such an even row, however, does not soon extinguish life, and their possessors either take small prey, which they swallow whole, or resort to various expedients to procure death. The pike holds his capture ten minutes in his mouth before pouching it, serpents kill by poison or compression, or are forced to swallow their prey alive, whilst crocodiles when they seize a large mammal hold its muzzle under water until it is drowned.

Among predatory fishes and reptiles we often find some of the front teeth elongated to emphasize their holding and lethal power, as in "Dentex," eels, and some crocodiles. These are not very definitely arranged homologically, and there are often several nearly in the same place, as if they were feeling about for their right and most efficient position. But they do not persist through many widely diverging genera, many of the crocodiles having an even row of teeth. A generalization suggests itself here, which, although rather hastily made, I suspect will prove near the truth—that in proportion as the canines approach their highest development the whole of the jaw will be found to be shortened, probably to give them greater power. For example, compare the head of the gangetic gavial, with its immensely long snout and row of sub-equal teeth, with that of the fossil machairodos, with its huge canines, or even that of the recent lion or cat.

In the highly developed mammals, of which the inference is that they are the result of a struggle for existence which has been more intensely severe and protracted than that to which reptiles and fish have been subjected, the definition of the canine tooth has become more precise, both in form and position, and much more retentively persistent through many groups. It varies slightly in form and function, but is of all the teeth the most consistent in its general characters, homologies or functions.

Its requirement as a weapon, either predatory or for offence or defence, seems to have been the external cause determining its evolution. It would have weakened its power by removing it too far from the acting muscles, if placed in the front of a long snout, and so the jaw is shortened; at the same time, if placed centrally or near together, there would not have been a sufficiently firm grasp, whilst if placed too far back in the mouth there would not have been the same facility for seizing the prey or foe.

The mean between these extremes finally settled the canines in carnivorous mammals, wide apart at the turning angle of a short comparatively wide jaw.

Notice that although the typical form of the canine tooth is one of the earliest developed, it is not finally determined in position so as to be of homological value until pretty high up amongst mammalia. If, then, "external conditions acting alone upon irrelative variation" have produced it, we must allow these forces to have acted for an immense time, all through the evolution of fishes and reptiles, before it was definitely *pronounced;* and we should expect that where we find a much more complicated tooth, the external conditions to which it is adapted, being less powerful and universal in time and space, it must have taken a longer series of gradations to develop, and *a fortiori*, an infinitely longer time to have produced a series of such teeth. But when we find, as we do, that not only is this the case, but that the row in the upper jaw is reversed to that in the lower, although the shape is maintained, in order to enable them to act more efficiently, I think we may be excused if our minds are staggered at the possibility of "irrelative variation" having ever produced such a result.

Instead, however, of this result being the product of a longer series of gradations than that which was required to produce the perfected canine tooth, it has been brought about within comparatively a very short range, and I think this, at any rate, indicates that to produce this result we must look for some factor within the animal having in some way a consciousness of, and being influenced by, what is going on in other parts of its organization.

Although there have been, practically, infinite varieties in the forms and arrangement of teeth among the lower vertebrates, fishes, frogs, lizards and snakes, there is no very perfect definition of character; roughly speaking, the teeth are bilaterally symmetrical, yet where they differ much in the same mouth, there is usually a complete series of gradations; nor is there the same exactness of classification possible between the different forms that we find among the higher animals—as if the lower animals had had a wider scope for varying the forms of their teeth independently under different conditions, but had not been subjected to the discipline of so fierce a competition. In the lowest large group of mammals, however, teeth begin to be well-defined, both for function and classification, so that we can arrange them under four principal heads, namely, incisors, canines, premolars, and molars. It cannot be said that all mammalian teeth can be perfectly so classed; but function has generally so definitely marked their relative position that their homologies are to be traced; this is not the case with the groups lower in the scale.

Let us consider the type of the dentition of ruminating animals. The form of the primitive tooth we have seen was that of a thorn or prickle. In the process of evolution this became coated externally with a harder crust called enamel, and became rooted; this latter process, however, we will dismiss from the argument, as it does not affect it, and attend only to the development of the crown. We find this prickly-shaped crown in some sharks' mouths becomes flattened, presenting a shape like the point of a stout surgeon's lancet, two smaller similar cusps bud off at the base on the edge, giving us a shape like that of some old spear-heads; this is the typical shape of the premolars in many of the carnivora. But let us suppose this lancet-shaped shark's tooth to be curved into a gouge shape, and two such blades placed side by side by their edges, then we should have the form of the lower masticating teeth of the rhinoceroid animals. If two such teeth are now placed surface to surface, so that the convex faces of one fit into the concave surfaces of the other, with the edges coalesced so that external coatings of enamel and internal substance of dentine flow together, each to its own tissue, we shall have the typical molar of the ruminant order.

This tooth, which, you see, is of considerable complexity, is one of high rank as an evolved form; it runs with little variation through all the sheep, goats, deer, antelopes and oxen, and traces more or less distinct show themselves among the pigs, rhinoceri and horses. It is doubtful if a trace of it can be found among the lower placentals, the very diversified forms of teeth of the marsupials, or in the lower forms of vertebrates.[1]

[1] I have recently found a somewhat similar pattern in the lower molars of the Koala (Phascolarctos Cinereous) a marsupial.

The necessity, or external conditional requirement for it, therefore, has not been of such universal potency, either in time or space, as that which called forth the canine type of teeth, and yet we find comparatively few species of animals intervening between its first sketch in the premolar of a pig, and the perfected type being adopted for all the masticating teeth above and below in the typical ruminants. How can mere "irrelative variation" account for this sudden change in shape of all the molar series, when we have seen how long was taken by the much simpler and more necessary canine tooth to be definitely pronounced? Surely the principle requires fortifying, by allowing it the aid of some internal uniting bond of sympathy. But even supposing that it were possible to conceive of some internal bond of sympathy having been itself developed by "irrelative variation," controlled and directed by the survival of the fittest, this would certainly place the series of the teeth homologically in their sockets in the same positions relatively to the cavity of the mouth in the upper, as in the lower jaws. However, this sympathy or polarity—for between the upper and lower jaws it is impossible that there can be any hereditary succession, as they are always contemporaneous—has not so placed them. In order to give the best functional activity, the relative positions of the curve of the teeth is reversed, the convexity pointing inwards in the upper teeth, outwards in the lower.

To this it may be replied that the skull is made of differentiated vertebra or parts of them, and that there may have been an inversion of the mandible so as to make the opposite parts of the teeth meet each other, instead of the homologous parts; for among the higher animals, a great many of those having highly differentiated grinders have this reversed arrangement. In this case, however, we should find the whole of the teeth of one jaw standing in reversed position to those of the other jaw, which is not the case, but only those teeth whose functions require it. We must, therefore, regard the functional efficiency as the determining cause, but must look further for a predisposing cause.

It is therefore plain that if we accept some theory of evolution as necessary and true, it is in evidence that it has taken countless ages to produce a ruminant's molar tooth, but being produced there has been at work some power able to recognize its efficiency, remodel the other masticating teeth in the same mouth on the same pattern, and reverse them in opposition—a feat of incalculably greater complexity, and utterly improbable to have ever been accomplished by irrelative variation alone, but which has in reality been accomplished in a very much shorter time than it took to arrive at the first sketch of the tooth. The evidence would be strong enough if met with in only one group, but we meet with the same facts in other groups, the mole and its congeners, and many rodents present the same features. In these cases, although the same general law is observed, it has been carried out by different details. It is scarcely possible to trace any connection between the teeth of a sheep, a mole and a guinea-pig, yet in all these species the functional parts the molars and premolars are repetitions of each other, and upper and lower series stand in reversed relative positions.

I think these facts almost give us ground for educing some general law. I cannot conceive of any merely chemical or mechanical laws intelligibly accounting for them.

The analogy seems to me very close between this group of facts and the history of an invention. Looked at merely from the outside and historically, we might infer that inventions were accidental discoveries, perpetuated and accumulated by the struggle for existence. To a certain extent no doubt this is true, but the adoption and quickly spread application of a new invention to different conditions requires also recognition and intelligence.

It will be asked, do I think there is any intelligence displayed by an animal in its own growth? I do not say that this can be proved, but at any rate there is evidence showing something very nearly akin to it, something which seems to have grown in intelligent work with the general rank of the animal in the scale of being, and therefore with its own general intelligence.

In a previous chapter on "Human and Brute Intelligence," I tried to show that "all organs must have in themselves in life all the instincts of which the organs were evidence." Now I shall try to show in the remainder of this paper that growth is an instinct, as much as any other inherited tendency of action.

In the chapter on perception it was maintained that we had to make the ideas with which we perceived things by a process of the imagination suggested by such difficulties as were met with in action. If this theory be true, or only true in part, it may account for the very different views we take on some subjects. The battle used to rage between freewill and necessity. Those who paid attention to the history of men as individuals, or reflected on mental science, generally leaning towards freewill; whilst those who had to do with the exact sciences gravitated towards necessity, and could not accept the idea of spontaneity, which was involved in the idea of freewill. Now, however, the flanks of both schools have been turned by the biologists, who previously observed a modest silence on these occasions. These latter do not usually believe in freedom of the will on the one hand and rank spontaneity, under the head of causal necessity, on the other.

Having understood that spontaneity was a necessary part of the doctrine of freedom of the will, I can the more readily recognize the possibility that spontaneity has had a large part to play in the evolution of species, nor do I see that such an admission at all imposes the tenet of causal necessity or in any way interferes with moral responsibility.

The farther histologists have traced the various tissues to their elementary functional constituents, more clearly has it been proved that although mechanics and chemistry have a very important share of the work to be done, they are but secondary causes, and that the primary agent in the growth of all tissues is a nucleus. This increases in number by division or proliferates, and takes from the nourishing fluids around it the material it wants, with which it proceeds to build up the tissues to which it belongs.

We are familiar with the idea that there is a certain parallelism to be drawn between the advance of species from the lower to the higher forms, and the development of a highly organized individual from its embryo. Here is an illustration, taken from "Carpenter's Physiology," of a parallelism between one of the lowest forms of life and the cells of bone, one of the commonest tissues of the body. In an amaeba we have a soft glutinous mass, capable of taking any form and receiving food through any part. It makes spontaneous movements, takes food into its substance and rejects what is unsuitable. In the *gromia oviformis*, a little higher in the scale, we have an animal that has encased itself in an ovoid case, through apertures in which it takes its food. It at once suggests itself to the mind that if a colony of these gromia kept out their feelers for the sake of receiving nourishment, and filled up the interstices between themselves with the same material as that of which they had already made their shells we should have such a substance as is represented by a section of bone. Different modifications of the same arrangement will represent the elementary structure of nearly all the organic tissues. Here, I think, we are forced to draw a parallel between instinctive and intelligent actions on the one hand and organic growth on the other.

Habit is second nature, it is said, and the proverb is perhaps "wiser than it was 'ware of." We know our own actions often repeated become habits. These may become hereditary, and will then be instincts.

If it be allowed that habits or instincts can be intelligently traced to intentional or spontaneous action, the same chain of reasoning will lead us to the conclusion that growth may be included in the same law.

We have in this lowest form of life a state of almost unconditional spontaneity. Its powers are small, but they can act in any direction, and the first action with intention seems to be to move and get food, that is, add to its own substance. Growth then, is an action. And if after a time an animal got to add a covering to its body in a particular manner so as to repeat the same action often, it would become a habit, and if when it separated into two parts the lesser preserved the same habit, it would be an instinct. Thus growth of tissues will be as much instinct as a bee making its comb.

On this theory the body is the expression of the whole past history of effort, experience and intelligence which any animal has passed through in its evolution—truly a wonderful temple of record. The poet Goethe has beautifully expressed it in the following lines in "Faust":—

> "Here in the roaring loom of time I ply,
> To weave the garment that thou seest me by."

Some recognition of this fact was probably made by the old philosophers when they termed man the microcosm, as having within himself a reflex of the whole external world, all of which is his habitation.

Plato makes Socrates give as one of his proofs of the immortality of the soul, the fact that man had more intelligence in him than was possible to have been derived from his own experience, and that, therefore, he must have had a previous existence. Recently, Herbert Spencer has boldly propounded that ideas are hereditary; he supposes that the universal recognition of time and space may be because they must have been experienced, and therefore, been inherited by every one. Canon Kingsley, in his beautiful story of "Water Babies," says three times over that the only true doctrine is that the soul makes the body.

In conclusion, therefore, I will say that I see at present no ground for believing that a living being ever springs spontaneously out of dead matter, yet I do see evidence for the necessity of some doctrine of evolution. Nor do I see any ground for fear that morality or the higher life of man need suffer by such an hypothesis. On the contrary, it seems to me to lend solidity to a belief in a yet higher life in the future, only to be entered by continual strife in the right direction, and to emphasize the warnings of those who would point out to us the importance of getting into, or keeping in, the life of that *branch* of the tree of life whose *habitation* will have no end.

CHAPTER VII.

HABITATION OR ENVIRONMENT.

The word environment not satisfactory—Habitation more ancient, scientific and vital—Decline of teleology—Herbert Spencer on environment — Interdependencies — Salmon probably evolved from trout—Relation between grizzly bear and bison—Camels and llamas and rainless regions—Similar forms of whales and fishes—Wide face of Asiatic man and orang-outang—Projecting face of negro and African apes—Reflection of habitation on inner life of animal—Reasons for supposing consciousness at organ end of nerve instead of in brain—Ferrier—Reflex of habitation in nervous centres produces acting conceptions, or building instincts—Query: Are the pyramids an instance of recognition of this—Position of dignified equivocation — Lauder Lindsay — Man differentiated from other animals, probably by words or weapons—The calendar's story.

IT is the object of this chapter to point out the relationship which exists between animals and those surrounding conditions to which each species is peculiarly suited.

In doing this, a word is required, applicable to these conditions, and at the same time definite as well as intelligible. The word environment, used in a certain class of literature, with somewhat of the meaning wanted, has a haziness and inflexibility about it which is not satisfactory; and as the differentiation of the organs and characters of animals seem to be formed in great measure by their habits, I shall use the word habitation in the sense indicated.

I have applied to several scholars to see if any connection were traceable between the words "habit" and "habitation" in their early use; but, save that both words have the same Latin derivation, have received no information on this head. I can, however, quote the book of widest distribution in the English language as using the word in the sense given. The Bible makes frequent use of the word, as, for instance, in the 104th Psalm; speaking of the "springs," it says, "By them shall the fowls of the air have their habitation." A little further on, the word house is used in the same way—"As for the stork, the fir trees are her house." The 34th chapter of Isaiah says, in speaking of a land unsuitable for man, "It shall be an habitation of dragons and a court for owls;" and in the 35th chapter, in referring to a further change, he speaks of "The habitation of dragons where each lay, shall be grass with reeds and rushes."

The word house, or mansion, is often used in this way, and a Hebrew scholar might tell us that in the context the same word was originally used, but had been differently translated. We have, for instance, in the 39th chapter of Job, a description "Of the wild ass; whose house I have made the wilderness, and the barren land his dwelling."

The word refers to those surroundings of man or lower animals, which are particularly convenient to habitual actions, suited to their manner of life.

Habitation is a word more definite, more substantive, more applicable, more full of purpose and life than the word environment, which reduces us to the region of abstract ideas at once. Teleology will always rank above abstract philosophy or exact science. It has seemed barren of results of late, because its problems are so complex that terms have become confused and the logical thread lost. No one seriously doubts that to feel, to think, to initiate good or bad purposes, to act, is really higher matter than all the facts of chemistry or astronomy.

Herbert Spencer himself does not seem quite satisfied with the word "environment." In his "Principles of Biology" (vol. i. p. 85), he says, "It requires to be observed that as the life becomes higher, the environment becomes more complex." Then he observes, "Though literally the environment means all surrounding space with the co-existences and sequences contained in it; yet practically it often means *but a small part of this*. The environment of the entozoon can scarcely be said to extend beyond the body of the animal in which the entozoon lies—that of a fresh-water alga is virtually limited to the ditch inhabited by the alga—and understanding the term in this restricted sense, we shall see that the superior organisms inhabit the more complicated environment." It is difficult to use the word so restricted. To say a simple or complex, large or small, humble or grand, strong or weak environment, is a mixture of concrete and abstract ideas which do not harmonize; but we can readily so qualify the word habitation, and may extend its use to morals and religion as a habitation of righteousness, justice, beauty, truth, wisdom or the reverse.

The higher animals, including man, depend for their existence on other animals and on plants, which are on the whole, though with some large exceptions, lower in the scale of being than themselves. They also depend directly or indirectly upon past generations of animals or plants, and on past geologic and geographic changes which have made their present existence possible. To use a teleological expression, the habitations on the present globe have been prepared by successive ages of change, generally slow and gradual, sometimes locally great and sudden.

We may safely build upon the fact that the chronological evolution of life corresponds with gradual geologic and geographic change. We find the older rocks contain the remains of the simpler forms of life, those of later formation yielding fossils of the higher types in direct relative ratio; and the present distribution of life on the globe, as far as known, corresponds in the main with geographical change and limitation.

I will give an illustration or two of the relationships which exist between the evolution of an animal, its habits and its habitation. Let us examine the facts which support the idea that the salmon was evolved from the common brown trout. The young of both fish are very similar, and if a brown trout finds a home of peculiarly good feed, his flesh acquires a pink tinge. There are fish answering in shape, size, and habits to intermediate forms between the trout and salmon. For instance, in the tidal waters of the Cork estuary there is a large pink-fleshed trout which seems to remain in the tidal waters. Then we have sea-trout, salmon-trout, salmon-peel, bull-trout, sewin, etc., varieties which approach more to the brown trout on the one side, to salmon on the other. The suggestion is, that the salmon was evolved from the trout by its having formed habits suited to a larger habitation; salmon migrating to the sea during a portion of the year, where they would have more abundant feeding-ground, more numerous and fiercer enemies, and have access to other rivers, whilst trout on the other hand always remain in fresh water. We infer that salmon is older than any of the intermediate varieties previously referred to, the one which had most perfectly adapted itself to its habitation, that the other varieties would be gradually amalgamated with it by the power of adaptability fitting them more and more perfectly to the habitation, and by inter-breeding with the salmon; or if any peculiarities of location gave either variety a decided advantage over salmon, there it would become the stereotyped and prevailing form. This is said to have taken place in the River Coquet, where bull-trout have nearly supplanted salmon. Here, if the facts are correctly interpreted, are two factors necessary to the case; a habitation, composed of rivers, sea, food, enemies, etc., and a fish having impulses and instincts capable of entering and gradually adapting itself to these conditions. There are many fish as favourably circumstanced as trout for adopting the habit of migration to the sea if they pleased, which yet do not do so, this fact tells in favour of species altering by *special* rather than individual tendencies to variation.

Let us take another example. The grizzly bear is only found at present in America, occupying the same area as the bison, on which he feeds. He is the only carnivore there capable of killing this beast. At one time he roamed over Europe and North Asia in company with the Bovidæ, but over Europe and Asia have also roamed lions and tigers, whilst the larger herds of Bovidæ have been almost exterminated or domesticated by man. Can we doubt that the presence in America of the grizzly bear is due to the presence of the bison and the absence of superior rivals in the lion and tiger?

Another instance of special adaptation to particular habitation is the camel. The range of this animal is the same with that given on hydrographical maps as the largest rainless region, and, curiously enough, I find the second largest rainless region, that down the coast of South America, west of the Andes, corresponds to the habitat of the Llamas, the animals most closely allied to camels.

Now, although camels and llamas may have had a common origin in North America, yet I think we can hardly avoid the conclusion that their present distribution in such widely separated regions as the deserts of Asia and Africa on the one hand, and Chili on the other, can only be accounted for by the conditions in which these regions so remarkably resemble each other, viz., their rainlessness.

A familiar instance of the effect which similar habitations have in producing animals externally alike, although their internal structure and their habits of life point to different places in a true classification, is found in the similarity of form possessed by whales and fishes.

It is difficult to avoid being struck, in this connection, with the analogy which exists between the wide flat faces of the Chinee and Mongul type of man, and that of the Asiatic ape, the orang-outang. The prognathous type of the negro's face and its similarity in this respect with that of the African apes, gorilla and chimpanzee. No evolutionist is bold enough to suppose that man could have arisen independently from these three sources. The inference is that some local peculiarity, perhaps of food, heat, or light has favoured the development of the broad face in Asia, the prognathous one in Africa.

Dentists of the present day are well aware of an instance in which modification of the conditions of human life is producing a variation, or to speak more correctly, stereotyping a variation in human dentition. The civilized races use much more luxurious food than the less civilized; this is prepared by cooking and other means, so that it is much softer and requires much less muscular effort in mastication. The consequence is, that the jaws are not sufficiently developed in size to receive in symmetrical order the full complement of teeth. These are, therefore, unduly crowded. Apparently to meet this difficulty, the wisdom teeth are being eliminated, as it is an established fact that among civilized races these are often absent or stunted in size. According to tables recorded by Mr. Weiss, in London, only about half the normal number of wisdom teeth are erupted in English patients. In a less marked degree the same process is taking place with the upper lateral incisor teeth, which are more frequently absent or dwarfed in size than any other teeth except the wisdom teeth. But although this tendency is often observed to be hereditary, it is far too widely spread to have had its origin in only one progenitor. It may, therefore, be taken as a very good example of how external conditions tend to create, or rather perpetuate, varieties.

An illustration of the persistence of the hereditary type showing its distinct nature from that of the surrounding conditions or habitation, is found in the fact that all the monkeys of the New World possess three premolar teeth on each side of each jaw, whilst all the Old World monkeys possess only two. As the greater number of teeth is the older type, the presumption is that the common ancestors of both branches had three premolars, but that one branch from this became established in the Old World, which for some reason or other dropped one of its teeth. This must have been advantageous or it would not have been maintained in the variations which it subsequently underwent to form all the species of the Old World. The monkeys of the New World have continued to the present time, and have, therefore, had just as long a time to vary in as their Old World relations; but although they have diverged into many species, they have all maintained the three premolars.

In the problems with which we are dealing, we have always two main factors to bear in mind—the internal life of the animal which builds its body and directs its actions, and the external surroundings of land, water, air, food, friends and foes being the habitation to which it has to adapt itself. It remains to be seen whether this latter does not produce a reflection of itself within the former, gradually forming those ideas and that intelligence by which it is perceived.

In a previous chapter (on human and brute intelligence) we came to the conclusion that on the doctrine of evolution, every animal, and all the organs of an animal, ought to have within themselves the instincts and intelligence which the past history of their development should have imparted to them. In taking the organs as evidence, we must remember that these are material witnesses of the consciousness which lay behind and produced them.

The nervous system being the chief organ of active consciousness, we should expect to find in it evidence of correspondence between animals and their environment, involving also their grade in the scale of being, the height of the habitation they had risen to.

The lowest animals have no nervous systems; yet we must allow them consciousness, of however low a grade. Impressions received from without pervade their substance, and produce corresponding action.

In the Ascidian we have an elementary type of a nervous system. Instead of the whole body becoming conscious of external impression and making a corresponding action, we have a special part told off to pay attention to change of circumstance and communicate orders for a corresponding action. This formulates for us three distinct relations between the animal and its environment: Firstly, what it can perceive by sensory nerves and senses. Secondly, how its desires are affected towards, or from, what it perceives, by previous preparation of motor centre. Thirdly, what it can do to achieve its desires or avoid its aversions in accordance with what it perceives of change of circumstance through the motor nerves and active organs.

In the progress up the scale of being the special senses are built up round twigs of the sensory nerves, the active organs around the twigs of the motor nerves; whilst the motor centres are increased in number and size in correspondence with the sphere of life in which the animal moves.

The sensory nerves are usually termed afferent nerves on the supposition that they convey impressions received from without by a sort of molecular change to the motor centre, which passes on the corresponding message to the necessary active organs through the motor nerves, thence called efferent nerves. Although I may use these names as convenient, I must object that I believe this efficiency of molecular change has not been proved by any actual fact. I am, therefore, free to suppose, on the other hand, that consciousness flows equally from the motor centre to the termination of sensory and motor nerves. The reasons which seem in favour of this view are as follows :—

Firstly, we must allow to consciousness the powers of extension and motion ; because we are conscious of both extension and motion.

Secondly, we must allow to the motor centres the power of sending out messages by the fact of action.

Thirdly, the nerves of sensation are precisely similar to those of motion ; and, therefore, as consciousness can send motion down the motor nerve, as far as similarity of organ implies similarity of function, it might also move down the sensory nerves.

Fourthly, there are special organs placed at the ends of the sensory nerves, especially differentiated to receive special external impressions. There are no special means of reproducing these impressions in the nervous centres. Is it possible to conceive such different impressions as those of sight and hearing, passing up similar nerves and being retranslated in that very dark chamber, the brain, without any special organ there to do it ? There is none, for the peculiar formations of the nervous centres, as far as known, may be explained on the hypothesis of gradual development and the requirements of packing. There are no arrangements for reproducing in the nervous centres the impressions received by the organs of the senses. On the other hand, so far as we can understand them, the external organs of the senses are exactly adapted to acquire the special information obtained by them.

If we allow that consciousness may flow down the optic nerve, and spread itself over the retina, the visual picture we see becomes to some extent intelligible; but to suppose that each nervous fibre transmits to the brain a certain sensation of colour, which is there re-arranged as a picture, without any corresponding organ for doing so, seems to me unnecessarily mysterious.

Other arguments in favour of this view, are that intense attention of consciousness through *part* of the nervous system, as that of soldiers in action, withdraws the function of sensation from other parts, and they are wounded without feeling pain. Persons giving great attention through the eyes or in thought, do not hear when spoken to. Although there is not ordinarily any effort in using the senses, yet, in times of weakness or disease we do feel a sense of fatigue in their action. When we take the most perfect rest, consciousness is withdrawn from them, to a great extent, and we sleep.

Assuming the nervous system, then, to be the particular organism of perception, consciousness and action, let us see what evidence it gives of particular adaptation in the lower animals and man, between them and their habitations or environment.

As we should expect, the exact functions of the nervous system are still extremely doubtful; the following is a slight sketch of what seems fairly established:

The lower in the scale of life, the less scope for variety of action will occur to the animal; as life rises in complexity of organization, the greater the variety of circumstance which will happen in its habitation. This calls for the exercise of imagination, speculation, hesitation and judgment. When life has risen from one habitation to another, so as to be perfectly adapted to it, a co-ordination takes place between the nervous centres and their perceptive and active avenues; so that immediately on a certain perception being made, a corresponding action would be ordered, not exactly unconsciously, but immediately, without speculation, hesitation or judgment.

As the habitation became still higher, the perplexities of occurrence would be such that a large nervous centre would be required to form complex sensations into relative acting conceptions.

In those animals which only perceive what actually touches their bodies, a series of nervous ganglia are found; but in those which have specialized senses, we find, at any rate in the vertebrate series, a nervous mass, the cerebrum or brain proper, set apart to acquire information through the senses, centralizing it, forming it into acting conceptions, judging of the relation of these to the general desires of the animal, and ordering the corresponding actions of the lower motor centres.

According to Ferrier, the spinal cord is the centre of reflex action simply, i.e., if the foot is tickled, it is drawn up, without there being any necessary connection between it and the brain. Ferrier says there is no consciousness in this (he seems to have felt the difficulty); because, although a decapitated frog moved its foot to the place, when part of the skin was irritated by an acid, as if to remove the cause of annoyance, yet it showed no sign of pain or other uneasiness when the water in which it was placed was gradually heated.

And here I must pause to remark, that although, considering the importance of the knowledge gained to curative science, the experiments recorded by Ferrier, were, perhaps, justifiable; having read them, I cannot but think that their repetition should be strictly limited to what is absolutely necessary.

We may remember that one of the functions which we assigned to the motor centre, was that it must have a special *previous* preparation towards any information which it is put in relation with before it will act in reference to it, and this may explain the apparent apathy of the decapitated frog. If the consciousness of the spinal cord of the frog had not been previously prepared with reference to heat, or if it had given up judgment of this sensation to the higher nervous centres, it might not be conscious of heat, towards which it did not re-act, without that fact proving that it was not conscious of the irritation of the acid towards which it *did* re-act.

The medulla oblongata, just above the spinal cord, seems to be the co-ordinating centre of the reflex actions, essential to the maintenance of physical life: as breathing, swallowing, digesting, heart-beating, etc.

The cerebellum seems to be greatly, if not principally, occupied in co-ordinating the actions necessary to maintain the locomotive equilibrium. It seems, in connection with the semi-circular canals of the ear, to maintain a very clear conception of the three principal directions in space in relation to the force of gravity, and the usual direction of locomotion of the animal. We should expect to find it large in athletes, wrestlers, tight-rope walkers, good skaters, and amongst the lower animals, in such as had a good deal of quick and dangerous climbing to do.

The mesencephalic centres co-ordinate more complex forms of activity, such as locomotion and emotional expression. They pay attention to occasion for grief, joy, pain, etc., and give expression to these emotions by crying, smiling, laughing, or other spontaneous emotional expression.

The basal ganglia, according to Ferrier, seem to "be the centres of a form of activity, subordinate to the hemispheres proper. The various sensory and motor centres which are differentiated in the hemispheres are integrated in these ganglia, and organic nexuses may be established between them, so that actions at first requiring volitional education and conscious exertion, become organized reflexly or automatically in these ganglia."

You will observe that all these great nervous centres have direct relations to the environment; the lowest, what touches the body; next, to swallow food, breathe, circulate blood through the body; thirdly, to keep the perpendicular, with a strong sense of the force of gravity; fourthly, recognition of occasion for and expression of grief, mirth, joy, etc.; fifthly, a power of co-ordinating fresh habits of action.

And above all, lies that part which has to imagine, speculate, combine, hesitate, form fresh conceptions, decide and command, allow or *forbid*, the actions of the lower centres.

As has before been said, in proportion as more variety of action, ideation, judgment is required or is forthcoming, so is this organ large or small.

The query will naturally suggest itself from these considerations as to whether, if there has been such a series of development of life gradually rising to higher and higher habitations, the very fact of the existence of these invisible habitations would not at last become an acting conception in the consciousness of animals. We certainly do find such an acting conception, instinct, or idea. The lower animals add to themselves coverings in their own bodies; as they rise in intelligence they seek for or construct external places of shelter. Although the rule is by no means universal, yet we find intelligence considerably developed in the direction of architecture, as those who have read "Homes without Hands" will readily admit.

We find no evidence among the lower animals that they have thought about the habitations of other animals, except as they are directly affected by them. Do we find any such evidence in man, and if so, may not this be one essential difference between them and him?

What would be the simplest diagrammatical expression of the recognition of such a series of habitations or houses as I have been attempting to describe? To form the lowest, take a simple superficial figure, say a square. The lowest life must cover a large superficial area, and as it occupies some space, we must raise a platform upon this square to represent a covered area. The next, more complex, life above this would be forced up by the one below having occupied all the available room, and as it would have to depend for subsistence to a great extent upon the life in the lower habitation, it would have to occupy a region restricted by the exigencies of the life below. Its habitation, therefore, would have to be smaller as well as higher. We must represent it by placing a lesser square layer concentrically upon the larger one, and thus by building up a series of such layers we should get a pyramid, and if we consider our king to be the head of the series, we might either place a monument of him on the top or bury him in the middle of it.

As Piazzi Smith's theory of the pyramids of Egypt seems to have broken down, the ground is open for this suggestion in explanation of them; but whether the illustration will bear this application or not, it may help us to form a conception of the various grades of real but unseen habitations, which have existed and do exist in relation to life in our globe.

A good deal has been said about the variation of species and their correct classification, and I think we may profitably discuss what we mean when we talk about correct classification. We may not call a porpoise or a lobster a fish; a bat a bird, a spider an insect, or a barnacle a mollusc. Herbert Spencer has well expressed the point when he says (p. 102, P. of B.): "Organisms do not admit of uniserial arrangement either in general or detail, but everywhere form fresh groups within groups. Hence having traced the phases of morphological composition up to the highest form of any sub-kingdom, we find ourselves at the extremity of a great branch from which there is no access to another great branch except by going back to some place of bifurcation low down in this tree." He says further on, that such terms as sub-kingdom, classes, orders, genera, species, etc., are "only convenient terms." This must not be understood to mean that they do not represent something real in the past and present; but only that they are not terms of constant value. We might speak of the limbs, branches, twigs and stems of a tree, without meaning that these words were of precisely definite value; but they would still bear real significance of life, growth and divergence.

The real classification of animals is that of a genealogical or hereditary tree. Whether life has proceeded on this plan by actual descent, or by providential, gradual preparation of habitation with simultaneous inventions and creations of life to suit them, the statement in either case holds good that the Creator, the Provider, and the Eternal Father are the same.

I am not going to assert that man is descended from the ape, as there seem great difficulties in the way of such an admission. The judicious place is one of dignified equivocation. But, although the safest place at present is to "sit on the fence," it must be said that the anatomical argument in favour of this view is so strong, that we are obliged to look about for some means of getting down on the ape side without breaking any bones, if it should be necessary. One of the difficulties in the way of the ape descent, is that the members of that family having the nearest approach to man, viz., the gorillas, chimpanzees and orang-outangs, are all found upon the equator. Nor can they bear the temperate climate of Europe for even a short time. It is hard to conceive that a branch of this family should have such a capacity for adapting itself to climate, that in a comparatively short time it has penetrated almost as far north as any other mammal however specially qualified to resist cold.

Another point to be noticed, in this connection, is the exceedingly slight anatomical difference which this divergence of location has produced. Supposing the anthropoid apes to have had a common ancestor, they have differentiated infinitely more than man, under slight difference of circumstance. They have shown much greater plasticity of form than man with much less power of adapting themselves to change of circumstance. Man, on the contrary, has shown a power of adapting himself to change of condition altogether unparalleled in the rest of the animal world, with an inveterate obstinacy as to change of form; in this respect contrasting markedly with the ape.

It may be safely asserted that a surgeon would feel much more confidence in operating on any man anywhere, than a comparative anatomist, familiar with the dissection of an orang, would feel if called upon, for the first time, to dissect a gorilla.

We cannot, therefore, yet accept it as proved that man is descended from the ape. If it be a fact, we must bow to the fact; but if so, relics of intermediate types, of no doubtful definition, should be forthcoming in abundance. These, indeed, would probably be found in equatorial regions, and this may account for their being at present conspicuous by their absence.

The following is a rough sketch of what may have been the line of descent of man on the evolutionist plan. I say may have been, because several genealogies may be laid down with about equal probability: protozoon, pollyp, molluscoid, mollusc, fish, reptile, monotreme, marsupial, small carnivora, lemur, monkey, man.

Now, how comes it that man, who comes down, at any rate, during the latter part of this career, a comparatively feeble line, should have suddenly flared out into dominance of all the rest?

Is there anything in man's consciousness to favour the idea of such a descent? If there has been this path, it ought to have left some record there. The struggle between a life that has at last resulted in an animal especially capable of feeling sentiments of religion, beauty, justice, pity, etc., and the life of the great dragons of a bygone period, the great carnivores and poisonous serpents of the present era, should have left strong terrors and aversions to these beasts. As a fact we may note that no animals, except birds, have such a horror of serpents as monkeys; that among men, dragon and serpent worship is a very old form of religion, and that the dragon, the lion, and especially the serpent, are almost universally taken as types of evil.

Supposing man to have descended from the ape, there must still be a line of distinction; it is of importance that we should consider in what the essential difference lies. Our authorities upon the great antiquity of man are remarkable for the clearness of conviction and unanimity with which they can pronounce upon his presence. Signs of weapons, drawings, cooking, ornaments, etc., are without doubt, good evidence of his presence. Whereas some evolutionists who have written upon mind in the lower animals as compared to man, Lauder Lindesay to wit, seem hardly able to find any difference between them.

Here the great fight and popular interest centres. It is almost impossible to take up a periodical without finding the theory of evolution touched upon in its application to morals, laws, arts, and sciences, and in these applications lies a particular danger. Frequently a writer who recognizes the general law correctly, stultifies himself in his application of it in the logical reduction.

I will take an illustration of what I mean from a supposed case of the application of the law of gravity. We recognize its universality of application in the material world. We buy by weight, with practical uniformity. But we may also deduce from this law of gravity, that a plummet will fall perpendicularly to the general surface of the earth, and that, therefore, if we build perpendicularly to the surface of the ground we should build right. As long as we built on a level plain no great harm would arise; but if we erected a wall perpendicularly to the side of a hill, we should find we had made a wrong application of the general law; our wall would fall.

In the same way, when writers on the subject of evolution get so carried away as to make wholesale applications of it to existing laws and institutions, they often make a wrong application of the theory, one of the mainstays of which is, that all change must be made very slowly.

Some of the attacks of this sort are exceedingly offensive and reprehensible, and will necessarily be passed over here in silence. Others are only amusing, and of these I will quote the following as being germane to a great deal of sentiment on the subject.

Lauder Lindsay ("Mind in the Lower Animals," vol. i. p. 238) says that he believes "that could they only be induced to bestow them, the patient efforts of our missionaries in this direction, i.e., on our 'anthropoid' poor relations instead of their fellow-countrymen, the negro, might produce results of a startling character, results that might put an end at once and for ever to current sneers as to the physical connection between men and monkeys."

Upon this question of the difference or similarity of man to monkey the popular interest mainly hangs: it is in vain for the evolutionist to assure his audience that this is only a bye-issue, and to try and excite attention on other ground. Back to the ape descent, and the essential difference between the mind of man and beast, the argument always comes, and is fought *pro* and *con*; disputants are angry or pleased with the theory to a large extent, whether this view of the case accords or not with their own preconceptions.

A definition has two principal parts. The first includes the subject in a class. The second distinguishes it from all the other members of its class.

Man, according to the first part of this proposition, must be defined as an animal. According to the second part he must be distinguished from all other animals.

Classical and theological authors have been so long engaged upon the second part of this definition that they seem sometimes to have forgotten the first part altogether.

Now, unless the first part, i.e., that man is an animal, be allowed, the second part, showing how he differs from other animals, is impertinent.

Some scientific evolutionists, and some other writers not at all scientific, have turned the tables upon this school, and for the time, at any rate, seem to have the whip handle. But these have often fallen into the opposite error of maintaining only the first part of the definition, i.e., that man is an animal. Indeed, some of them seem fascinated with this part, Lauder Lindsay in particular. On this subject will hang a great deal of future law, and the attitude civilized nations will adopt towards those lower in the scale. If there is to be no definite line between man and the lower animals, what is to prevent man high in the scale of intelligence and power, treating those lower down on the same footing as the *other* lower animals? Instead of such treatment being wrong and reproachful, it will be justifiable and right.

One explanation of the wide distribution and diverse conditions under which man is able to live without much change of organization, may depend upon his faculty of adding to his active powers by the invention of implements. By these he can make clothes and fire which will enable him to bear change of climate, and with the latter cook food otherwise indigestible.

The importance of weapons has attracted so much notice, that periods in civilization have been named after the advance in the materials of which weapons are made. The stone, bronze, and iron ages, reminding one of the prophet Daniel's description of Nebuchadnezzar's dream. Perhaps the use of teeth of other animals as weapons may have even preceded the stone age, in which case we might find an explanation of the classical legend of Cadmus, who sowed dragon's teeth and they came up armed men; at any rate, teeth have been so used by savages.

But the central and dominating faculty seems to be that of language. By means of this, experience could be transmitted by tradition, so that what advance was made towards a higher life could be handed down, not only in the line of organic descent, but in a much wider and more accurate manner. The lowest types of man have articulate language, and generally some sort of depicted representation of this, which may be taken as an inception of writing. Figures of animals are generally the first step in this direction.

To name the animals that are brought to him seems to be always one of man's essential prerogatives; from the savage, who is always interested in distinguishing and defining those around him, the infant, who as soon as it has learnt to say "Da-da" and "Ma-ma," proceeds to define the "bow-wow" and the "gee-gee," up to the scientific naturalist, who has no greater delight than to get a new animal to name. Certainly he would be a bold man who, if he found a delineation of an animal, no matter how old, should suggest that it was the production of any other animal than man. We can conceive that the faculty of language, and writing, or drawing, would result in the production and perpetuation of weapons; but not that the occasional use of a stone or stick as a weapon should lead to its universal adoption and the final evolution of language.

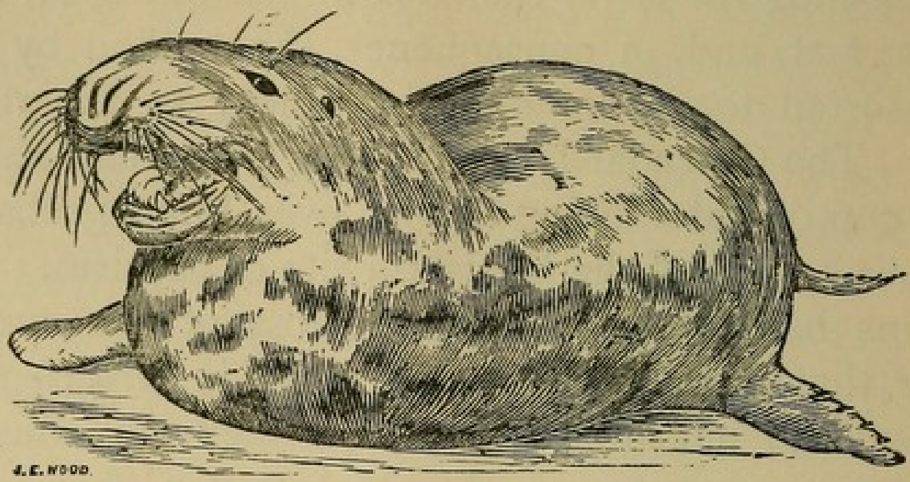
The question here arises whether we get any direction from the facts of evolution, as to what would be the state of the higher nervous centres, towards the rest of creation, should this be towards manifesting a higher development of the power of weapons or of words?

The answer seems, on the facts of evolution, decidedly in favour of words. The higher animals rise in the scale of being, the more is parental affection developed as a fact, not a theory; birds and mammals standing highest in this respect; and although there are fierce birds and mammals, still, without doubt, the progress of parental affection is against carnage.

It is a question whether the famous doctrine of

"Survival of the fittest" may not require to be supplemented on the facts of the case by the doctrine of "Survival of the highest and best"; that is, if we are agreed that parental affection is better and higher than the reverse, however fit for selfish survival. Without the importation of any sentiment into the case, the facts are on this side; i.e., the dominant species are mammals and birds in whom the greatest warmth of parental feeling is manifested.

There is a Mahometan myth which seems to have touched so graphically all the heads of this question that I cannot forbear quoting it: "The Second Calendar's Story in the Arabian Nights." The Calendar, you may remember, descends into an underground vault or chamber—that is, he becomes a materialist; this contains a beautiful lady, with whom he has an illicit amour. In consequence of this he falls into the power of an earth spirit or genius, the spirit of materialism or sensuality, who transforms him into an ape, as this spirit always does when it can. In this guise he wanders about; but, finally, because he retains the faculty of writing, he is made acquainted with a king's daughter, who should have been his legitimate bride. She undertakes to bring him back into human form again. In doing this, there is a terrible fight between the princess and the earth spirit, representing a logical contest between spirituality and materialism; and a retrograde metamorphosis is represented. First, the struggle lies between a sword, our weapon, and a lion; then a wolf and cat; serpent and scorpion; large and small fish; cock and pomegranate. In demolishing the latter the cock misses one seed, i.e., cell or fact, and, in consequence, the method by fire is resorted to. This ends in victory to the right side. The Calendar is restored to his human shape by a cup of water being thrown over him; probably a reminiscence of the Christian rite of baptism. He regains his humanity, with the loss of one eye to show that a man, after such a fall, is imperfect in perception; but loses his bride, a regretful allusion to the separation of the Mahometan from the Christian religion. The metamorphosis, no doubt, is very faulty, and yet we cannot but wonder that the main points were hit off so correctly. Still, we may be heartily glad that we have arrived at a period when we may try to pick up the grains of the pomegranate without fear of having the method by fire resorted to.



Grey Seal caught off Plymouth.

CHAPTER VIII.

ON THE EVOLUTION AND GEOGRAPHICAL DISTRIBUTION OF SEALS.

Sir J. W. Dawson's opinion not accepted—No close affinities with manatees or whales —Three main divisions :—otaries, walruses, and earless seals—Distribution, habits, and commercial pursuit—Seals found in Caspian and Lake Baikal—Behring Straits centre of distribution—Other probable derivation.

SIR J. W. DAWSON, in his excellent little work "The Chain of Life in Geological Time," written ostensibly to controvert the evolutionary theory, remarks of seals, "They are more elevated than whales in type, appear much later, and without any probable ancestry." The latter part of this sentence I cannot accept.

Pinnipeds form a very natural and circumscribed sub-order of mammalia, and some of the facts of their comparative anatomy, habits, and geographical distribution are in favour of the hereditary derivation of different species from the same ancestry—the doctrine of evolution.

In the first place, notice the close affinities which constitute seals a natural sub-order. They are all distinctly marine in their habits; with two exceptions, never frequenting rivers or lakes at any distance from the sea. There are two other marine mammalian sub-orders inhabiting similar localities—the Sirenia (Dugongs and Manatees) and the Cetacea (Whales). From these they are distinguished by the fact that they are all well covered with hair or fur; have hind as well as fore limbs; tail small, in no case broadened into the piscine-like member of the other two groups; and possess also the power of erecting and turning the head with a double angle, more or less like the letter *Z*, in a dog-like way. This, in the eye of common observation, has always saved them from the ignominy reserved to cetaceans, of being generally classed with fishes.

Another striking point of affinity in which they differ from other marine mammals, is that they all bring forth and suckle their young out of water, for which purposes they resort to rocks, beaches, or ice; and it is on this necessity in their economy that the hunters place their principal reliance for a supply. These rendezvous, to which many of the species resort in vast numbers, are sedulously sought for, and in some cases carefully preserved. In others, indiscriminate slaughter has sometimes destroyed the whole species inhabiting the locality.

The characters of their teeth differ entirely from those of the Sirenia which have broad or flat-topped teeth, suitable for vegetable feeding, and closely approximate the terrestrial carnivora, on the one hand, whilst on the other they show a slight tendency to degenerate towards the dentition of the dolphins, and as this point is interesting as suggesting a possible derivation for the latter cetaceans, it will be dealt with a little more in detail.

In the skull of an Icthyosaurus we have a long series of slightly recurved acute cones arranged along the sides of each jaw, in two nearly parallel or converging lines, continued so as to meet in the front of the mouth. As we advance higher in the scale of life, these teeth are gradually differentiated, those in front becoming chisel-shaped for cutting; those at the angle being greatly elongated and strengthened for seizing; those next in order shortened and made more blade-like for splitting or breaking; and those behind blunted on their crowns and gradually transformed into grinders. The differentiation between these teeth at first is not very marked, the intermediate teeth often partaking of an intermediate character; but as the teeth become more highly specialized, the intermediate forms are eliminated, the jaws shortened, and the teeth reduced to four or fewer definite classes of teeth, each being often very distinct from its neighbours. These four classes are known as incisors, canines, premolars and molars.

In the land carnivora these teeth are all more or less marked. They have six incisors above and below, with one or two exceptions, two canines above and below of the highest type, and behind these, premolars and molars of at least two definite forms and functions ranging from a large amount of grinding surface in some mixed feeders, as bears and badgers, to teeth almost entirely formed for splitting bones and cutting flesh, as in the cats, etc.

The dolphins show a degradation, or reversion, towards the older type of animals which had long narrow jaws, and rows of similar conical teeth.

Seals show some tendency in the same direction, inasmuch as whilst their general cranial and dental aspect is unmistakably canine or leonine, the teeth behind the canines approximate more or less to this type of a series of cones. The teeth of various genera and species differ a good deal, but they all agree in this, that in each species all the teeth behind the canines are similar; there are not here, as in the land carnivora, two or more distinct sorts of teeth,—and where the species differ, they still keep up the type of a series of recurved, more or less acute cones.

A very common form of carnivorous tooth was perhaps taken as the pattern of an old-fashioned spear-head, having a central sharp blade, supported on each side by two smaller cusps to help give it grip and steadiness in action; such teeth are quite common in the land carnivora, as anyone may judge by examining a cat or dog. Such teeth are the basis of the pattern of the back teeth of seals.

Sometimes, as in Lobodon carcinophaga, a seal from the Antarctic Seas, there are three minor cusps behind the principal one, as well as one in front, making five, whilst in others, as in our own Halichærus grypus, the inferior cusps are reduced to a mere indication, and the teeth have all nearly arrived at the degradation of a merely conical type. Still, in each case all the teeth behind the canines are similar.

Pinnipeds include the eared seals (Otariidæ), the "sea-lions," and fur seals: The Walruses (Odobænidæ), and the earless or true seals (Phocidæ), comprising the common seals, the "sea leopards" of the South Pacific, and the "sea elephants." It has often been suggested that an affinity between the walrus and the dugong is indicated by the tusks of the latter; but the relationship is only superficial, the tusks of the dugong being enlarged incisors, while those of the walrus are canines. The dugong is a true vegetable-feeder, whilst the walrus—in spite of a recent writer in the *Century* magazine, who considers it a vegetable-feeder—is a true carnivore, the peculiar conformation of the skull being correlated with the support and use of its enormous tusks. With these it digs up the mollusca which form its principal food.

The Otariidæ, or eared seals, form the first division; these are chiefly distinguished from their congeners by the following characters:—They all possess external ears or conches, turn the hind limbs forward to aid in terrestrial progression, and are distinctly and jealously polygamous in their habits. Some of the species are commercially valuable, as furnishing the "sealskin" of fashion; these, which are known as "sea bears," are smaller than those without this valuable coating, which are called "sea lions."

In his "History of North American Pinnipeds," Mr. Allen recognizes nine species of Otariidæ, of which five are hair seals or sea lions, and four are fur seals; but as they are very widely distributed and still imperfectly known, there are probably a greater number. They are:—

1. Otaria jubata. The large "Sea Lion" of the south coasts of South America.

2. Phocarctos hookeri. Auckland Isles.

3. Eumetopias stelleri. The large northern "Sea Lion" of the coast of California, and North of Japan.

4. Zalophus californianus. The lesser "Sea Lion" of California and Farallone Islands.

5. Zalophus lobatus. The lesser "Sea Lion" of the Australian coast, with soft under fur.

6. Callorhinus ursinus. The northern Fur Seal of California and Japan, northward to Behring Strait.

7. Arctocephalus australis. Round the south coast of South America, from Galapagos Isles to Rio de la Plata.

8. Arctocephalus antarcticus. Cape of Good Hope.

9. Arctocephalus forsteri. The fur seal of Australia and New Zealand.

Of the walruses, Mr. Allen labours hard to establish two species, which he names:—

1. Odobænus rosmarus. The walrus of the North Atlantic and Arctic Oceans.

2. Odobænus obesus. The walrus of the North Pacific.

The differences which he points out, however, are slight, and as the "Vega," in its north-eastern passage to the Pacific, found the walrus in nearly all parts of the Arctic Ocean, it seems more probable that his second species is only a variety which has attained a larger size than its congener by obtaining better food, or being less disturbed.

The walrus is earless, like the true seals, but differs from them in its huge canines, and in the fact that it bends its hind legs forward to assist in progression on ice or land. It is also truly Arctic in habitat, abounding in all parts of the Arctic Ocean from which it has not been driven by man. Mr. Allen speaks of it as polygamous in its habits, whilst other authors assert it to be monogamous; it is, at any rate, not so decidedly polygamous as the Otariidæ.

The true or earless seals have hairy bodies, but no fur, have the hind limbs bent backwards so as to serve as a tail in swimming, and are incapable of turning them forward to assist in progression on land. The most noticeable species are:

1. Phoca vitulina. The common seal of our Islands; ranges all round the Arctic circle from the North Atlantic to the North Pacific and Japan.

2. Phoca greenlandica. The Greenland seal, the seal of the Newfoundland and Jan Mayen Fisheries.

3. Phoca fætida. North Atlantic, North Pacific, and Arctic Oceans.

4. Phoca caspica. Caspian and Aral (?) Seas.

5. Phoca siberica. Lakes Baikal and Oron (?).

6. Histriophoca fasciata. The Ribbon seal of the North Pacific.

7. Erignathus barbatus. The great seal of the Arctic circle from the Atlantic to the Pacific.

8. Halichærus grypus. The grey seal of North Britain and Newfoundland northwards.

9. Monachus albiventer. Mediterranean and Black Seas.

10. Canaries, East Coast of Africa.

11. Crystophora cristata. The bladder-nosed seal, North Atlantic and Arctic.

12. Macrorhinus leoninus. Sea elephant, South Pacific, South Indian and Antarctic Seas.

13. A variety of above. Coast of West Mexico and South California.

Four sea leopards in Antarctic and South Pacific, New Zealand, Lord Howe's Islands, etc., viz.—

14. Ogmorhinus leptonyx. New Zealand Coast.

15. Lobodon carcinophaga. Antarctic Seas.

16. Leptonychotes weddelli. East Patagonia.

17. Ommatophoca rossi. Antarctic Seas.

Of these it will be seen that four, namely, P. vitulina, P. greenlandica, P. Fœtida, and E. barbatus, range from the North Pacific across the Arctic into the North Atlantic. One, viz., H. fasciata, has its habitat where the North Pacific and Arctic join.

Two, viz., H. grypus and C. cristata, range down from the Arctic Ocean, north of the Atlantic, into the latter ocean.

One, Monachus, is certainly found in the Mediterranean and tropical Atlantic, although the seal of the West Indies is supposed to be of a distinct species.

One, Macrorhinus, is found in the tropical Pacific, coasts of Lower California and Mexico, and in the South Pacific and South Indian, and Antarctic Oceans; whilst four species of the genus Leptonyx are found in the Antarctic Ocean and the southern parts of the oceans bordering thereon.

One great distinguishing feature between the true seals and the eared seals is evident. The true seals and the Walrus are more capable of bearing cold, and as none of the Otariidæ reach above Behring Straits, the seals diminish in species and numbers as they approach the equator. It is also noticeable that the eared seals are not found in the Atlantic north of the Cape of Good Hope; nor are there any Pinnipeds in the North Indian Ocean.

I will now give a few extracts from Mr. Allen's work on the life histories and manner of hunting some of these animals, beginning with the Otariidæ. The most interesting account, perhaps, is derived from the culture of the northern fur seal, Callorhinus, by the United States on the Prybilov Islands, two small islands near Behring Straits, which they received with Alaska territory from Russia. These islands were leased to the Alaska Commercial Company, with the right to take 100,000 skins annually, and of course it became a matter of pecuniary importance to take these in their best season and value, so as to keep up the stock on the island. The number of fur seals present on St. Paul's Island, as estimated by Mr. Elliot in 1872, was three millions, and on St. George's 163,000.

A party of natives live on the islands to attend to the interests of the company and collect the skins. At first, when indiscriminate slaughter was allowed, the yearly take was reduced to 7000 or 8000 in 1882; but by preserving them, and driving away the "Sea Lions" so as to give more room, they have increased in numbers, so that it was calculated there were over 4,700,000 on the islands; and Mr. Elliot conjectures that this is as many as that breeding station will hold.

St. Paul's, which is the largest island, has a coast line of forty-two miles, of which sixteen miles of sandy beach are occupied by seals. To these beaches the old males begin to resort about the middle of May, when, till about the middle of June, there is a continual accession to their numbers, each on its arrival taking the best position closest to the water which it can. By the 12th of June all the best positions have been appropriated and fought for by the strongest males, who are, as a rule, never under six years of age. These stations are about ten to twelve feet square, and are jealousy guarded. Those who cannot keep or get in the front rank take the next, and so on till the whole beach is full to a depth of five or six rows, and each "bull," after occupying a position, never leaves it an instant till the end of the season in August, being thus three months without food, and undergoing the most arduous exertion in maintaining his position.

Some of these "bulls" show wonderful strength and courage. Mr. Elliot remarked one veteran on the water-line, where at least fifty or sixty battles were victoriously fought by him. The fighting is mostly done with the mouth, opponents seizing each other with the mouth, clenching the jaws, each bite leaving an ugly wound, shredding the skin into ribbons.

About the middle of June the females begin to arrive, and are received by the males with much attention; but no sooner is wife No. 1 fairly installed in the home of her master than he sees another about to land whom he immediately approaches to escort, and, whilst so engaged, the male on the station next above his reaches out his great neck and abstracts wife No. 1, to be placed in his own pen; and this process is repeated until the whole of the pens are supplied, averaging to twelve each. The cows have one "pup" within a few days of landing, so that family life on the beach is tolerably stirring. By the 8th or 10th of August, the pups born nearest the water begin to swim, and by the 9th of September the colonies are broken up.

It will be noticed that only males of six years old and upwards are able to keep their ground as beach-masters, and the younger males range in large squads in the sea and on the beach, and from these bachelor squadrons are taken those which furnish the required 100,000 skins. It is found that the young four-year-old male furnishes the best skin, and the natives select by careful management droves of these, and drive them further inland, where they kill and skin them.

A small colony of "sea-lions" is preserved on the islands for the subsistence of the natives, who find its flesh more palatable and its skin more useful than that of the fur seal.

All writers agree in describing the very playful character of the young, and many intelligent traits might be mentioned. One hunter had his rifle in hand levelled at the head of an old "sea-lion" which was roaring and barking at him from the water, and had his finger in the act of pulling the trigger, when a cub swam up to the irascible parent and put up his nose for a kiss, which was immediately bestowed. This had such an effect on the sealer's heart, he not having seen his own family for some time, that his gun was lowered and the beast allowed to go in safety. Another observer coming suddenly upon the nursing of some "sea-lionesses," said that they looked at him with so intelligent, so distressed, and yet so lady-like an air, that he retired with the sense of having committed an impropriety.

The walruses (whether two or one species) may be considered as now nearly confined to the Arctic Ocean, though at one time they came much further south. In 1534 they occurred as far south as Cape Sable in Nova Scotia, exemplifying the rapidity with which pinnipeds are exterminated on their breeding-grounds. In the sixteenth and seventeenth centuries great numbers were killed in the Gulf of St. Lawrence. They are now found in western American waters, south of Davis' Straits, and the north part of Hudson's Bay. East of Greenland they are still met with on the N.E. coasts of Spitzbergen and the eastern shores of Nova Zembla in considerable numbers. In the Pacific they occur on the American and Asiatic coasts as far south as the Aleutian Islands, and in numbers (according to a late writer in the *Century*) in Bristol Bay and Norton Sound.

The chase of the walrus has been so often and so popularly described that I need not dwell upon it. In one respect this animal differs remarkably in its domestic economy from its congeners. The young is suckled by its mother until nearly three years old; for, living upon mollusca principally, it cannot get its own living until its tusks have grown a certain length to enable it to dig for them itself.

Besides a great number caught locally by the native Esquimaux in America, and Tchuckchees and other tribes inhabiting the north shores of Europe and Asia, there are two large seal "fisheries" carried on in the North Atlantic; one, a small area about 200 miles N.E. from Jan Mayens Island (about the middle of April), where annually some 200,000 are killed. The majority of these are young Greenland seals. Their rapid increase in size is remarkable; at birth their weight is six or eight pounds, they are suckled for fifteen or eighteen days, in which time they increase to from fifty-five to sixty pounds, of which the skin and fat—alone the object of pursuit—is about forty or forty-five pounds. It is at this age that the sealers prefer to take them, as they are then left by their mothers to shift for themselves, and, consequently, for some time they deteriorate in condition.

Another great breeding station is on the loose ice off the coast of Newfoundland, where the season begins about the middle of March and lasts for two months. About 500,000 are annually taken here.

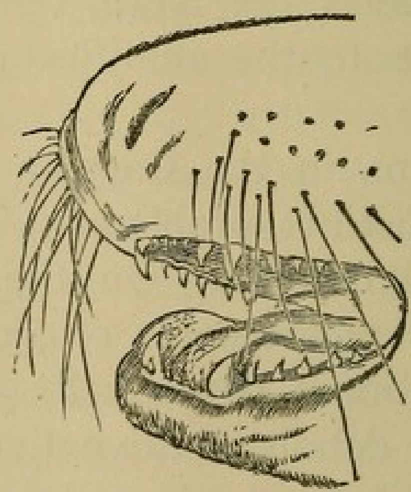
In the Pacific, South Atlantic, and South Indian Oceans the only true seal that has been found in sufficient numbers to form a regular "fishery" is the sea elephant. This immense beast is described by the first observers, Peron, Anson, Pernetty, and others, as from twenty-five to thirty feet in length with a circumference of sixteen to eighteen feet. Modern observers do not find them of this size; but as two authentic skeletons measured sixteen feet, which would make the animal when in the flesh about twenty-two or twenty-three feet long, it is probable that the systematic hunting to which they have been subjected does not allow them to attain their full growth. This species was formerly found by Peron in large numbers on the Falkland Islands, where it is now extinct, and along the west coast of Patagonia. It was also taken in large numbers off the coast of Mexico and Lower California. Mr. Allen thinks this a distinct species; it is said to occur still in small numbers at St. Barbara and Cerros Islands, in this locality. In the South Indian Ocean, the Crozets, Kerguelen, and Heard Islands used to be regular stations for these seals; but they are probably only to be found in any great numbers now on Herd Islands. In Kerguelen Island they would long ago have become extinct but for one inaccessible beach, "where they still haul up every spring (October, November); the beach is limited at each end by precipitous cliffs, across which it is quite impossible to transport oil in casks; nor can boats land from the sea, or vessels lie at anchor in the offing, as the beach is on the windward side exposed to the full violence of wind and waves." So that here, at all events, there is some hope of the species being preserved.

I possess an interesting account of these seals, with a narrative of four years spent on the Crozets after shipwreck there, by a sealer named Goodridge. One habit is generally noticed of this species, although it is common to the group, which is to swallow large quantities of stones. Sealers and sailors usually attribute the function of this action to its use as ballast; some naturalists seem not disposed to allow this, and attribute it to a digestive craving. The point may be one for discussion; I rather incline to the sailors' theory, for the reason that fishes seem to require some means of altering their gravity, which is furnished by an air-bladder, and as seals have not this arrangement, the taking in stones as ballast would seem to fulfil the need very well.

Now I think that the facts of distribution, etc., recapitulated all point to Behring Straits as the centre of distribution of seal life. Here, and here only, the three large groups meet. Here are walruses, eared and earless seals. From here we may suppose the walrus and earless seals spread over the Arctic Circle into the Atlantic Ocean, one species, at any rate, reaching as far as the Mediterranean. From here the Eared Seals, accompanied by earless species, spread all down the Pacific coasts of America, doubling Cape Horn, and creeping up the South Atlantic shores of South America, perhaps to the Gulf of Mexico; another stream, following the Antarctic ice, reached up to the Cape of Good Hope and some of the islands in the South Indian Ocean; but we do not find that any reached the eastern coast of Africa, the coasts of India, or the Malay Peninsula. Another stream seems to have migrated from Behring Straits down the Japan Archipelago and part of the N.E. coasts of China. Whether it was this stream which supplied the seals of the South Pacific, Australia, and New Zealand, or the one from round Cape Horn, remains to be settled by reference to the affinities of the different species.

How seals came in the Caspian Sea and Lake Baikal are two distinct problems. That they exist in both is beyond doubt. On the Caspian is a regular "fishery," where some 100,000 are annually taken; and various trustworthy travellers and missionaries give details of the native "fishery" for seals on Lake Baikal. As to seals reported to exist in the Sea of Aral, or Lake Oron in Siberia, I can find no authentic account. The Caspian being below the general ocean-level, and the species being similar to Arctic species, points to some former connection between these oceans. Lake Baikal, however, is several thousand feet above the sea-level, the River Yenisei running down some 1200 miles from it into the Arctic Ocean. If seals have ascended this distance from the coast, the case is unique; for nowhere else are they found much above the tidal part of a river. This case therefore remains a mystery.

Behring Sea is also the headquarters of the sea otter, *Enhydris lutris*, which occurs from Behring Island down the north-west coast of North America, as far as upper California. In many respects this animal forms a sufficiently good link between river-otters and seals to emphasize the locality as the centre of distribution and evolution of the group of pinnipeds. Its fur, the most costly of any, has more affinity to that of an eared-seal than that of any



Mouth of Grey Seal.

other otter. In size it approaches many seals. Its feet are more webbed and its tail shorter than in river-otters; and, lastly, its pelagic habits make it a very good forerunner of Otariidæ. If we assume that one branch of the otter family acquired pelagic habits and a beautiful fur, its exclusively piscine food gradually tending to the differentiation of its molars and premolars into a series of tridents, whilst another branch of the family, preferring crustacea and mollusca, developed its hind teeth into sufficient shell-crackers, and, requiring more prehensible power in its paws to search for its prey under stones, etc., did not develop these so completely into fins as its congener—the relative geographical distribution of the different species seems sufficiently plain.

CHAPTER IX.

THE POSITIVE EVIDENCE OF THE TEETH ON MAN'S LINE OF DESCENT.

"Thy teeth are like a flock of sheep that are even shorn, which came up from the washing; whereof everyone bear twins, and none is barren among them."—Canticles, chap. x. 2.

Weight of evidence—Modern variation from normal human dentition—Typical formula of dentition—Cases of reversion—Probable progression—Opinion of Cope—Approximal derivation from ancestors of chimpanzee—Seven cervical vertebra—Case of solidification in Rissos grampus—Weapon the human factor?—Upright gait—Absence of close hairy fur—Clothes—Fire—Rob Roy—Batten skull.

HOWEVER strong a theory may be, positive material evidence in verification thereof must always be adduced to gain for it general acceptance. But even for material evidence to gain a hearing, some judicial training is necessary before its weight can be duly estimated, and on this ground the writer claims for this chapter more weighty consideration, if the reader is interested in the subject, than he can pretend to for some of the preceding essays, having been professionally engaged in the critical examination of the peculiarities of the teeth of the British public for more than thirty years.

The facts which will be given he believes will verify the following points in confirmation of Darwin's theory:—

Firstly, that there is a frequent occurrence of variations from the normal type.

Secondly, that there is evidence of occasional reversion to older types.

Thirdly, that this reversion is towards the apes and particularly the chimpanzee.

Fourthly, that there is evidence of a further alteration of the human dentition in the elimination of the wisdom teeth and upper lateral incisors, and perhaps the addition of another cusp to the superior molars (back grinders).

Fifthly, that there is evidence that man's resemblance in organization to the lower animals is not an ideal one merely, but one of actual descent.

There are a number of variations from the normal standard, which seem to be aimless, or the result of disease or degradation, these need not be noticed.

The typical number of permanent teeth in the higher mammalia is given by Owen as forty-four, that is on each side of each jaw above or below, or for four repetitions, 3 incisors, 1 canine, 4 premolars, 3 molars, $=11\times4=44$, or to place it more diagrammatically, $\frac{\overset{m}{3}\ \overset{p}{4}\ \overset{c}{1}\ \overset{i}{6}\ \overset{c}{1}\ \overset{p}{4}\ \overset{m}{3}}{3\ 4\ 1\ 6\ 1\ 4\ 3}=\frac{22}{22}=44$. Few animals have the exact numbers, the pig being the most familiar instance; but none of the higher mammalia have more, although many have less, of any particular class of teeth.

Man has only $\frac{16}{16} = 32$ permanent teeth, therefore in the progress he must have lost 12 teeth, that is 3 from each half jaw. These are 1 incisor, and 2 premolars, so that his formula for each half jaw is incisors 2, canine 1, premolar 2, molar 3.

Not a single monkey of the old world has any other formula than man.

The first deviation we find going backwards is in the American monkeys, which possess three premolars, i.e., the teeth between the canines and large molars, and which have had milk predecessors; nevertheless Mr. Andrew Wilson mentions two cases of man coming under his notice, in which there were three premolars or bicuspides on each side below; such cases are, however, rare, and I have never seen one myself.

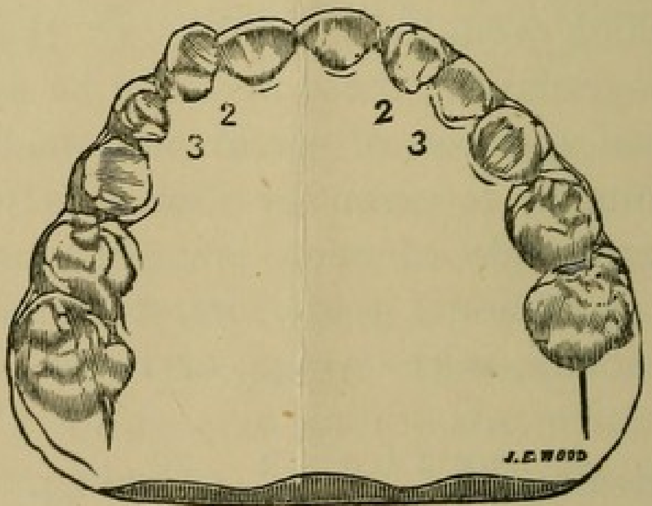


FIG. 1.

2 2, Deciduous second incisors. 3 3, Deciduous third incisors.

To find 3 incisors in the line of our probable ancestry, we should have to go back to the lemurs;

nevertheless I hold in my hand the model of a child's upper jaw, taken by myself, Fig. 1, and having for the first set of teeth 3 incisors, and the accompanying figure is from the model of the upper jaw of a clergyman's son, also taken by myself, showing 3 incisors on one side of the permanent dentition. (See Fig. 2.)

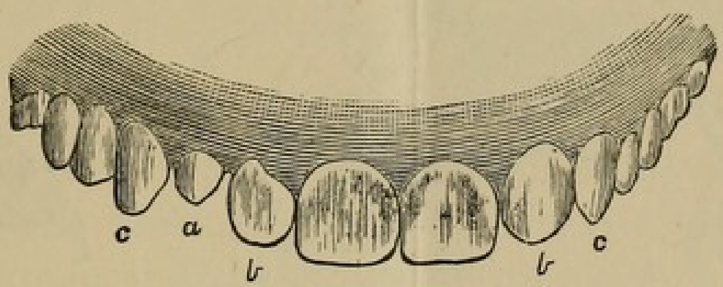


FIG. 2.

b b, Permanent second incisors. *a*, Permanent third incisor. *c c*, Canines.

The additional one in this case is evidently on the wane.

These cases may be quoted as reversions; on the other hand, pointing in the direction that the same path of gradual diminution of teeth is being followed. Every dentist is familiar with the fact that the wisdom tooth or third molar, is frequently absent, but I think Mr. Felix Wiess, of London, was the first to definitely establish from a series of tabulations, that only about half the normal number appear in modern Englishmen.

In a paper which I read at a dental meeting at Bath, in 1880, I showed, by models produced, that the superior lateral incisor was the tooth, next to the wisdom tooth, showing symptoms of disappearance.

In the same paper I adverted to the fact that an additional cusp was apparently being added to the upper molars. The accompanying figure shows a good example of this, Fig. 3, in a model from my own little boy of seven years old.

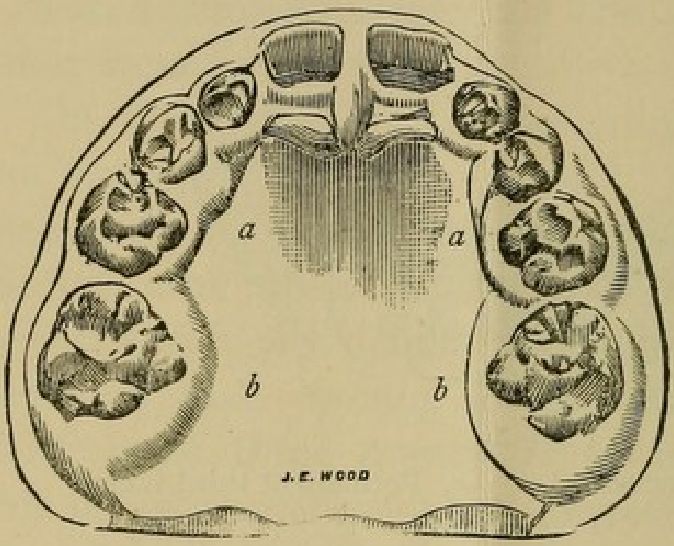


FIG. 3.

a a, Extra lingual cusp on second temporary molar.
b b, Extra lingual cusp on first permanent molar.

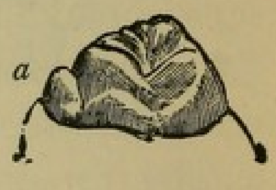


FIG. 3′.

a, Side view of extra cusp.

The extra cusp is shown on both second temporary molars as well as the first permanent molars.

It may be questioned whether this development does not rather indicate that the three permanent molars belong to the first set of teeth, and that the term second set ought correctly to be only applied to the premolars, and those teeth anterior to them which actually supersede a milk dentition.

Oscar Schmid in his popular handbook to the mammalia, 1885, quotes the American Naturalist Cope, as predicting for the man of the future incisors $\frac{1}{2}$ canine $\frac{1}{1}$ premolars $\frac{2}{2}$ molars $\frac{3}{3}$ and i $\frac{1}{1}$ c $\frac{1}{1}$ p $\frac{2}{2}$ m $\frac{2}{2}$.

I cannot myself verify this prediction for English people, having only seen one instance in which the lower lateral incisors were missing; the following would be in accord with my own observations: in. $\frac{1}{2}$ c $\frac{1}{1}$ p $\frac{2}{2}$ m $\frac{2}{2}$ with an extra lingual cusp on the superior molars.

The general type of teeth with similar formulas seems quite sufficient to establish the relationship between men and the old world monkeys.

For it must be remembered that on the wide face of the earth there are no animals possessing similar dentitions; still, there are considerable distinctions between them.

In the three great anthropoid apes, the upper premolars are implanted by three roots, the lower by two, as they are in most other monkeys. In the human first upper premolar there are often, perhaps usually, two roots, the others have only one each.

Out of many thousand recent English teeth which I have examined, I have occasionally found upper bicuspids with three roots, more rarely lower ones, with two, but I think the fingers on both hands would number up these cases. In 1880 I examined a collection of skulls in the museum of the College of Surgeons, London, and found in about 400 skulls, two cases, a "Gilbert Islander," and an inhabitant of the Malay Archipelago, in each of which five out of the eight premolars possessed more roots than normal.

Another point to be noted is that the human lower premolar is usually nearly circular in horizontal section, whereas many of the old world apes have these teeth considerably compressed laterally. The accompanying figure compares a tooth from a

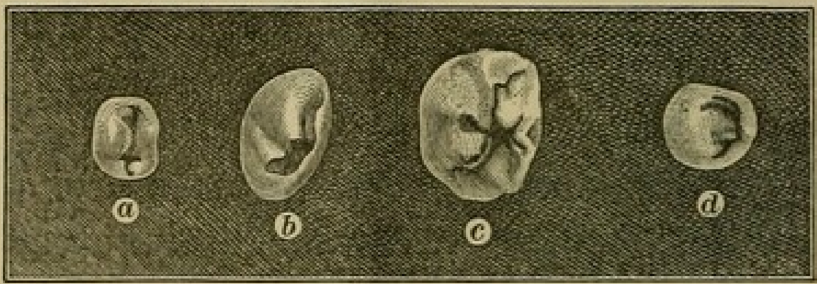


FIG. 4.

a, Old world monkey's tooth, left second premolar (Semnopithecus Sp.?). *b*, Recent human tooth, left second premolar, from model taken by author. *c*, Melanesian, left second premolar, from model of skull in R.C.S. Museum, No. 1245. *d*, Ordinary English left second premolar, for comparison.

monkey (Semnopithecus Sp. ?) with one of a patient of my own, a tooth of an African in the College of Surgeons Museum, and a normal English tooth, all being second lower premolars of the left side.

The second upper premolar in man is more feebly pronounced than the first, in that it has only one root, whilst the first has usually two. The crown of the first also is rather larger and better defined than that of the second, in the lower jaw this is reversed, the first premolar being decidedly feebler than the second.

In the illustrations of the anthropoid apes, given by F. Cuvier and Owen, there does not seem much, if any, difference between their premolars in this respect; but in the Museum at South Kensington, where skulls of all three apes are beautifully exhibited with their roots displayed, it will be noticed that, whereas in the Gorilla and Orang, if there is any difference in the size of the first and second premolars in the upper and lower jaws, it is opposite in relation to what holds good in man, in the chimpanzee it is the same as in man; and that notably the upper second premolar of the chimpanzee has only one root displayed, whilst the first has two. Probably in each case there is a hidden root, but the tendency towards the human character is manifest.

There is yet another point illustrated by these three skulls, which is interesting as pointing to the chimpanzee as our probable ancestor, which was kindly pointed out to me by Mr. Charles Tomes, namely, that in both gorilla and orang, the roots of the teeth are huge and out of all relative proportion to the size of the crowns, as compared with human teeth, whereas, those of the chimpanzee, barring of course its large canines, were not strikingly different.

Those who are of a grateful disposition, may remember, when they go to have out a tooth next time, to be thankful that their ancestor was a chimpanzee, and not an orang-outang.

It must be allowed, however, that the illustrations of F. Cuvier and Owen do not show such striking contrasts in the implantation of the teeth, in the three species, as the specimens at South Kensington Museum, and knowing how much teeth do differ in individuals, it is not impossible that these have been specially selected to illustrate the affinity and contrast; certainly they do it exceedingly well.

That any animal which is examined shows more intelligence in the construction of the adaptation of its organs to its habits of life, than it can display by its actions on the occurrence of current unexpected emergencies, is a very old observation; whether this is entirely the result of an intelligence, acting from without, or entirely during the course of ages, by the intelligence acting from within, is perhaps one main point of present controversy.

The following consideration of rather a wider generalization than those preceding may help the reader towards understanding the point.

It is usual for comparative anatomists to say that all mammalia, except the sloths, have only seven cervical or neck vertebra, that is seven distinct bones in the backbone between the skull and the ribs, and certainly this is itself a sufficiently remarkable fact. A giraffe and a pig have exactly the same number of neck-bones.

The statement, however, has other exceptions, which we shall see still further emphasize the fact, that this relationship in number of the neck vertebræ is a mark of ancestral relationship.

In 1886 I was fortunate enough to secure a recent example of a Rissos Grampus, caught near Plymouth, and prepared the skeleton for our museum; in doing this I found that the seven neck vertebræ were anchylozed into one bone, still completely showing their separate derivation.

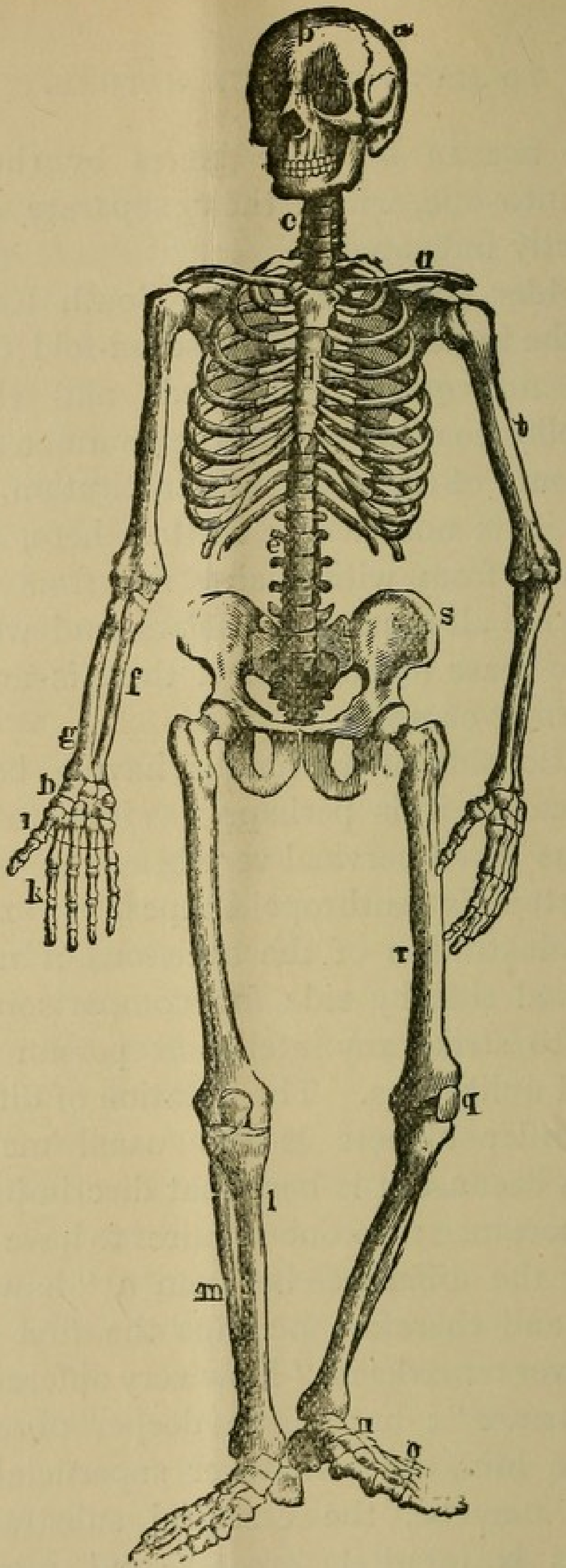
Here we have a complete abandonment of any functional use in separate bones by their being solidified into one, whilst their separate origin is still distinctly indicated.

In an older specimen in the South Kensington Museum, the indications of the seven-fold origin are almost, if not quite obliterated; and the same remark applies to a skeleton of the common porpoise, in the museum of the Plymouth Institution.

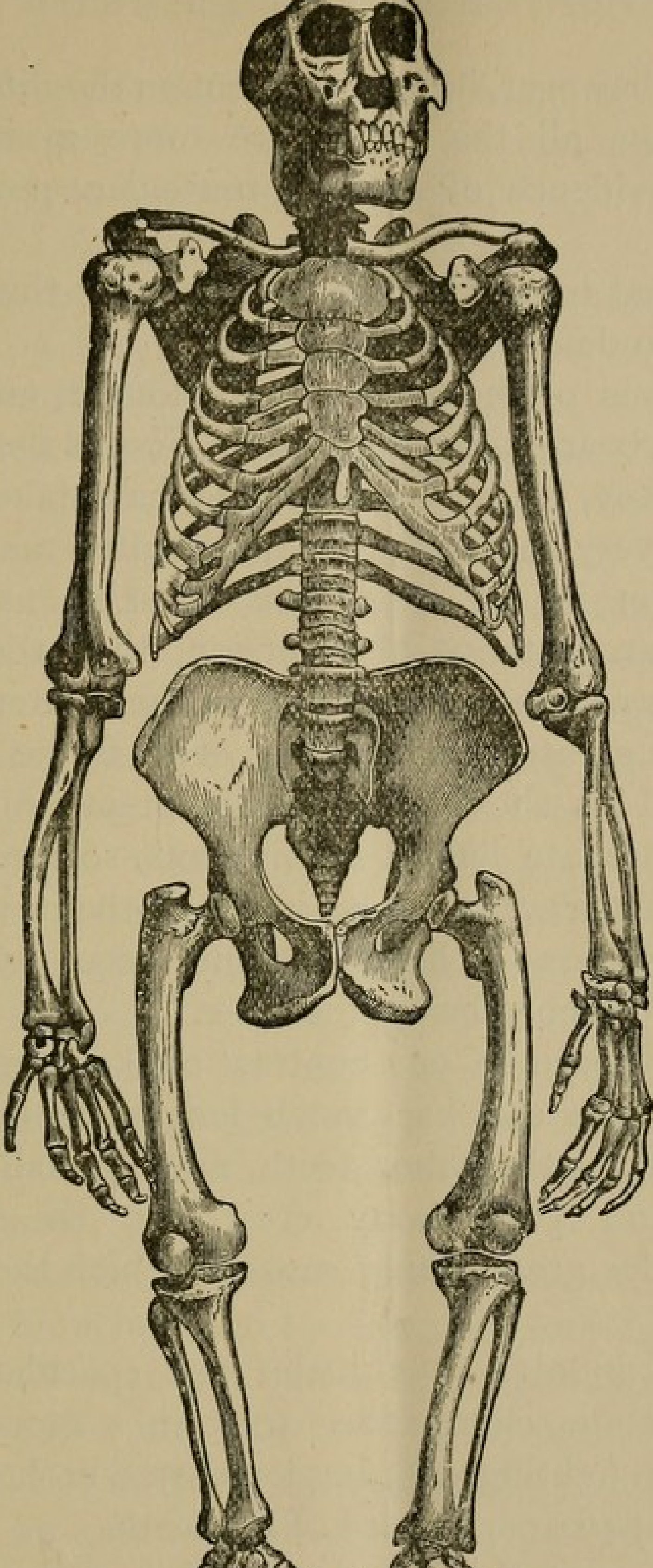
Now, if it is not clearly written here, that the formation was from within, and not from without, it seems to me all inquiry is useless, and we may as well at once cease to consider if there is any meaning in anything or not.

The relationship of mammalia having been thus clearly indicated, it is perhaps needless to say that man also has seven cervical vertebræ.

In "Hartman's Anthropoid Apes," p. 132, is a very good illustration of the skeletons of man and gorilla, placed side by side for comparison, which cannot fail to strike any intelligent person by their likeness and unlikeness. The notation of differences between similar objects is the usual method of observation, because it is here that discrimination is of most importance; no one requires to have pointed out to them the difference between a "hawk and a hernshaw," and therefore perhaps the first thing a casual observer remarks is, "How very different these two skeletons are"; but a little deeper observation will convince him, that whatever superficial differences there may be, the essential substratum of resemblances is infinitely greater and more profound.



Human skeleton,—*a*, Parietal bone. *b*, Frontal bone. *c*, Cervical vertebræ. *d*, Sternum. *e*, Lumbar vertebra. *f*, Ulna. *g*, Radius. *h*, Carpus. *i*, Metacarpus. *k*, Phalanges. *l*, Tibia. *m*, Fibula. *n*, Tarsus. *o*, Metatarsal bones. *p*, Phalanges. *q*, Patella. *r*, Femur. *s*, Os innominatum. *t*, Humerus. *u*, Clavicle.



Skeleton of an aged male gorilla.

Let us, however, dwell a moment on the differences. In the ape all the bones are more massive and rugged, evidence of greater muscular power and exertion.

The great toe of the ape is a grasping thumb, and there is no definite heel as in man.

The arms of the ape are much longer, and here I cannot forbear giving Sir Walter Scott's description of Rob Roy, whom he seems to have taken as the type of a very natural or unsophisticated man, which observation is all the more valuable as giving, perhaps, an instance of reversion, that the author cannot be accused of prejudice in the matter.

[1] "The greatest peculiarities of his frame were the breadth of his shoulders, and the great and almost disproportionate length of his arms, so remarkable, indeed, that it was said he could, without stooping, tie the garters of his Highland hose, which are placed two inches below the knee."

But to continue our contrast of skeletons of man and ape, the ape has much longer canines comparatively to the other teeth, much smaller brain cavity, and large bony crests on the skull to support the great biting muscles which the canines require.

Let us indulge in a little free speculation and suppose some chimpanzee took in a more definite manner to fighting with implements, a broken branch of a tree, perhaps, instead of his teeth.

We can see that as this path was pursued his

[1] Notes to "Rob Roy," by Sir W. Scott.

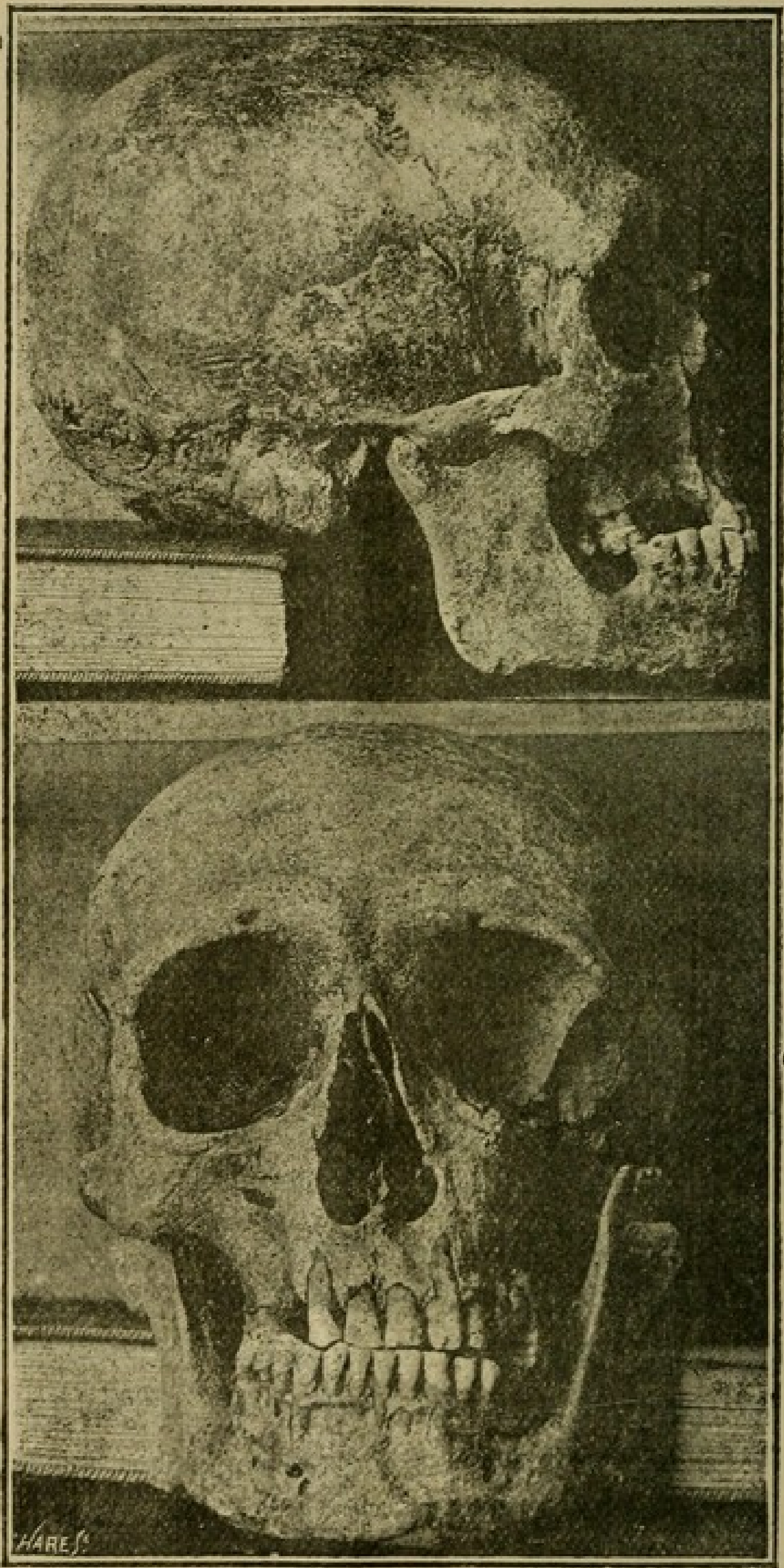
canines would decrease from want of use. He would cling to his weapons for defence, hence would not be able to use his arms in climbing, so that these also would diminish in size and power.

In his retreats he would be thus thrown almost entirely on his hind legs and thus reduced to the ground for locomotion, where the great toe would be more useful in the spring of the foot than as a grasper. In fighting with weapons, the one who could get above the other would gain an advantage, and the upright position would be indicated.

The upright position and locomotion on the hinder extremities might lead to the human walk, this giving the greater length of leg and enlarged calf, thigh and buttock, muscles, whilst the complication and improvement of weapons would tend to increase intelligence and the size of brain, until at last he attained to the flint implement and later the bow and arrow.

The importance of the invention of the stone hammer or axe is handed down to us in the Scandinavian myth of Thor, and his achievements with his stone hammer.

What was the chief factor in eliminating the hairy covering reducing man to external clothing is more obscure. The acquisition of fire may have occurred in making flint implements or from natural sources. We have, however, an inverse analogy in the mammoth of an animal gaining a hairy covering in consequence of general change of conditions. Bodies of these animals as well as of the rhinoceros having been found in Siberia thickly covered with hair,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whilst in hot climates, presumably their original home, they are almost hairless.

The Ainos, a lower race of men inhabiting North Japan, according to modern accounts have many hairy individuals amongst them.

In receiving the evidence described in this chapter and the accompanying appendices I think we must admit that there has been an unbroken line of life through the apes to man; that his teeth on close inspection do corroborate Darwin's views by showing continual slight deviations and occasional reversions, and also a forward movement on the lines indicated by the previous path in life.

Whilst preparing this paper, Mr. R. N. Worth drew my attention to a skull which had been disinterred at Mount Batten, near Plymouth, and which he described in a paper on "Crouched interment at Mount Batten" in the transactions of the Devon Association, xix., 38.

The accompanying illustration is from a block kindly lent by him.

The skull is interesting in this relation as possessing no upper lateral incisors, the canines being close to the central, as can be seen by reference to the lower figure.

CHAPTER X.

APPENDIX TO CHAPTER IX.

ON BI-LATERAL SYMMETRY IN IRREGULARITIES OF DEVELOPMENT IN HUMAN TEETH.

APPENDIX I. Read August 2nd, 1880. Read at the meeting of the British Dental Association, Western Branch, held at Bath, Mr. Parkinson in the chair:

Mr. President and Gentlemen,—A year ago, whilst studying the theory of evolution in its application to the development of teeth in the higher animals, the question suggested itself whether there was not some law relating to the development and formation of teeth capable of being traced in connection with the repetition of a complicated type of tooth in the same mouth.

For instance, the masticating teeth of the sheep, although of considerable intricacy of form and precision of definition, are all on the same pattern. The same may be said of the guinea-pig or the mole.

Now, if these teeth have been formed by gradual slight alterations, according to modern theories, this would tend to show that there was some hidden link, perhaps in the nervous centres, controlling the development of the teeth, which was able to appropriate and reproduce in the other teeth any advantageous variation which may have arisen in one tooth.

Since then I have collected such cases in human dentition as seemed to corroborate this idea, and I have brought them before you to-day, thinking that they might have some general interest; for the theory of evolution is entering into every-day questions on all sides; and also in the hopes that some of my brethren may be thereby induced to give me models or specimens bearing on the subject, which shall be duly acknowledged if I find anything more to say on the subject, and also that by placing the facts and models I have before a body of experts in the observation of the human dentition, they may be authenticated.

The variations are not of any startling monstrosity, or often, perhaps, of practical importance; yet, as showing a tendency, are worthy of remark.

Beginning with the lower jaw, I will describe such irregularities as I have found also bi-lateral. The lower canine sometimes has the roots divided, as in these specimens [1] (No. 1). I have had under notice for some years a lower jaw in which the teeth were absent, but which clearly showed by their alveoli that both the canines had divided roots. The next tooth having a noticed peculiarity is the second bicuspid. I have seen at least three examples in which this tooth is much compressed from the lingual

[1] Specimens shown.

to the labial sides—something like a deciduous first molar or the corresponding tooth in some monkeys. (No. 2 model shown). The first lower molar has sometimes one of its roots divided so as to have three. Of course, on extracting such a tooth one is not in a position always to verify the fact of the corresponding tooth of the opposite side being similarly formed; but on one occasion after extracting two of these teeth under nitrous oxide gas for regulating, I was equally pleased to find I had secured an example of this variation and mortified to find I had left both the extra roots behind. (Specimens shown, No. 3.)

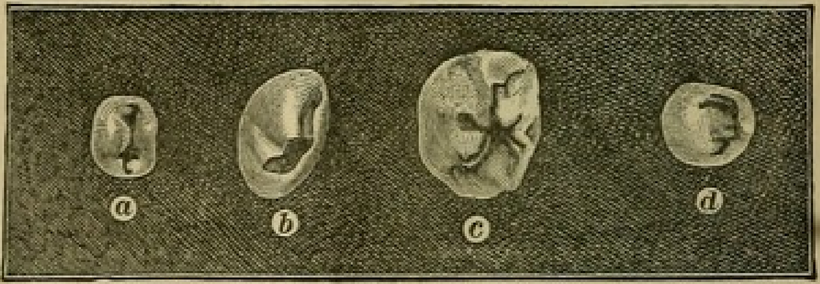


FIG. 4. (*For description, see p.* 174.)

(Specimens shown No. 4.) These are the second lower molars of a Chinee, showing a slight peculiarity in the confluence of the roots on labial aspects.

The irregularities of the wisdom are too familiar and too well established by Mr. Weiss to need referring to here. In the upper jaw the laterals are those which will first take our notice. These teeth show, although in a slighter degree, similar evidences of degradation or abortion to those shown by the wisdom teeth. The presiding genius, if I be allowed a metaphor, seems to be full of vagaries, sporting, hesitating, and stammering, in its definition of this tooth, and sometimes refusing to produce it at all. Some of these variations are so common that I have not thought it necessary to bring models to prove the point.

Firstly, a definite lingual cusp is sufficiently common.

Secondly, a folding round of the two lateral buttresses, forming a sulcus, is often a source of decay needing filling. Model shown (No. 5), has both these peculiarities.

Thirdly, supernumerary teeth are more frequently thrown off in the neighbourhood of this tooth, and it

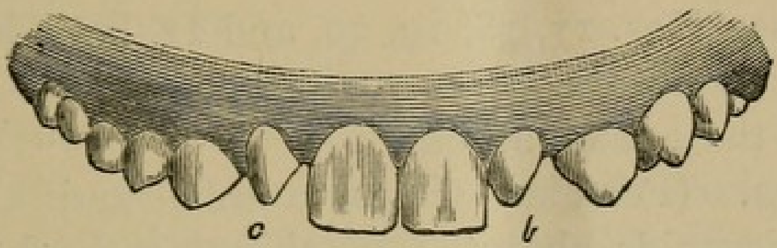


FIG. 5.
b c, Second incisors, spiky. From a model taken by the author.

is more often malformed than any other tooth except the wisdom tooth.

No. 5. Malformed lateral.

Then we have diminutive cylindrical laterals, spiky laterals (see Fig. 5), and lastly the tooth is deficient altogether.

Nos. 6 and 7 are cases showing the left lateral absent.

No. 8. Left lateral spiky; first molars have extra cusp on lingual side. The two daughters of this lady also had extra cusps on their first and second molars.

No. 9. Left lateral spiky, right small.

No. 10. Right spiky, both small.

No. 11. Both laterals small and cylindrical (lady).

No. 12. Right lateral spiky, left extracted in youth (lady).

No. 13. (Male.) Both laterals small and cylindrical.

No. 14. (Female.) Both laterals spiky, right, very small.

No. 15. (Female.) Right lateral absent; patient said she never had it.

No. 16. (Female.) Right lateral absent; patient said she never had it.

In cases Nos. 17, 18, 19, 20, and 21, both laterals are entirely absent. No. 21 thinks one of her sisters also has these teeth absent.

No. 22. (Female.) Both laterals and all the upper bicuspids absent. As this mouth shows a general deficiency of developing powers, the palate being excessively narrow and arched, this case would hardly have come within the scope of the subject, were it not that her sister (No. 23) also never had any upper laterals.

No. 24. (Female.) Both laterals absent. This lady's eldest daughter, whom I have seen, also has them absent, and she says her father and a sister have the same deficiency.

No. 25. (Female.) Both laterals absent; says she thinks a brother and a sister have them absent also. The first molars in this case also have an extra lingual cusp.

No. 26. (Female.) Both laterals absent; says she has a sister with the same deficiency as well as the brother.

No. 27. (Male.) Brother of above.

For the lay reader it may be mentioned that a dentist's model, so far as it goes, is as authentic as a photograph.

In strong contrast with the aberrations and occasional absence of the lateral comes the canine teeth, and a practical point in regulating teeth may be noted here, that if retarded in eruption or not showing, we may confidently rely upon its presence within the bone, which is evidently not the case with the laterals. Only two cases worth noticing have come under notice.

No. 28. (Male.) Two upper deciduous canines with a small but decided lingual cusp.

No. 29. (Male.) Small spiky right canine.

The second deciduous upper molar often has an extra cusp on the lingual surface.

No. 30. Right upper deciduous molar with extra cusp, no sign of the same on first molars.

No. 31. (Male.) In the mouth of this lad extra cusps on both deciduous second molars and first permanent molars seem to point to some developmental bond of sympathy between them, although I believe it is considered to be established that their germs arise independently. A duplicate of this model was forwarded to Professor Flower, who said that he had not noticed this cusp on any aboriginal races, so that it is possible that this extra cusp is now being added to the definition of upper molars in the English race. It is exceedingly common on first molars, sometimes occurring on one tooth only, sometimes on both, and less frequently on the second molars, and more rarely on the wisdom teeth.

No. 32. (Male.) Good example of this cusp on both first molars.

No. 33. (Female.) Ditto.

No. 34. Extra cusp on right second molar only.

I have to thank the late Mr. Spence Bate, F.R.S., and my partners, Mr. Stratton J. Coles and Mr. Robert S. Coles for some of the models, etc.[1]

[1] Since the above was written I have seen a case of a healthy English lad of nineteen, where all four lower incisors were absent, the two permanent canines being nearly close together; without any history of accident or other sign that they ever were formed or at present exist in the jaw.

APPENDIX II.

NOTES ON SOME MORPHOLOGICAL DENTAL IRREGULARITIES IN SOME OF THE SKULLS IN THE MUSEUM OF THE ROYAL COLLEGE OF SURGEONS OF ENGLAND.[1]

Mr. President and Gentlemen,—In 1880, when interested in the development of irregularities in the cusps of modern English teeth, I wished to compare these with those of less civilized races. Through the courtesy of Professor Flower, I was allowed to examine the collection in the Museum of the Royal College of Surgeons in London, of which at that time he was Conservator.

I took notes of the teeth of about 400 crania, and hoped at some future time to enlarge these observations, which, however, not having done, I wish to place these notes on record as some of them may prove interesting, and at any rate are then at the service of future investigators.

The skulls were on shelves in cabinets, and apparently had been frequently re-arranged, as the

[1] Transactions of Odontological Society, Great Britain, June, 1891.

numbers on the skulls were by no means consecutive, but the numbers on each particular skull do not seem to be altered; as during the summer of 1890, wishing to take models of two, I easily found them again, although a large collection had been added since I previously examined them; I should think, therefore, that any skull might be referred to by the numbers here given.

On examining each batch of skulls, I noted any peculiarity observed with the number of skull, and then, before closing the cabinet, counted the number of skulls examined with such description, if any, as was labelled on the shelf.

The following is a transcript of the notes:—

First lot of skulls examined—24.

1542.—Old Roman. Sulcus in upper lateral.

327.—St. Michael's Church, St. Albans. Two supernumeraries between laterals.

302.—From Tumulus, Cemetery, Berkshire. Extra cusp to upper molar.

Second lot of skulls examined—52.

1301.—Boschisman girl. Wisdoms not through, teeth crowded, extraordinary development of second lower bicuspids on both sides, teeth approaching in size a badly formed molar, all the teeth very clubbed.

A model of the lower jaw accompanies the paper with photograph;[1] these do not, however, give a good idea of the teeth, as from their crowded position the model was a good deal dragged.

[1] See Proc. Odontological Society.

154.—African Negro, Bahia, Brazil. Left supernumerary opposite wisdom.

1234.—Amazon, Dahomey, Africa. Slight sign of extra cusp on second and third right molars only. (Note probably upper.)

1228.—Dahomey. Supernumerary molar.

1650.—Eboe, Old Calabar. Upper wisdoms absent; second bicuspids smaller than first.

1363.—Negro. Lower left canine and lateral apocryphal.

1624.—Debeara. Apocryphal left central.

35.—Apocryphal lower bicuspid.

36.—Ditto right upper canine.

31.—Ditto all over.

84.—Apocryphal.

52.—Ditto.

125.—Ditto left upper bicuspid.

1290.—Left wisdom slight extra cusp.

1261.—Apocryphal.

1292.—Right upper first bicuspid crowded in.

1284.—Upper first molar slight extra cusp anterior (lingual?) aspect.

Third lot of crania—15.

1302.—Only left wisdom (upper?) second molar same side decayed, teeth crowded, second lower molars decayed.

AFRICA.

1264.—Right and left upper first bicuspids decayed on both sides. Three roots, or nearly so, on one side more than the other.

Fourth lot of crania—48.

292.—Eboe, Guinea. Anterior extra cusp, as in 1284, on both first upper molars.

Fifth lot of crania—48.

MELANESIA.

1079.—M. Fan, first upper molars, extra cusps as in 292.

1626.—Debeara. Cluster of supernumerary teeth in region of left bicuspids; alveolus for third bicuspid on right side.

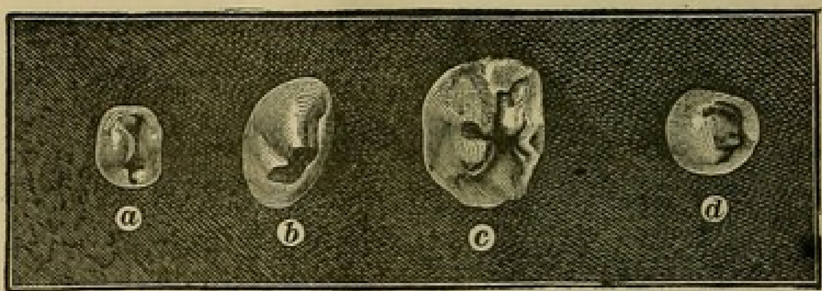


FIG. 4. (*For description, see p.* 174.)

1245.—Extraordinary lower second bicuspids width of molar (*See Fig.* 4).

3380.—Slight mark of extra cusp, upper molars.

1224.—Ditto, ditto.

1216.—Teeth crowded, sulcus in upper laterals.

Sixth lot of crania—22.

PAPUA.

82.—Extra cusp on first molar.

Seventh lot of crania—47.

NEW CALEDONIA.

1159.—Right upper first molar, extra cusp

AUSTRALIA.

1062.—Upper wisdoms dwindling.

Eighth lot of crania—25.

AMERICA.

Comparatively feeble.

Ninth lot of crania—37.

ESKIMO.

I have no note taken of these thirty-seven Eskimo skulls, but speaking from memory the arches of the jaws were full, round, and uncrowded; the shape of the cranium, on the other hand, was long and narrow, an observation contrary to my expectation. The suggestion occurred whether if the Eskimo are in the habit, as related by some travellers, of chewing the seals' skins in dressing them to render them soft, this practice may not account for their fully arched jaws.

Tenth lot of crania—34.

OWYHEE.

803.—Left upper wisdom, extra cusp small.

MAORI.

769.—Supernumerary between upper centrals.

766.—Extra cusp both first molars (upper ?).

749b.—Skull of Gilbert Islander; large masticating teeth; feeble upper incisors, which are decayed; three roots in right upper pre-molar (first or second ?), left bicuspid alveolus, showing division as if for two external roots; lower left second bicuspid, signs of division in external roots; lower right first and second bicuspids, the same strongly.

Eleventh lot of crania—47.

INDO-MALAY ARCHIPELAGO.

284.—Nay Kay. These roots right first lower molar.

1376.—Signs of slight divisions in outer bicuspid roots in first and second upper right side, first upper left side, first lower right side, first lower left side.

Twelfth lot of crania—8.

ASIA.

Thirteenth lot of crania—26.

ASIA.

The following are the points which seem worthy of noting:—

In the first place it was evident that many of the skulls belonged to owners who met violent deaths, which had often spoiled the dental armature.

Interested parties had supplied the deficiencies thus caused to make up appearances before parting with the skulls to the museums. Those skulls found in this state have been marked apocryphal. I had supposed that the extra lingual cusp of the upper molar often observed in English patients would not have appeared in savage tribes; in this I was mistaken, as I found ten crania having extra lingual cusps on the superior molars out of the four hundred and thirty-three examined, but this cusp was situated rather anteriorly to the position observed in English patients.

Two skulls, No. 749b and No. 1376, had extra roots or indications of them in five bicuspids, in each case showing a Simian approximation.

Two skulls, No. 1301 and No. 1245, have peculiarly formed and large second lower bicuspids, as shown by models and photographs.

In practice I have occasionally met second lower bicuspids with peculiarly flattened crowns.

CHAPTER XI.

FLIGHT OF BIRDS.

Preliminary remarks—Flight in insects but not in spiders—In fishes—Reptiles—Mammals—Birds probably an offshoot from reptiles — Pterodactyls — Archeopteryx — Anatomical affinities between reptiles and birds—Toothed birds—Plumage of birds—Mechanism of feather—Flight by rowing—Flight by sailing—By buzzing—By skating—A cone of air compressed by downward stroke—M. Marey's work—Swoop of birds of prey—Captain Hutton—Power of visual picture—Problem of soaring—Will man ever fly?

THERE are probably few natural tissues of which the evolution is more difficult to establish than that of a feather; yet, to the elaboration and adaptation of this skin appendage no doubt birds owe the perfection to which they have attained in atmospheric navigation.

But although evidence of a strict gradation in the evolution of a feather is conspicuous by its absence, there are a good many isolated examples of efforts, more or less successful, to accomplish or extend aerial progression.

Animals in the pursuit of prey, or whilst making efforts to escape capture, either in passing through water or over land, sometimes leaped or were propelled through the air, and found from its gaseous nature facility for more easy and rapid movement. Leaping and jumping was then, perhaps, the initial step towards flying. But between casting their bodies through the air by spring of legs or fins, because of its offering less resistance and friction than accompanied the support of water or solid bodies, and making use of such comparatively slight resistance as it possesses, for their continued support, and progression was a very wide gap which required something beyond mere effort and good-will.

The following illustration will explain my meaning, and is at the same time a curious fact.

Most insects possess in greater or less perfection the power of flight, and although they are pursued everywhere by spiders by all manner of snares and direct hunting, we know of no case in which a spider has begun to develop links in the direction of flight; the nearest approach being gossamer spiders which float in the air on web filaments. I once caught such a small spider as it floated by, and, breaking away the thread connected with it, confined it to the top of my finger, expecting it to drop by a line as spiders are wont to do, as I was curious to see how it would detach the line from my finger end. Instead of this, however, the spider, when it saw that there was no other escape, went to the highest point, elevated its abdomen and discharged a thread perpendicularly into the air; this slowly rose till about eighteen inches or so was paid out, when the spider tucked up all his legs, left my finger and securely floated away into space.

The lowest animal which seems to have made any attempt or flight beyond a jump, is a calamary, a mollusc something like a squid.

According to Owen "Calamaries by means of powerful muscles in their terminal fin, and by the elasticity of internal pen, not only propel themselves in the sea, but raise themselves like a flying fish, and dart for some distance through the air."

Above calamaries (omitting insects) come fishes; of which there are at present two species, one a Gurnard (dactylopterus volitans), the other (exocætus calleropterus) somewhat resembling, though not nearly allied to a herring. These fishes make short flights of from 150 to 200 yards, and to a height of 30 or 40 feet, as evidenced by the height of the freeboard of vessels on whose decks they have fallen in their excursions.

Among reptiles there have been some efforts in this direction.

In our own time there is a lizard (draco volans) whose ribs are extended and covered by a wing-like membrane, having quite sufficient surface to enable it to fly if actively used, but in fact it is only used as a parachute to sail down from some elevated place.

Wallace, in his Malay Archipelago, describes a tree-frog which was seen to descend from a tree, in a long curve to the ground; this, on examination, showed an expansion of the webs of its feet of 12 square inches, its own body being about four inches long.

The greatest perfection of flight in reptiles was reached probably a little before the Mesolithic epoch, by a whole group of lizards called Pterodactyles, ranging in size from a crow to a beast, with an expanse of wing of twenty-five feet. The wing, something like that of a bat, was membranous, but instead of being spread over several phalanges was extended from one lengthened finger down the side of the body. Some of these strange beasts had teeth, and some had not, and, as we shall presently see, there are reasons for assigning to birds a reptilian ancestry.

Bats are the highest flying mammals, led up to by flying squirrels, phalangers and lemurs (galeopithicus). These are a feeble or degraded race, flying at night only, and subsisting on insects or sucking blood from sleeping animals, or at best living upon fruit.

Strange as it may seem, it had long been suspected by comparative anatomists, that there was an affinity between birds and lizards, and this is now generally conceded.

In the triassic, jurassic, and chalk periods of the Mesolithic epoch, are found many fine remains of flying reptiles—long-tailed rhamphorynchia, and short-tailed pterodactylæ, of many species; some possessed teeth, some beaked.

There were other reptiles belonging to this period: anomodontia, also possessed of beaks, and from one or other of these groups birds probably sprang.

In our own day turtles and tortoises are the only representatives of reptiles possessing horny beaks.

There are other affinities of structure connecting birds with reptiles, one of the most obvious being their habit of depositing eggs to be hatched in the sand.

There is a region on the coast of Celebes, as described by Wallace, where beaches of a black volcanic sand are regularly visited by a gallinaceous bird, for the purpose of laying its eggs in the sand, where they are left to be hatched by the heat of the sun. According to Wallace, these birds are so fully developed, that on being hatched the chicks are able to fly. This is a wonderful instance of the power of inheritance of instinct, and development of organ, at the same time; the bird having retained or retrograded to the old reptile instinct of laying its eggs in sand to be hatched by solar heat, the chick at the same time having in it so perfectly developed the organs of flight, as to be able to use them successfully without previous trials.

Another point of affinity which may be mentioned classifying reptiles with birds; but distinguishing them from mammals, lies in the articulation of the head to the back bone. Taking the head of a dog or cat in the hand, we observe that there are two points or knuckles by which it is articulated to the atlas, whereas in a turtle or crocodile, a pigeon or an albatross, there is only one.

A stronger and more remarkable link, however, has been discovered.

In 1861, Herman von Meyer described a bird's feather, found in lithographic slate of Solenhofen, in Bavaria, belonging to the upper jurassic deposits. This was much earlier than birds were before known, but was confirmed by Professor Owen, and named archæopteryx lithographica.

In 1863, Professor Owen described a slab found by Doctor Haberlein, of Pappenheim, which showed clearly the bird from which, doubtless, the feather came.

There was a pelvis, the legs and a long rat-like tail furnished with feathers, and a few wing feathers, but no head or other anterior parts. Here was another link in the direction of lizards, as no known bird has a long bony jointed tail.

Pictures of the restored animals were drawn to represent the tail, but with a beak!

In this retrospect, however, naturalists for once were wrong. About ten years afterwards, 1874 or 1875, the son of the same Doctor Haberlein found a slab containing a very perfect example of the archæopteryx with the head, which he exposed with great care and success. In this the head was a true reptile's head, without beak, and possessing in front two small teeth.

Amongst other affinities to recent birds, the feet possess four toes, of which one is placed behind, giving its grasping power in perching.

Here is a link which will well bear some reflection, an animal with a long jointed bony tail, a small lizard-shaped head, teeth, no beak, but with feathers and perching feet.[1]

Hesperornis regulis a sort of diver, and Icthyorais Victor a sort of gull; other extinct forms of birds

[1] *Ibis*, 1880, p. 436.

show their origin by still possessing teeth with a beak.[1]

In the struggle for existence, however, in order to lighten the head, the powers of the beak suppressed the teeth, the comminating functions of which were fulfilled by a gizzard.

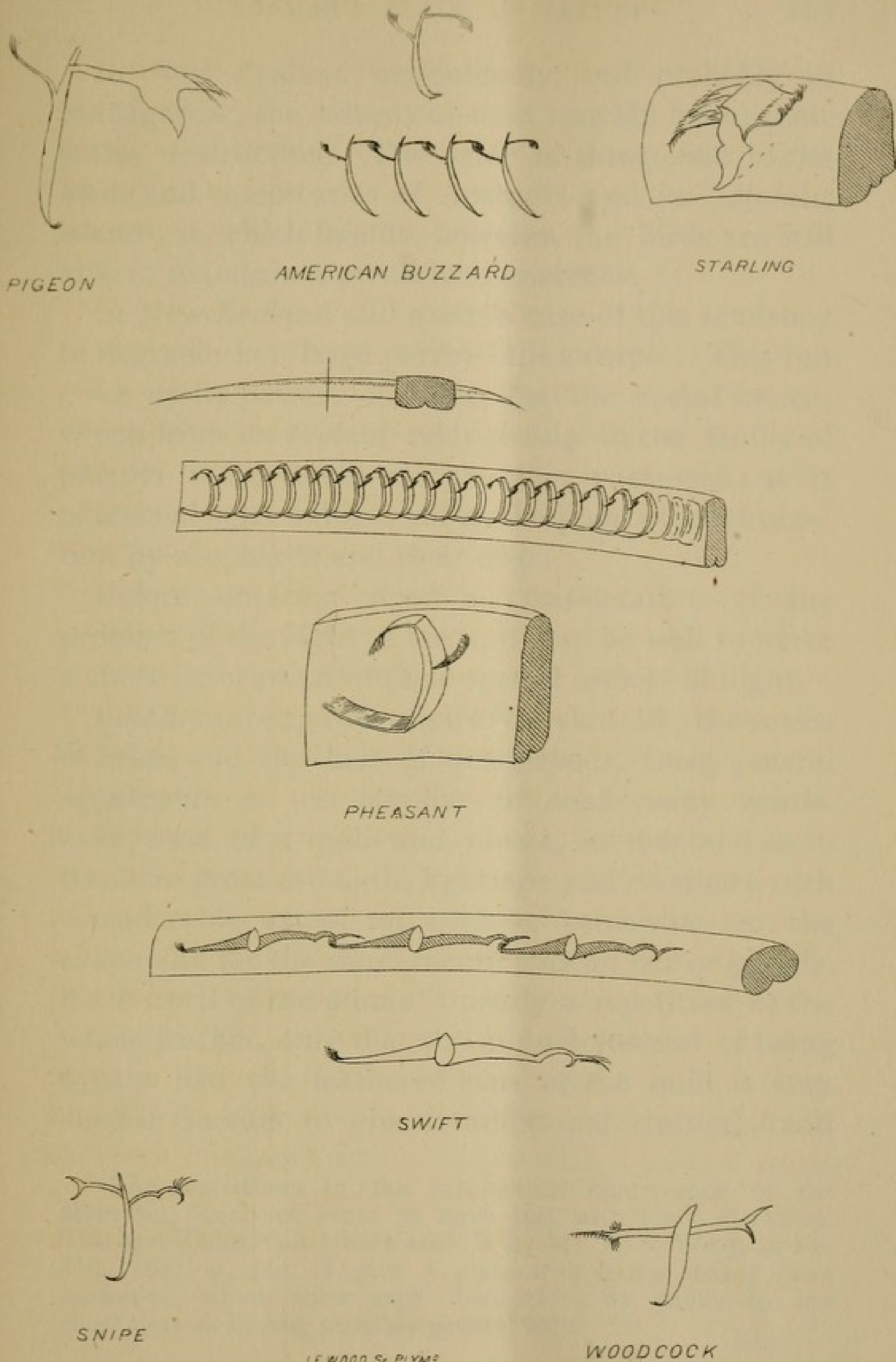
From the Archæopteryx, all through the Mesozoic rocks, the strata of Triassic age, the Jurassic into the Cretaceous beds, we find in different parts of the world many forms that show in their skeletons every imaginable shade in point of structure between reptile and bird; some were of mastodontic proportions, others were small; undoubtedly some were covered with feathers, some had beaks, others had teeth, a few could fly, some lived on land, some on sea, while others were amphibious.

Recent birds are divided into two great orders. Birds with a breast bone, flat like a raft—Ratitæ; and birds with a keeled breast-bone—Carinatæ. It might be thought, that, as the keeled breast-bone is correlated with the power of flight, giving attachment to the large breast muscles necessary for the powerful downward stroke of the wing, the ratitæ preceded the carinatæ in the process of evolution. Yet in all probability this was not so.

Many of the largest extinct remains of these flightless birds have been found on Madagascar and New Zealand, islands devoid of rapacious foes; so that they developed here probably by finding the labour of flight unnecessary to their protection, until finally they lost the power.

[1] Professor Marsh, U.S.

MECHANISM OF PLUMULES OF BIRD'S FEATHERS



J.E.WOOD Sc. PLYMo

In New Zealand undoubtedly, and probably in Madagascar, the advent of man quickly led to their entire destruction. The same is threatened to the emus and cassowaries of Australia and its adjacent islands, in which haunts, however, the birds are still able to maintain a precarious existence.

In New Zealand still exists a case of this tendency to degrade, in a large parrot—the kakapo. This has given up its powers of flight, lost the keeled breast, which from its evident relationship in the family of parrots it no doubt at one time possessed; it is nocturnal in its habits, and on the point of extermination by shepherds and their dogs.

Before entering upon a consideration of the problem of the flight of birds, it may be well to make a short description of their special organs of flight.

Feathers are a production of the skin; like the scales of fishes and the hair of quadrupeds, their general appearance is too familiar to need many words. Composed of a quill and plume, so disposed as to combine great strength, lightness and elasticity with considerable extent of surface, somewhat in the shape and for the same function as an oar or paddle. Each fibril of the plume is nearly a repetition of the whole feather, only that the mid-rib instead of being square like the feathered part of the quill is very deep in section to give it additional strength,[1] and

[1] The variations in the mechanical contrivance of the plumules does not seem to have met with much attention. The best illustration I have seen is by Mr. R. S. Wray, in the *Ibis*, 1887, p. 420. I give a plate with a few that I have examined, which show such distinctions as points to the characters as having possibly generic value.

the fibres of the plumule hook over those of its neighbour, so as to present an unbroken surface to the air. Besides their office as organs of flight, feathers form a warm covering, and are adapted by their position, in lying in a tiled manner all pointing backwards, to make a smooth surface offering little resistance to the air or other obstacles.

They fulfil this purpose also in another manner by plumping out and padding over many inequalities of a bird's body, in a manner which is easily seen when comparing the body of a bird plucked with one in full plumage. In the latter case the body without the wings has a great resemblance to that of a fish, or, as the tail is horizontal, to a porpoise; whereas the shape of a plucked bird does not strike us at all with the same ideas of beauty in adaptation to speed of locomotion.

Another use of the feathers, by their coloration, is to aid in concealment of their possessor from their enemies; and anyone who knows how difficult it is to see a partridge when lying at your feet in a stubble field will readily concede this.

Another point is, by ornament to attract the opposite sex, that the parties concerned, may, by the appropriate display thereof, assure each other of harmonious tastes, suitable rank in life, powers to make a proper provision for the future home, and ensure a family of which each parent may be justly proud.

The coloration of a bird's feather presents one of the most difficult problems in evolution, for it must be remembered that the pattern on the wing has no direct structural deposition such as might be supposed to occur on the skin of a fish.

The pattern appears as if stamped on the feathers, whereas the fibres of which it is composed are quite separate down to the barrel of the quill. How each fibre should receive transverse bands of different colours, so that when laid down side by side they form a pattern, is still, so far as I know, an unexplained mystery.

Any lover of nature who spends a day at the Museum of Natural History at South Kensington, must be very dead to all feelings of wonder and admiration if his imagination is not stirred to awe and worship at the extraordinary productions of the Creator, displayed there.

The mimicry by insects of leaves for the sake of concealment, of more powerful or noxious insects by harmless or feeble ones for the sake of protection, as well as the imitation by the plumage of birds of their habitat, all suggest some law by which this desirable resemblance is produced.

I must say that the mere conservance of occasional variations seems hardly adequate to the task.

Mr. Cunningham, of the Plymouth Biological Laboratory, has been investigating this subject in fishes, and proves that the pigment cells on the surface of the skin of fishes undergo rapid change in size under changed colour of the surrounding bottom, though I do not understand that he claims to have made out how the original pigmentation takes place.

One idea is, that it is through the visual picture continually before the eye in some way conveying a similar coloration to the terminal twigs of the nerves or at any rate stimulating them with a selective power in coloration of the visible surface of animal. Jacob's method of increasing his own stock by use of this idea is of course familiar to all of us, and I hear from a rabbit breeder that he considers at the present time that they can control the future coloration of a litter of young rabbits by surrounding the doe at certain seasons with particular colours.

Jardine's Naturalist's Library is easy of access to most, and a very good example of gradation in this respect is given in the volume on "Fishes of Guiana."

If the reader will turn to the illustrations, he will find a curious series in nearly every degree from a slight dark spot to the most vivid reproduction at the root of the tail, of the brilliant colours of the fish's own eye.

My own opinion is, but the point wants working out, that feathers of birds are coloured from without, not by pigments laid down in the fibres as they grow, but by a pattern laid on after formation by the external enclosing capsule.

There seems no doubt that the coloration of eggs is thus laid on nearly the last thing.

The wing of a bird is as you all know more or less triangular in shape with the base next the body, the apex extended, the anterior margin flexed, with the point bending backwards, convex above, concave below; the bones are nearly the same as in the human arm, the bones of the wrist and hand being reduced in number and size continuing the member to a point. The flight feathers continue and extend the anterior margin of the wing, and thus take the greatest duty in the stroke; for this reason they are the stiffest in the body and the vane is arranged so as to have the greatest surface along the posterior edge. These feathers, called primaries, are arranged on that part of the limb which would correspond to our hand and wrist, and as their posterior margin is much longer than the part of the limb into which they are inserted, they gradually radiate backwards, each lying partly over and supporting its anterior neighbour.

Behind these, implanted in the fore arm, come the secondaries, which in the extended wing lie nearly directly backwards, and in these the quill becomes more nearly central.

Between these and the body come the tertiaries generally still feebler, shorter, and broader in the blade.

These feathers are supported both above and below by successive rows of other feathers, each superior layer being shorter and feebler than that beneath the upper and lower wing coverts.

When the wing is extended, the feathers are retained evenly in position and retracted in due order, when it is flexed, by an elastic network of ligaments which also slightly rotates them when stretched.

Two points in the economy of the wing are worth noting which I have not found previously mentioned. One is the advantage of a flexed anterior margin: if this were perfectly straight it would be almost impossible to prevent its being completely rotated by the resistance of the air to the surface of the wing, all of which is posterior to it, by which means either the bone would be dislocated or all power lost.

Another point is the perfect power of accommodation in folding which feathers allow of. A bat finds his wings sadly in the way when on the ground, and figures very badly beside a mouse in his attempts at pedestrianism; even a flying squirrel or lemur looks somewhat as if encumbered by a bag of old clothes, whereas a land or water-rail runs as nimbly through close vegetation as a rat or weasel.

The other principal organ in the act of flight is the tail, which is composed of longish feathers with a stiff quill placed in or near the centre of the web.

These feathers, in all birds of the present day, are attached to a short representative of the originally long vertebral tail, popularly known as the Pope's nose, which practically places them as starting from the same level arranged like a fan, the outer feathers lying and folding beneath the more central; like the wing feathers, the tail is supported above and below by upper and lower coverts.

The principal function of the tail seems to be that of raising the bird by presenting an inclined surface when depressed to the current of air through which the bird is passing, and on the contrary, by being elevated and thus removing this resistance, it allows the force of gravity to direct the bird downward. In a lesser degree also, it may quicken the direction downward by pressing upon the current of air above the bird's back, although this action must be considered more in the light of a theoretical hypothesis than an actual observation, at any rate its power in this way is very feeble.

The Duke of Argyle in his essay on the flight of birds in his "Reign of Law," says this is the only power of the tail; considering that as the plane of the tail is horizontal and not vertical, it can have no power in steering a bird by any lateral motion; but I am far from sure that he is right in this conjecture. Birds differ greatly in their powers of quick turning, and also in the shape of their tails, and there is, I believe, a correlation to be established between the two.

Since writing the above, I have met the following observation in Audubon:—

"The flight of the goshawk is extremely rapid and protracted. He sweeps along with such speed as to enable him to seize his prey by deviating a few yards from his course, assisting himself on such occasions by his long tail, which, like a rudder, he throws to the right or left, upwards or downwards, to enable him suddenly to alter his course."

Tails are short and round, presenting an outline, something like that of a scallop-shell, like those of a partridge, a snipe, or a common wild duck; long and square ended like a sparrow or kestril, wedge-shaped like a pheasant, a magpie, or the passenger pigeon of America, notched like in a kite or swift, or fully forked like in the chimney swallow, some humming birds, the swallow-tailed falcon and some of the terns.

No doubt many birds with short tails are capable of quick turns, as, for instance, the short-eared owl; the common peewit also is an example which everyone must have observed who has tried to find the nest in the breeding season. Still, these birds are comparatively light for the expanse of their wings, which gives them a sort of butterfly flight with no great momentum to overcome in turning. But I cannot help believing that the forked tail acts as a rudder in the exceedingly rapid flight and turns of such birds as the chimney swallow and swallow-tailed falcon.

The swift, with a more powerful flight, indeed, has not so deeply forked a tail as the swallow, but keeps more to the open, high latitudes of the air; whereas the swallow threads his way down lanes between high hedges, misses your head by a yard or so, and twists sharp round through a gateway and round a rick picking up a fly here and there with a snap of his bill at the highest speed. Of course the tail is not turned vertically like a rudder, but I imagine, and I fancy I have observed, that in the swallow and in other birds the tail is depressed and turned slightly towards the direction to which the bird wishes to turn.

It seems also probable that in the highest attainment of flight, that of soaring without flapping the wings, or as Marey calls it, "flight by sailing," the tail is directly used as an organ of propulsion. To this I shall refer at greater length further on.

In Marey's work on the "Flight of birds," the latest book on the subject, flight is classified under two heads: "Le vol rame" flight by rowing, and "Le vol voile" flight by sailing. Neither of these designations is perhaps quite correct, but the titles are sufficiently descriptive as indicating what appears to the eye the method of progression.

Flight by rowing or flapping, the more ordinary method, has many variations.

There is flight by buzzing, as in the humming-birds, where the vibration of the wings is so rapid as to leave only a blurred image on the eye, and to give the humming sound of an insect from which the birds have received their name. This buzz of the wings is so rapid that, when performed when the bird is stationary, whilst sucking honey from a flower, which is effected by the bird placing its body in a vertical position so as to neutralize its forward tendency, it is difficult to imagine that the air beneath the pinion can resume its density between each stroke; and the suggestion arises that it is more to the friction of the end feathers on the surrounding atmosphere, than to the separate strokes of the under-surface of the wing that the bird owes its suspension.

Many of the gallinaceous birds, as the partridge or pheasant, possess this buzzing flight, only in a much less rapid manner.

As the Duke of Argyll has pointed out, many of the flying, diving water-fowl use their wings in swimming under water; this necessitates a short powerful stroke, and a small wing, which requires a strong quick stroke, to raise them in the air and continue their flight; yet these are capable of long-continued flights which the gallinaceous game birds are not. It might be supposed from this that the muscles of flight, the great pectoral muscles, forming the flesh of the breast, would be found more powerful in the water-fowl than in the game birds, yet such is not the case.

A pheasant or grouse has a better breast than a wild-duck or widgeon ; the explanation I would offer is that the fibre of the muscle of the water-bird is capable of more protracted energy than that of the pheasant, etc., as evidenced by its darker colour, in the same way that the darker coloured muscle of a hare is possessed of greater endurance than the white muscle of a rabbit.

A great many birds possessed of only limited powers of flight, give a few vigorous flaps, and then with closed or open wings, swing down a curve which brings them nearly up to the previous altitude ; this they attain by a few flaps to repeat the manœuvre. Familiar examples are our common jay and woodpecker.

The flight of swallows, and especially swifts, is more comparable to the action of a first-rate skater, the rapidity with which they glide through the air seems to have given it such a solid character in support, whilst yet so easily penetrated by their shape, that very little effort in flapping is required. I have repeatedly watched swifts darting through the air in all directions ; a sudden swoop downwards, a sudden presentation of their wings at a different angle to the air, and as sudden a swoop upwards again ; again a change in the presentation of their wings, and a further elevation without any distinct flapping of the wings at all. All that could be seen was an occasional slight vibration of the end of the wing, indicating an apparent flapping of about an inch.

The swallow, on the other hand, frequently flaps its wings; its flight seems to be a swoop in a long curve, then a few flaps to recover its elevation, perhaps a change of direction and another swoop.

The action of a bird's wings in flight by flapping or rowing is not usually from above backwards and downwards, indeed, some writers say that it never is so; but some birds, as hawks and pigeons, in very rapid flight, seem at any rate to half open their wings and completely close them at each flap with a backward direction. The usual impulse, however, is, with wings extended, to bring them downwards in a plane at right angles to the line of flight, or obliquely forward until the tips approximate in front below.

In considering how this action produces a forward motion, the force of gravity and the resisting action of the air to bodies in motion are the principal factors.

If we take the figure of a gull, pigeon, or stork, as given by M. Marey, from instantaneous photographs taken during volition, and imagine a plaster of Paris cast to be made of the lower surface, when the wings are at the lowest point of the downward stroke so as to give us the actual form of the supporting surface of the air at this time, it would show us this as a nearly complete convex, stunted cone, with the axis pointed upwards and forwards.

The enclosure by the wings and forcible compression of a cone of air, with such an axis would give by contre-coup and the resolution of force an upward and forward impulse to the bird.

According to Col. Reid, wind going

10 miles an hour gives a pressure of $\frac{1}{2}$ lb. per square foot.

15 miles an hour gives a pressure of 1lb. per square foot.

20 miles an hour, brisk gale, gives a pressure of 2lb. per square foot.

25 miles an hour, brisk gale, gives a pressure of 3lb. per square foot.

30 miles an hour, storm, gives a pressure of $4\frac{1}{2}$lb. per square foot.

35 miles an hour, storm, gives a pressure of 6lb.; great storm.

40 miles an hour, tempest, gives a pressure of 8lb.; great storm.

100 miles an hour, violent hurricane, gives a pressure of 50lb.

Now, the speed of a body through the air gives of course the same resistance as the pressure of air passing a stationary body. The flight of homing pigeons is given lately in poultry newspapers at a little under 60 miles an hour. A year or two ago the *Field* newspaper made some experiments on the speed of partridges and pheasants, and found it about 35 to 40 miles an hour. The speed of a swift is usually put down at 150 miles an hour, and of the eider duck at 90 miles an hour; though I believe these figures require confirmation, at any rate we can form some conception of the power for support which the air becomes to a bird at high speed.

The weight of the bird is neutralized by the downward flap exactly counteracting this tendency. The forward motion is communicated by the structure of the wing in having its anterior margin rigid, and by the elasticity of the feathers which bend upwards at the tip under the pressure of the air to the down stroke, and by thus moving over the air as an inclined plane presses the bird forwards.

Monsieur Marey has just published a work on the subject which gives a number of beautiful photographs of birds flying. One in particular, in which twenty-six images of a pigeon in rapid ascending flight were obtained in half a second, gives five distinct flaps. This figure has five attitudes depicted for each flap.

Table from M. Marey.

Stork, $1\frac{3}{4}$ wing strokes per second = 105 per minute.

Seagull, $3\frac{1}{2}$ to $5\frac{1}{2}$ wing strokes per second = 211 to 330 per minute.

Pelican, $1\frac{1}{6}$ wing strokes per second = 70 per minute.

Pigeon, 10 wing strokes per second = 600 per minute.

Duck, 9 wing strokes per second = 540 per minute.

Buzzard, 6 wing strokes per second = 360 per minute.

Another of his photographs of a gull flying can be easily painted to be placed in a zoetrope, so that you may to some extent test its fidelity, by reproducing the optical illusion of a bird flapping its wings.

As we might expect, pursuit of prey and escape from capture form a great element in the function of flight. Perhaps this began in the hunting after insects, for these seem to have existed ages before birds, their remains having been found in the coal formation, which our geologists will tell us was long before the Jurassic Period.

Weight has a great deal to do with speed; not only does greater weight develop a greater momentum under speed, thereby giving the bird as it were a capital of onward force to draw upon at emergency, but it also enables that greater speed to be obtained. A light-bodied bird is not capable of giving a powerful blow to the air, as it would lift its body out of its course in doing so, consequently we find all the swift winged hawks heavy birds for their size. But this principle of weight giving speed and momentum cannot go beyond a certain point.

The power of a muscle increases as the square of its section; whereas weight increases as the cube —a much more rapid ratio.

Hence we see that as birds increase in size above five or six pounds, their flight by flapping becomes more laboured until weight overcomes muscle and the bird gives up flight and takes to running instead.

The extreme weight of flying birds does not, I believe, often exceed thirty pounds. Audubon gives the average weight of the wild turkey at 18 to 24 lbs., with one instance of 35 lbs. The great bustard is said to weigh 28 to 30 lbs., the wild swan, 18 to 24 lbs., the largest American eagle, 14 to 16 lbs. I cannot get the weight of the condor and lammergeyer, but probably about 25 lbs.

Birds of prey utilize the force of gravity largely in taking their prey. Owls flying near the ground suddenly drop upon their victims.

Many hawks of the noble species and even the peregrine itself, according to Audubon, check upon seeing game on the ground, perch upon the top of the nearest tree from which, taking aim, they swoop down at once upon it.

According to Marey, the noble falcons as used in falconry, immediately on being cast off flew to the height by a series of steps, first rising against the wind, then with the wind horizontally until they had attained a sufficient altitude where they "waited on" for the game to be raised. When this was done the falcon swooped down upon the game in a series of catenary curves; this swoop was made with closed wings and a rushing noise; if nearly perpendicularly over the game, it was called a "Royal Swoop." The game dodged and the falcon missed "Footing her prey;" immediately the falcon changed the direction of its body, opened its wings when the pressure of the air acting against their lower surface under the momentum of the stoop, threw the bird to nearly as great a height as that from which he had just come without any further effort on his part. From this point he instantly made a fresh stoop and continued a series of them, until the bird was taken or reached cover.

A great many birds may be seen gliding, wheeling, and swooping in their flight, as gulls, rooks, swallows, hawks, etc.; their actions are entirely performed by the action of gravity pulling the bird down with accelerated force, the direction being given by the angle at which the wings are held by the bird; and then by altering the presentation of the wings to the resistance of the air, at a fresh angle the momentum gained by the speed of descent is converted into an ascent to the same height as that started from, less what the momentum has lost by the resistance of the air during the passage. Exactly as a car in the switch-back railway comes up very nearly to the same level as it started from, the difference representing the loss by friction.

Flight by soaring, or, as M. Marey calls it, *vol a voile.*

Flight by sailing must not be confused with this swooping. It is continuously performed for hours without a single flap, sometimes rising, sometimes falling, sometimes gliding in horizontal circles; sometimes proceeding with, sometimes against the wind: but according to most observers being protracted indefinitely. Birds which practise this sort of flight in perfection are large ones. In this way eagles and vultures wheel for hours around the precipices and buttresses of most large chains of mountains, surveying the ground below for game or carcases of animals that have died or been killed by falling over the cliffs. Some storks, albatrosses, the frigate bird, and some hawks and kites, are mentioned by observers as soaring in this manner.

Many theories have been advanced to account for this flight, nor is it I believe yet considered as satisfactorily explained. Mr. Bennet, a surgeon to a Pacific whaler, considered the flight analogous to sailing, and gave a plate to show that a frigate bird could sail closer to the wind than a cutter.

Captain F. W. Hutton, writing in the "Ibis" in 1865, shows the fallacy of this, and has observed an albatross of fifteen pounds' weight sail directly against the wind, and for more than an hour. He attributes the action entirely to momentum previously gained by flapping, and considers that this in so large a bird is sufficient to overcome friction for an hour without being spent.

The Duke of Argyll and some others consider that the bird places its wings at such an angle that the force of gravity is sufficient in the resolution of forces to result in the flight, like a boy's paper kite.

But the ideas of sailing like a cutter or like a paper kite are untenable, because in both cases the motion is controlled; by attachment to the ground by the string in the case of the kite, and by part of the body moved being immersed in a fluid of much greater density, water, in the case of the cutter; cut the string of the kite and down it drops, blow the wind ever so high. Sink the yacht entirely into the water and it will cease to sail; no matter how fast the stream flows, it will sink and only drift a little with the current.

Wind only affects the flight of a bird actually in two ways; first, in starting from a fixed object. A falcon, for instance, always rises against the wind;

now if this is a stiff gale, say of twenty-five miles an hour, this starts the bird with the same momentum as if it were flying at twenty-five miles an hour. Secondly, by the optic conception of stationary objects, these seem to be moving away from the bird in a wind, and she has to put on extra speed to go from one place to another; or they appear to be moving obliquely, or, as the case may be, in the opposite direction to the wind. The wind, therefore, will not help to support a bird at all except just after rising from a fixed object, and until the momentum of the start is lost.

Some observers have thought that the bird in soaring, gets an impulse by circling, as this course is a very common one in flight by sailing; but this does not seem well made out.

I think it was Dr. Livingstone, but cannot find the quotation, who suggested the "Surging head," and this seems to be on the right track.

I will hazard the following guess at the difficulty for what it is worth.

When a heavy bird like an albatross has attained sufficient momentum to support itself by gliding on out-stretched pinions for an instant, this motion would continue indefinitely if it were not for the loss caused by the friction of the air, the speed and momentum of the bird, acting through the incline of the out-stretched wings to the line of flight, receiving exactly sufficient support from the air to counteract the force of gravity. There is nothing to prevent this continuing indefinitely, except the resistance of the air, in the horizontal line of flight, yet this, if not compensated for, is sufficient soon to bring down the bird.

Now, I believe that a sufficient impulse to overcome this friction may be obtained by an undulation of the body and tail of the bird, as if swung on pivots between the wings with very much the same motion, only less perceptible, as that by which a porpoise progresses through water. This is a point, however, on which we want more observation.

The question has often been asked, Will man ever be able to fly? There is no exact ratio established between the weight of a bird and the area of its wings, but for larger birds one square foot to the pound weight seems about the average; at this rate, taking a man at 150 pounds, it would require wings with the base next the body of five feet with a length of twenty-five feet to support his weight in the air.

The picture is sufficiently portentous for me not to wish to follow it further.

CHAPTER XII.

THE BIBLE AND EVOLUTION.

The reconciliation between the Bible and evolution—A question for theologians—Time of solution of difficulty not yet come—Apology for making suggestions—Ezekiel considered the term "Garden of Eden" allegorical—The tree of life—The Eternal Father—The Kingdom of Heaven—Moses' definition of ruminants—Rod becoming a serpent—Gothic sacred Ash—Ezekiel on evolution—How did the Son of Man first come on the earth?—The science of geology, a house builded upon the rock—Origin of language in love of the Father—Abraham's substitution of animal for human sacrifice—Exclusiveness of Jews in their religion met by sacrifice of Christ.

I AM frequently asked how the doctrine of evolution agrees with the Bible? The question is, no doubt, an inevitable one, but I must protest against its being pressed upon the evolutionist. It would be just as fair to ask a geographer how he accounts for America, by the Bible. Natural history is not religion any more than physiology is family affection. Still, when one of the family is ill we are often glad to make use of the laws of physiology, and when religion is in danger of schism or heresy a reference to the acts of the Creator as seen in the creation may throw light or direction in the difficulty.

It is a good maxim that "a shoemaker should stick to his last," and therefore the proper persons to apply to in the difficulty are professed theologians. This I have done, but I cannot say that I have received so much help from this quarter as I expected; most of the ministers of religion are so absorbed in the practical work of their congregations that questions of this nature hardly interest them. Some do not consider themselves free to look at matters from the standpoint of nature at all, whilst others did not seem to be capable of appreciating the weight of the evidence in favour of evolution. Nor does it seem to me that the time is come when any positive teaching on this subject is possible. The first thing necessary for a solid structure of reconciliation would be a certain knowledge of the dates and authorship of the various books of the Bible, so as to be able to see the consecutive structure of Doctrine in connection with current events. This, as I gather from theologians, is far from being at present the case. A great many things will probably be found allegorical, which are often held to be narratives of material history. The doctrines rightly derived are no doubt perfectly true, but still we should be glad to know what is allegory and what history, and what again history told in the language of the faith of the time, but of which we have lost the right sense.

Conversing one day with a Roman Catholic priest on the dates of the books held by the English Church to be apocryphal, he questioned in "what sense Protestants received the Bible?" to which the reply was, "In the sense in which the books were originally written, as explained by the facts as they actually occurred," to which he made no demur. That this is not always the same conception as is gained by their simple reception, is only too evident from the numerous conflicting apprehensions which at present exist.

In a question of such vital importance affecting so essentially our estimation by our fellow-citizens, and the truths which it is necessary to teach our children, it is impossible not to have been exercised by the present conflict of opinion.

Perusing the sacred Scriptures under the pressure of these conditions, I have been continually struck by the fact that there is hardly one of the questions raised, or doctrines arrived at in pursuing the enquiry into the evolutionary hypothesis which is not already stated or hinted at in the Bible or Apocrypha.

No doubt it will be said that I have put into the texts the sense which I find there, but this objection is of such universal application to all explanations that I must ask my readers to dismiss it from their minds, and take the following suggestions for what they are worth; they may at any rate be a help to some.

The question arises as to whether the first chapter of Genesis is to be accepted as allegorical, or actually historical. The evidence of geology is in favour of its being allegorical, and I believe it is so accepted by many good theologians. The following passage from Ezekiel shows that it was so accepted or at any rate used by that Prophet.

Speaking of the struggles between diverse nations, he likens them to trees in the Garden of the Lord, chap. xxxi. 8: "The cedars in the Garden of God could not hide him (the Assyrian); the fir trees were not like his boughs, and the chesnut trees were not like his branches; nor any tree in the Garden of God, was like unto him in his beauty." ib. 16: "I made the nations to shake at the sound of his fall, when I cast him down to hell with them that descend into the pit; and all the trees of Eden, the choice and best of Lebanon, etc." ib. 18: "To whom art thou like in glory and in greatness among the trees of Eden? yet shalt thou be brought down with the trees of Eden unto the nether parts of the earth, etc."

We may therefore feel justified in accepting the first chapters of Genesis as allegorical.

Now, modern science teaches, and the theory of evolution asserts, that animal life has proceeded down through the ages as a genealogical tree, insists on the indwelling factor of hereditary life, as influencing, acting and reacting on all the other phenomena of the environment.

We see here almost parallel statements in different phraseology of the main line of doctrine running through the Bible; the Eternal Father; the tree of life; the kingdom of heaven. It is true that Ezekiel restricts his "trees in the garden" to human national life, but it seems probable that in Genesis it is not so restricted.

I know that some doubts have been raised as to whether Moses actually wrote all of the Pentateuch or more than Deuteronomy; but we are told that he was learned in all the learning of the Egyptians, and there is so much more classified scientific knowledge in the Pentateuch than in any of the later books, that one feels inclined to take it as it stands until more positive information is forthcoming. Take, for instance, the definition of ruminating animals, Lev., chap. xi. 3, "Whatsoever parteth the hoof, and is cloven-footed, and cheweth the cud among beasts."

Except that it omits the camel, this definition would stand good at the present day for the order of ruminants; and the camel indeed is only a seeming exception, as the two hoof-like nails on its foot show, the rest of the foot having been functionally modified to suit it for sand travelling.

There is only one instance given in the Bible of an animal supposed to have been created as by a *Deus ex Machina* from without; namely when Moses threw down his rod before Pharaoh and it became a serpent; but as the Egyptian magicians also did so by their enchantments, I do not think we can be asked to found any doctrine on this statement.

I thought of giving a list of all the texts in the Bible which allegorize the process of life in the world as a tree or vine, being at the same time typical of the Creator and Eternal Father, but they run through the whole of it, and no one can miss them. Any one who will look at Mr. Darwin's hypothetical diagram of the procession of one species to another, cannot help being struck by its resemblance to the branching and budding of a vine. In the Gothic theology I find also the same figure used in their sacred Ash, whose roots and branches filled the whole earth, also connected symbolically with the "All Father." Probably it was the same symbol, degenerated from an intelligent conception to a fetish, which furnished the sacred trees of the groves of Baal.

The term "kingdom of heaven" has been so much used ecclesiastically as a kingdom of righteousness, or harmony, or the projected future state, that sometimes persons are in danger of forgetting its original definition.

Gen. i. 8: "And God called the firmament heaven."

We see here that the word "heaven," or firmament, almost corresponds to Herbert Spencer's environment, or the subsequent biblical term "habitation" in its most comprehensive form. My readers will be familiar with the idea that biologists are now working hard at the connection which the particular surroundings of many animals have upon their surface coloration and markings, as of flat fish to the sandy bottom of the sea where they lie; partridges to a stubble field; as if they were formed in some similitude to that place in which they dwelt, and which may be said in a certain sense to have created them. To this may be added the thought that the continual growth and action under the vicissitudes of surroundings, is simultaneously implanted in the nervous muscular and general anatomy; and that in the constant nourishment by food and change of the particles of the body, in the wear and tear of life, in the various organs, there must be some directing, discriminating power within the body, placing each molecule in its proper place, and sweeping away the refuse into the drought.

Ezekiel is called the "Dark Prophet," but seems rather to be the "Physiological Prophet." Not that he can make any pretence to the systematic or ethical science of the Pentateuch, but he appears to have had all these problems in view in his vision in chapter i. We have first a cloud and a fire unfolding itself, chapter i., verse 4, which puts us in mind of modern astronomical theories of the formation of the world on the nebular hypothesis; and then "out of the midst thereof came the likeness of four living creatures."

The following verses to the 10th are unintelligible, but then we have verse 10: "They four had the face of a man and of a lion and an ox and an eagle," which would seem to be a very rough generalization of the prophet's views of the principal lines of life. Then verse 13, the likeness of the living creatures was like fire and like lamps. Now, life and spirit are constantly symbolized in the New Testament as a fire or lamp or candle. Then verses 15, 16, 17, 18, 19, they are described in close connection with wheels: "a wheel within a wheel"; "and they turned not as they went," that is they did not move on them as a carriage does, but the wheels were somehow in the life of them.

Verses 19, 20, 21: "For the spirit of the living creatures was in the wheels."

The circulations of the body of biologists seems here almost plainly stated, though mixed with other matter, and then we have verse 22: "and the likeness of the firmament upon the heads of the living creature was as the colour of the terrible crystal." Here we have *likeness* of the firmament or environment or habitation reappearing on the heads of the living creatures. This analogy, perhaps, would not appear so striking if modern science was not now still in amaze at the fact that within the unity of life of a single fertilized ovum there was the potentiality for the building up of all the complicated organisms of the most highly organized animals and man. A fact of which we are not in a constant state of amazement at, merely because we are so familiar with it; by the side of which all other miracles are as nothing.

Was it not this truth, as showing the immense importance of preserving our life in unity, to which our Saviour referred when he said: "If the eye is single thy whole body shall be full of light." We have the law of the reproduction of some similarity between that which surrounds and produces any animal or man, recognized in the first chapter of Genesis, where man is represented as made in the image of God, in "whom we live and move and have our being"; in the contrivance of Jacob to produce a particular colouring in the fleece of Laban's flock; in the likeness of the firmament on the heads of the beast and man of Ezekiel, and in many passages of the New Testament which will no doubt occur to the reader.

Idolatry was strictly forbidden in the Decalogue, no doubt because of the facilities which it afforded for dividing the national faith and countenancing many forms of sensual vice.

Yet it may be doubted whether the highly beautiful forms which image-worship gradually advanced to in the sculptures of antiquity, did not tend in their worship to produce a higher standard of physical beauty in their worshippers.

It will probably be conceded that the great question of antiquity, as now, was in what form the Son of Man first came on the earth : by metaphor he is represented as created in the image of his Creator and talking with him.

There are many works written to prove the existence of God ; but I cannot say that they seem to justify themselves to my mind. Man is a worshipping animal ; this is evident wherever he is found, except in a most degraded condition, or where by philosophy or transcendentalism he has confused his terms ; and the object of his worship has received the name of God or its equivalent in all languages. The written word in English would be spelt G-o-d, in other languages it is spelt differently, but the internal sentiment or word for which it stands is universal. In the words of the apostle John : "The word was with God, and the word was God," chap. i., verse 1. "In him was life ; and the life was the light of men," verse 4. "That was the true light, which lighteth *every man* that cometh into the world," verse 9. That is to say, as I understand it, that the distinguishing feature of man's intelligence or light from that of the lower animals is this word or idea or worship of God, of which we have the Mosaical metaphorical account as Adam made in the image of his maker and walking in the Garden of Eden and talking with God.

Different tribal worship and consequent warfares had produced polytheism, and in the search after the true unity of God, he appeared to Moses as a burning bush, which yet was not consumed, perhaps a vision of the process of life, and from this revelation Moses was inspired to bring into unity of narrative a great number of earlier traditions and scriptures now lost or unknown, as in Numbers xxi., verse 14, "Wherefore it is said in the book of the wars of the Lord."

The name or definition of God which Moses' ears were opened to at the same time, "I am that I am," comes very near Descartes' "I think, therefore, I exist," the statement of God as the substance of phenomena. His spirit is described as moving on the face of the waters, as being in the rock, as being a rock, and Moses is described as viewing the back parts of God in a cleft of the rock.

Geology may be also said metaphorically to have seen the back parts of the Creator in the clefts of the rocks. Our Saviour said that "God was able of these stones to raise up children to Abraham," and that a house built upon the rock will not fall though storms assail it. Again geology may be said to be a house built upon a rock, and as so rightly builded it will not fall. The position of the Pentateuch, of God being the substance of all things, and the Creator, seems unassailable, and must have been the origin of religion everywhere.

The following from the Wesleyan missionary, Egerton Ryerson Young's account of a sojourn among the Cree and Salteaux Indians has so much of the ring of reality in it that it is given as a typical example of the universal origin of religion among primitive races, that is of "Adam walking in the Garden of Eden and talking with God." Mr. Young met a heathen Indian who had made a wooden idol, and with the refuse wood made a fire and cooked his food in the very manner described by Isaiah xliv. 16. Said the Indian (page 87), "Missionary, the Indian's mind is dark and he cannot grasp the unseen. He hears the Great Spirit's voice in the thunder and storms. He sees the evidences of his existence all around, but neither he nor his fathers have ever seen the Great Spirit or anyone who has, and so he does not know what he looks like. But man is the highest creature that he knows of, and so he makes his idol like a man, and calls it his manito. We only worship them because we do not know what the Great Spirit looks like, but these we can understand."

Here we see that the origin of idolatry was the making of God in man's image, the inversion of the real process. It may be asked, how came the prophets, particularly Ezekiel and Job, to do the same thing in language which was forbidden to the hands; it will be replied that the figures were understood metaphorically, which is, no doubt, the true answer. It has always been one of the greatest difficulties in religion to give such an object of worship as shall not be liable to idolatry.

In the Decalogue and other laws which were bequeathed as the direct application of the Mosaical revelation one main point was to keep their seed pure and unmixed with the surrounding nations, and their minds free from the fear of the incomprehensible by the performance of certain religious duties and the employment of a special body of priests for their due observance. This seems to have resulted in an intensely tough persistent life, passionately attached to its own tribal life and very intolerant of all other forms of religion.

That their religion did not save them from being carried into captivity seems to have been a benumbing shock to their religious convictions, and we consequently see in the Book of Esther that the name of God is not once mentioned : although afterwards, when they had recovered from this shock, this omission seems to have been attempted to be rectified in the Apocryphal book of Esther, where the name occurs nine times in the first thirteen verses. But although the name of God is omitted in the Book of Esther, the same human virtues are emphasized. Mordecai is represented as faithful to his niece, to his king, and to his people, as is Esther.

Audubon narrates a story of a heron, which so graphically illustrates the apparent mood of the Jews at this time that I cannot forbear quoting it.

He saw a heron wading in the sea near the shore, when it struck its beak into a large fish; this dragged the bird under water and to some distance before it could disengage itself. When the bird did so at last, it returned to its original station, but turned its back to the ocean and remained apparently sulky and ashamed of itself as long as it was observed.

What are usually termed the supernatural narrations in the Bible scarcely come within the scope of my subject; but the age of the patriarchs in Genesis merits a little attention, as, if their ages could be established as being given in solar years, it would of course upset any derivation by descent from the lower animals; but a reference to the habits of primitive races will easily account for such records being handed down by tradition or otherwise, as among these races reckoning by months or lunar years is quite common; and Plutarch in his Lives suggests this very reason to explain the great lengths of the reigns given in Egyptian history.

It is curious in this connection that Moses, as if struck by the immense ages imputed to the antediluvian patriarchs, seems to have made his own investigation on the subject which is recorded in Psalm xc., verse 10. "The days of our years are three score years and ten, and if by reason of strength they be four-score years, yet is their strength labour and sorrow, for it is soon cut off and we fly away!" An estimate of life sufficiently exact for a life insurance office at the present day.

In trying to gain an idea of the human factor by retrospective projection, as exemplified in the earliest typical man, two methods present themselves. We can track him back by records and material traces of his doings, or we can make a circle and enclose a retrospective time, when no animal showed the distinctive intelligence of man, and say between such and such times the factor has arisen. We find these distinctions in language, laws, literature, and weapons in biblical language in "The Word," "The Law," "The Scripture," and "The Sword."

How language first arose it is impossible to tell, but if we recur for suggestions to the infant, as passing through in quick stages the history of its ancestors, it would give us the word Dad-da or Bab-ba or Mam-ma. Is not this the "Abba Father" of our Saviour?

The rise of articulate language by giving rise to proper names, would individualize personality and give the possibility of much greater definition to the domestic, tribal, moral, and legal relations, which have been finally settled in the Bible under two heads, Life and Law; the talking with God of Adam with imposed restrictions. The two staves of Zechariah xi. 7, "And I took unto me two staves; the one I called Beauty, and the other I called Bands." The love of God coupled with regard for our neighbour's rights, of our Saviour and the life and law of St. Paul.

The terrible superiority of made weapons over natural organs of offence and defence may have given man his superiority over the lower animals, and by quickening his brains in invention of diverse

Does the monkey or ape —

implements have laid the foundation for that diversity of occupation, with slight difference in organization, which, by giving him a choice of occupation, laid the foundation for free will.

Deadly wars between different tribes would lead to strict tribal laws and mutual obligations; and intense stress to find the right direction for founding these laws may have led to human sacrifice as a means for propitiating the unseen Creator in the first place, and by reflex action of clearing their own minds from any sense of reservation, and giving determination its highest tension. At any rate, human sacrifice was established, and to the present day still occurs. If any charge of unorthodoxy can be brought against my views, it is here only that I plead guilty to any leaning which may seem in that direction.

The great blessing of Abraham's revelation was not so much his obedience in offering up his son, as in his having grace to see an angel of substitution in the ram caught by its horns. According to the record, he established animal instead of human sacrifice, although it still continued, as in Israel by Jephthah and very nearly by Saul when Jonathan broke the order against eating whilst in pursuit of the enemy, though this latter example partakes partly of the character of a punishment. The Decalogue, sublime as those laws are, was however very difficult of application. It seems to have degenerated at last into very narrow tribal rites, combined with a tenacious grasp of keeping their seed pure, which led to great injustice in their wars, and when they returned from the captivity by Nehemiah in his ordering them to put away their strange wives.

This exclusiveness in life, whilst it could not be denied that their theology was the leading science in that direction, produced a terrible problem for the world. How could it accept their religion without their domination?

The solution, as it seems to me, was arrived at by our Saviour, who, going back to the life which preceded Moses or Abraham, founded his religion on parental love, the love of the Father, and thus threw open the doors for a universal religion. Almost all his parables turn on the love of the Father and faithful human relationship. No doubt he sometimes speaks of God as a king gone on a far journey, but these figures of speech were metaphorical, and his meaning seems clear when he says that not a sparrow can fall outside the consciousness of the Father.

The Jews are very much to be felt for. Moses distinctly forbade them to take any laws but his, until a prophet should arise like unto him. Some writers have supposed that this referred to Christ, but he was not like unto Moses. The religion of Moses was objective from the scientific revelations of the Creator in the creation, whilst that of our Saviour was spiritual or subjective.

Taking the measure of life in death, he set a pattern of a life of faithfulness to truth, nor do I find in him, either as depicted in the New Testament or in my own consciousness, that which requires the belief in anything which is not true in fact, or the rejection of anything which is; although there may be times when it is prudent to maintain a reserve in statement.

THE END.

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