

ON THE DEVELOPMENT OF THE POWERS OF  
THOUGHT IN VERTEBRATE ANIMALS IN CON-  
NECTION WITH THE DEVELOPMENT OF THEIR  
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ALTHOUGH Mind can never be identified with Matter, nor the acts and states of the mind reduced to acts and states of the brain, yet as the latter are the physical antecedents of the former, the study of the one class of phenomena is calculated to give light and guidance in the study of the other. The object of the present paper is to consider some general outlines of the development of the powers of thought in Vertebrate Animals in connection with the development of their brain, in the hope that such a general view may throw some light, both on the powers of the mind and on the functions of the brain.

An obvious characteristic of mental action in the lower animals as compared with the higher is, that it is to so large an extent instinctive. Now the nature of such instinctive action as involves thought may be well studied in the case of the Beaver, though his mental action is not limited to instincts. The following is an instructive account given by Mr Broderip of one which he kept in his house. I quote it from Dr Carpenter's work on *Mental Physiology*, p. 92.

"The building instinct shewed itself immediately it was let out of its cage and materials were placed in its way; and this before it had been a week in its new quarters. Its strength even before it was half grown was great. It would drag along a large sweeping-brush or a warming-pan, grasping the handle with its teeth, so that the load came over its shoulder, and advancing in an oblique direction till it arrived at the point where it wished to place it. The long and large materials were always taken first and two of the longest were generally laid crosswise, with one of the ends of each touching the wall, and the other end projecting out into the room. The area formed by the cross-brushes and the wall he would fill up with hand-brushes, rush-baskets, boots, books, sticks, cloths, dried turf, or anything portable. As the work grew high he supported himself on his tail, which propped him up admirably; and he would often, after laying on one of his building materials, sit up over against it, appearing to consider

his work, or, as the country people say, 'judge it.' This pause was sometimes followed by changing the position of the material 'judged,' and sometimes it was left in its place. After he had piled up his materials in one part of the room (for he generally chose the same place), he proceeded to wall up the space between the feet of a chest of drawers, which stood at a little distance from it, high enough on its legs to make the bottom a roof for him, using for this purpose dried turf and sticks, which he laid very even, and filling up the interstices with bits of coal, hay, cloth, or anything he could pick up. This last place he seemed to appropriate for his dwelling; the former work seemed to be intended for a dam."

Here we see that though the labours of the Beaver in its natural condition seem to be full of purpose and guided by a wonderfully intelligent reference to the end which they are to serve, the animal is really urged to form its constructions by an impulse which is quite irrespective of that end and purpose. Mr Broderip's beaver can hardly have had any idea of a dam acting as such, connected with its successive acts of construction, and guiding those acts as what they were to realise; for its surroundings were inconsistent with such an idea. And if its successive acts were not quite independent of such an idea they would not have been performed under the circumstances. At the same time, however, the labours of the Beaver were far from being destitute of thought. On the contrary, it seems to have had a very distinct idea of the particular step of construction in which it was engaged, and to have been careful to make its work conform to that idea. Each constructive act was in continuation of what had been already done, and its regulative idea was suggested by the then state of the work. But the realisation of each such idea was sought in succession as an end, without reference to the ultimate result of the entire series of actions.

In our own mental constitution we are familiar with a process by which means come to be sought for themselves without reference to the end which they subserve; the desire having been transferred from the end which was originally its object to the means which have been successfully used for the attainment of that end. The money which was first prized only for what it could purchase comes gradually to be desired for itself, and is sometimes preferred to any thing that it could buy, the means having become the end, and the original end being compara-

tively disregarded. And in truth many, if not most of the objects which we seek in mature life, are examples of desire similarly transferred. In such cases the means successfully used to attain the object of our desire become associated in the mind with the pleasure of that attainment, so that a sense of such gratification combines with the thought of those means, and forms part of the idea of them; and in proportion as this takes place the means attract to themselves the desire, and are sought as an end. When a variety of ends are attained by similar means, as when money is found to purchase all other commodities, then a corresponding variety of desires become combined with the idea of those means, and the compound attractiveness which they thus acquire is different from any of the original desires, and may supplant them all. But when the same means continue to be used only for the attainment of the same end, it is the gratification of the original desire which is combined with them, and this desire, after having sought the means, goes on to seek the end. A succession of means may in this way come to be sought, each one attracting action after the other, and leading to the attainment of the original end. And if this process be often repeated it will become habitual, and may even be transmitted to offspring as an hereditary tendency, so as to generate an instinct; though there are some instincts which could not have been originated in this way. Now in human nature, according as such series of acts become more and more habitual and easy, they are performed with less and less thought, till at length they may be performed without any thought at all, being guided only by sensation. But when they do engage thought, that thought generally involves intelligent purpose; and the mind thinks not only the present act but what that act will effect. Now the peculiarity of instinctive action, like that of the Beaver, is that it is not an unthinking hereditary habit connected only with sensation, but that each successive act is performed with thought; while, at the same time, thought is confined to the present act, or at most includes very little beyond it. The native impulse or desire seeks each step in succession irrespective of the result of the whole, because thought cannot take in the end of the series.

But this limited scope of thought which is unable to take

in a series of acts, is far from being characteristic of the intelligence of Vertebrate animals in general. On the contrary, those which have a more developed brain plainly exhibit in their actions intelligent purpose, a power of thinking the means in connection with the end, so as to have present to their consciousness a sense of a series of acts leading to a desired result. Of this many examples might be given, but it may be sufficient to quote as an illustration of it the following anecdote of a dog, from Mr Watson's book, on the *Reasoning Power in Animals*, p. 130.

“Count Tilesius, a Russian traveller, who wrote at the beginning of the present century, relates a most remarkable proceeding of a dog of his, which he himself witnessed. The dog in one of his excursions from home had been worried by an animal of greater strength than himself, and returned crest-fallen. For some time afterwards it was observed that he abstained from eating half of the food given him, but carried away the other half and laid it up as a private store. When he had gone on thus for some days, he one day went out and gathered round him several dogs of the neighbourhood, whom he brought to his home and feasted on his hoard. This singular assemblage attracted the count's attention. He watched their movements, saw them all go out together, and followed them at a distance. They proceeded deliberately onwards through several streets till they came to the outskirts of the town, where, under the guidance of their leader, they all fell upon a large dog, whom they punished with great severity.”

Now this series of actions is of such rare or merely occasional occurrence in the life of a dog, that it cannot be accounted for on the supposition that by that process of association which grows out of frequent repetition, the gratification of attaining the end had mingled with the thought of all the means, and rendered them in themselves attractive in succession. There may, indeed, be in the dog, as a gregarious animal, an inherited tendency to look for help in circumstances which make help needful, and possibly a tendency to court the alliance of other dogs by giving them food, though this is more probably due to his own intelligent sense of their feelings. But the further step of saving his food instead of eating it can hardly be an instinctive impulse awakened by the circumstances but without conscious purpose; for it requires so strong an impulse that the instinct should be one in full action, and

therefore of frequent occurrence. The sense of injury would arouse the instinct of revenge. This from inherited or acquired association would be followed by a desire for help. This would suggest the giving of food, and this the storing of food. And each time that food was present the sight of it might awaken these thoughts in succession. But if it was only in succession that the dog could have these thoughts, losing the consciousness of each as he passed to the next, the original desire for vengeance which would mingle in some degree with the second thought, and perhaps might even tincture the third, would be so faint in the fourth, if it were present at all, that the strong instinct of eating the food would prevail over the mere idea of storing it. That there might be an active desire to store the food sufficiently strong to make the dog abstain from it, there must have been present to his consciousness along with the idea of storing it a thought of giving it to the other dogs, and gaining their help to gratify his revenge. He must have had a power of thinking a particular act as a part of a series, combining with the idea of that act a thought of the series of acts leading to their result.

Now wherein does this differ from the power which the human mind possesses of forming a plan to attain an end? If what has been stated contains the whole of the action of intelligence which was involved in the proceedings of the dog, then those proceedings reveal only a power of thinking, as a whole, a series of acts, each with its effect, and all with their result. But the human mind adds to this the further power of believing, with more or less certainty, that each step in the series of acts which it plans will be followed by the consequence connected with it in thought. Now this implies inference from past experience; and after all that has been written on the process of inference or reasoning properly so called, we must, if we are to distinguish it from mere association of facts, come back to the old theory, that inference is the process of imparting to the idea of a fact the degree of assurance which belongs to it, as a case of a general principle.

Mr Darwin, in his *Descent of Man*, p. 41, mentions a female baboon who adopted young dogs and cats, which she continually carried about; and he tells that an adopted kitten scratched

this affectionate baboon, "who," he says, "certainly had a fine intellect, for she was much astonished at being scratched, and immediately examined the kitten's feet, and without more ado bit off the claws." Now such an act of intelligence seems to be beyond the powers of a dog. In the *Wonders of Animal Instinct*, from the French of Ernest Menault, p. 363, the following acute distinction is drawn between the intelligence of the ourang-outang and that of the dog.

"The ourang-outang, without being instructed by man, does accomplish acts of which the most sagacious and best instructed of our dogs is incapable. If the dog is chained up, and the chain becomes entangled, the animal pulls it forcibly towards him, and often increases the evil, instead of removing it. If the obstacle continues, he becomes frightened and cries out, but never thinks of searching into the cause of the mischance. It is not so with the ourang-outang. The moment a similar accident happens to him, he tries to find out the real state of things. You will not see him pulling against a powerful obstacle with blind force. He stops at once, as a man would do in similar circumstances. He turns round to examine the cause of the occurrence. If the chain be entangled by a heap or weight of any kind, he disengages it. In every case he seeks the why and the wherefore. Is not this seeking for causes a manifest sign of intelligence?"

Now it is much more than a sign of intelligence, it is evidence of the power of thinking a fact with belief as a case of a general principle; and that power is the power of reasoning. The dog whose chain is entangled finds himself unable to perform the action which has become usual to him under the circumstances; and he is merely disturbed by this impediment to the regular play of his associations. The ourang-outang sees in this check to his usual action something more than the fact that he is checked, namely, the presence of a thing not yet known, altering the usual action of the chain. If, indeed, such a thing had been observed before acting in this way sufficiently often to form an association, the dog would think of it as well as the ourang-outang. And if its removal on those occasions had relieved him, the dog too would think of removing it. The supposed case, therefore, is one in which such an association has not been formed. The ourang-outang may never before have been confined by a tangled chain; the baboon may never before have been scratched by a paw. The thought which each occur-

rence suggests to them is a fine abstraction from a far wider experience, namely, the presence of a new condition to a new action. This is a fine element of fact which belongs in common to a number of facts. It might be connected in thought with the present fact by mere association of those other facts in which it was an element. But when thus thought, it would be too faint to attract the attention of the mind and govern action. In order that such an abstract element of past experience should govern action, it is necessary that it should be strengthened with a new element of belief and combined in a sense of reality with the present object. It will thus become strongly noted as part of that object, and will engage the desire which that object inspires. To the ourang-outang in the one case, and to the baboon in the other, the thought of a new circumstance as condition of a new action was no abstract conception, but a special part of the idea of the present fact; and it attracted action, suggesting the way in which the unpleasantness was to be removed. It was thought with a power which the dog does not possess, the power of combining in an assured sense of reality with the idea of an object some abstract coexistence or succession which has been gathered from similar objects as a uniformity of experience; the power, in a word, of thinking a case of a general principle with the belief which belongs to it as such.

Now this step of mental development which may be observed in the ourang-outang, as compared with the dog, is similar in its essential nature to the previous step to which it is superadded, and which may be observed in the dog compared with the lower vertebrate animals. The dog can combine with the idea of an act, a thought of a further series of acts leading to a result, so as to think the act with purpose as part of the series. The ourang-outang can combine with the idea of a fact or thing, a thought of other similar facts or things, singling out an element in which they more or less uniformly agree, so as to think the fact or thing with more or less assurance as another instance of the uniformity. Each is a new power of combining thoughts which otherwise would have required a long course of repetition in conjunction with each other, before they could have grown together. And each combines those thoughts

in a closer and more vivid union through the medium of a new element, namely, sense of progress towards an end in the one case, and belief in the maintenance of a uniformity in the other.

But can the progress of mental development be traced through the Vertebrate series of animals as having advanced by these steps? Can they be classed in reference to their mental powers in three groups, of which the lowest can comprise in one act of thought only what can be perceived by sense all at the same time, the second can comprise in one act of thought a series of successions in time so as to think a single object of sense as part of such a series, and the third can comprise in one act of thought an entire class of coexistences or successions so as to combine with a particular fact the common element of coexistence or succession belonging to the class?

The operations of birds in the building of their nests are evidently of the same character as those of the beaver in the construction of his dam. They plainly proceed from an instinctive impulse which is independent of conscious purpose, and which acts even where the circumstances are inconsistent with the end to which it leads. They indicate therefore no larger power of mind than that which is limited in each of its acts to the thought of one object of sense, and which cannot think a successive series with its result; and the same may be said of the migratory instincts of birds. But it is rather in occasional manifestations of intelligence that the highest mental power possessed by any class of animals is to be seen; for in every class the actions which are habitual come to be performed by the lower powers. Now the intelligence of birds never reaches to the comprehension of a number of different successive acts, nor to the thought of a principle.

The case of the jackdaws, quoted from Mr Jesse by Dr Carpenter, seems indeed to indicate a power of thinking in one thought a series of acts leading to a result, but closer examination shews that this is only apparent.

“A pair of jackdaws endeavoured to construct their nest in one of the small windows that lighted the spiral staircase of an old church-tower. As is usual, however, in such windows, the sill sloped inwards with a considerable inclination; and consequently there being no level base for the nest, as soon as a few sticks had been laid,



and it was beginning to acquire weight, it slid down. This seems to have happened two or three times; nevertheless, the birds clung with great pertinacity to the site they had selected, and at last devised a most ingenious method of overcoming the difficulty. Collecting a great number of sticks, they built up a sort of cone upon the staircase, the summit of which rose to the level of the window-sill, and afforded the requisite support to the nest. This cone was not less than six feet high, and so large at its base as quite to obstruct the passage up the staircase; yet, notwithstanding the large amount of material which it contained, it was known to have been constructed within four or five days. Now, as this was a device quite foreign to the natural habit of the bird, and only hit upon after the repeated failure of its ordinary method of nest-building, the curious adaptation of means to end which it displayed can scarcely be regarded in any other light than as proceeding from a *design* in the minds of the individuals who executed it."

The question is, does this indicate that jackdaws possess the power of comprising in one act of thought a series which sense could perceive only in succession?

Now the cone of sticks is a single object of sense. The idea of it may have been formed by successive acts of thought, suggested first by the need for a support at the base of the nest, and then by the need for an additional support for this, and so on, till a bottom was reached; but each such thought would combine with the preceding ones into an idea of a single object of sense. The last element added to the idea would be the thought of the foundation; and this would suggest the first act of construction; and the process of construction would proceed, realising in succession the ideas of the successive parts without ever involving the thought of more than a single object of sense. The device was foreign to the natural habit of the bird, yet not quite foreign to the thoughts which the nest-building instinct involves. For the various peculiarities of the sites chosen for nests must awaken in birds instinctive associations of corresponding varieties of construction, and these must involve ideas of supports, and of the other requisites for stability.

The nest-building instinct must also often involve a desire for shelter and protection; and with those birds which have vivid and distinct mental action, a special need for shelter may awaken instinctive associations which suggest the construction of artificial shelter. Such constructions may seem to require a number of different ideas thought together in a plan, but they

do not really imply the thought of more than a single object of sense at one time. Thus a pair of magpies in a neighbourhood where there were no trees, built their nest in a gooseberry-bush, and frequented it for years. But as it was accessible to foxes, cats and other animals, they barricaded with a circle of briars and thorns not only the nest, but the whole bush<sup>1</sup>. In this case the desire for protection would operate successively with regard to each side of the nest, and would suggest successively the erection of each piece of the barricade, without ever thinking more than a single object at once.

For it is to be noted that when an object is thought with desire, and when it suggests through former association what led to its own attainment, the desire will attach itself to this suggested idea, even though there be no power of thinking means and end together. In order that the original desire should thus be taken up by a series of means, so as to cause them to be sought after one another as ends, a process of association is necessary which requires a long course of repetition; but this would never take place, unless there was a partial transfusion of desire to the nearest means in the first instance. And when the desire is strong this transfusion will be sufficient to cause the immediate mean to be sought even where each thought is limited to one object of sense. Thus birds as well as mammalia seem to have intelligence enough, when accustomed to the company of man, to associate human intervention with relief of their distress in special cases, and to apply to man for help; and when his help has come to them in a painful form, as for example in a surgical operation, they continue to desire it notwithstanding the present pain. But there is no evidence that any animal below the order to which the beaver belongs can think a series of sense perceptions, or a general principle; though there may be cases which simulate these powers. The old story of the raven throwing pebbles into water as if to raise its level, seems to indicate the knowledge of a general principle, but if the incident ever occurred, it was more probably a suggestion from the familiar act of standing on a stone to drink in a stream; in which the bird thought only this single act.

<sup>1</sup> Watson's *Reasoning Power in Animals*, p. 348.

In the order of Rodents to which the beaver and the rat belong, we first meet the power of thinking a series of acts, but this power is still so limited in them that the series of acts which they perform with conscious purpose, consist only of one or two acts, or of one or two acts repeated over and over again. A more diversified series of acts, like that which is required in the construction of the beaver's dam, is with them instinctive. Moreover they seem to have a tendency to perform those actions which involve the most design in combinations in which several are engaged, each one doing a part of the action. This is a feature of resemblance to the intelligence of insects, and corresponds to a limited power of thinking a series of acts. For this simultaneous performance by the community, of all the steps leading to an end, helps to enable each to perceive by sense the entire series all at the same time. The Ruminants have a larger power of thinking a series of acts, as may be seen in the artifices of the hunted stag, though it is hard to say how much of these may be instinctive; and still more clearly in the intelligence of the oxen of the Hottentots, which in war fight with the Hottentots against their enemies, and in peace perform for them the same services that are elsewhere performed by dogs. In the Pachydermata, the power of plan and purpose, and of understanding a series of acts which is expected from them, is clearly manifested by the elephant. And though the other pachydermata are so inferior in intelligence to the elephant, the inferiority is not in the nature of their thoughts, but in vividness and distinctness. In the Carnivora, the intelligence of the dog and of the fox, and of the other animals of the order, exhibits clearly the power of design; and the Dog moreover shews his power of thinking a series of acts by the signs which he gives of feeling guilty or ashamed or proud on account of his conduct. In the Quadrumana there appears for the first time, in addition to the powers of purpose, a sense of general principles; and this, as has been shewn, appears with clearness in the anthropoid apes.

Now such being in outline the development of the powers of intelligence in vertebrate animals, what is the course of development of their brain?

This question may be answered by the following quotation from Dr Carpenter's *Mental Physiology*, p. 116.

“That the different portions of the Cerebrum should have different parts to perform in that wonderful series of operations by which the Brain as a whole becomes the instrument of the mind can scarcely be regarded as in itself improbable. But no determination of this kind can have the least scientific value that is not based on the facts of comparative Anatomy and Embryonic Development. In ascending the Vertebrate series we find that this organ not only increases in relative size and becomes more complex in general structure, but undergoes progressive additions, which can be defined with considerable precision. For the Cerebrum of Oviparous Vertebrata is not a miniature representative of the entire Cerebrum of man, but corresponds only with its ‘anterior lobe,’ and is entirely deficient in that great transverse commissure, the corpus callosum, the first appearance of which in the Placental Mammals constitutes ‘the greatest and most sudden modification exhibited by the brain in the whole Vertebrated series.’ (Huxley.) It is among the smooth-brained Rodentia that we meet with the first distinct indication of a ‘middle lobe’ marked off from the anterior by the fissure of Sylvius; this lobe attains a considerably greater development in the Carnivora; but even in the Lemurs it still forms the hindermost portion of the Cerebrum. The ‘posterior lobe’ makes its first appearance in Monkeys, and is distinctly present in the Anthropoid Apes. The evolution of the Human Cerebrum follows the same course. For in the first phase of its development, which presents itself during the second and third months, there is no indication of any but the anterior lobes; in the second, which lasts from the latter part of the third month to the beginning of the fifth, the middle lobes make their appearance, and it is not until the latter part of the fifth month that the third period commences, characterized by the development of the posterior lobes, which sprout as it were from the back of the middle lobes, and remain for some time distinctly marked off from them by a furrow.”

These facts of embryonic development give great significance to the facts previously mentioned of Comparative Anatomy. And the latter have such correspondence with the sketch just given here of the development of the powers of intelligence, as at once to suggest that the functions of the anterior lobe belong to the act of thinking single objects of sense, those of the middle lobe to the act of thinking such objects with a sense of a succession of them and as part of that succession, and those of the posterior lobe to the act of thinking a coexistence or succession of them as a case of a general principle. But as the development of intelligence in

vertebrate animals, even if the view just taken of it be correct, may be thought to be connected rather with other features of the development of the brain, and as the view taken of the course of development of intelligence may itself be questioned, it may be well to study the question from another point of view. I shall therefore consider briefly the functional meaning of those other features of brain-development as it may be suggested by the analogies of the nervous system itself, and that of the successive addition of the three lobes as it may be inferred from the analogies of development in general.

There are two other striking features in the development of the brain in the vertebrate series of animals, namely the progressive increase of the superficial or cortical layer of the brain, and the increased development of the fibres which connect together the different parts of the brain.

Now the superficial layer of the brain is the part where the nerve-force of the brain is developed, and its increase, supposing the functional activity of any given extent of it to remain undiminished, must be accompanied by an increased development of cerebral force, and therefore of mental action. Moreover, such an increase of the superficial layer, without any change of the relations of its parts, would magnify each part so that an amount of cerebral force corresponding to a thought might be developed in a smaller fraction of the whole. Thus the actions of the brain in connection with the mind would be subdivided and thought analysed; and the effect of the increased size of the cortical layer of the brain, in consequence of the increased number and depth of its convolutions, would be not only an increased amount of mental action, but also an increased subdivision of thought; that which was a single idea of an object being broken up at pleasure into a number of different ideas.

An increase of mental action corresponding to an increase of the convolutions may perhaps be seen in the indications observable in dogs that they dream in their sleep. It is more distinctly manifested in the curiosity displayed by monkeys, and in that general interest taken by them in objects irrespective of utility, which has caused some authors to impute to

them an inferiority to other animals in common sense. But the increase of mental action is chiefly to be seen in whatever shews a habit of reflection. And though the higher animals may be observed contemplating objects, the power of reflection is scarcely open to our observation except in ourselves. In us it is developed in a degree corresponding to the enormous increase of the cortical layer of the brain and of its functional activity as shewn by the increased supply of blood.

The analysis of thought which is probably also connected with this particular brain-development breaks up the idea of a single object of sense into ideas of parts which are seen to constitute it. It is no doubt concerned in that observation of the way in which things act on other things which leads monkeys and apes to use instruments, though this is of course facilitated by their having hands. With this analysis of thought is connected the development of the powers of abstraction and comparison and perception of relation. For though these powers are possessed in their essence by all animals which can at will observe either separately or together objects which are together before their senses, yet in order that they may act with any degree of fineness a fine analysis of thought is needed. In human language, the analysis of thought reaches its acmé.

The second principal feature in the development of the brain is that of the system of nerve-fibres which connect the parts of the brain with each other. These must serve to make the action of the different parts of the brain consentaneous, and in doing so give correspondence to the muscular action of the two sides of the body, and strength and steadiness to thought. Attention and volition require this unfaltering unity of action; for if any part concerned did not concur decisively, its indecision would affect the other parts. And in proportion as powers of thought are developed which are less closely connected with sense, there is still more need of these connections to preserve that unity of action which the impressions of special sense, by reason of their decisive unity, give to cerebral action immediately connected with them. Accordingly the great transverse commissure which connects the two lateral halves of the cerebrum appears first with any degree of development worthy of notice in the Rodent order of the mammalia along with the

middle lobe. Thus neither the convolutions nor the fibres of the brain seem to have any tendency to give that extension to thought which has been assigned to the three lobes. They improve the action of the brain rather than enlarge the range of its objects. But the development of each additional organ of intelligence extends the range of the objects of thought. And it is as superadded developments that the three lobes appear both in the vertebrate series of animals, and in the development of the human embryo.

And now what suggestions as to the functions of the three lobes may be derived from the general analogies of development as giving successively the advantages which are needed in the struggle for life<sup>1</sup>?

The general function of the cerebrum is to direct the actions of the body by thoughts of the mind to the attainment of desirable ends, and each distinct addition which it receives may be expected to correspond to a distinct enlargement of that power<sup>2</sup>.

<sup>1</sup> The development spoken of is only that which is to be observed as a matter of fact in comparing the higher animals with the lower. Whatever theory be adopted as to the mode in which that development has been produced, it is a fact that in general each new development gives an advantage in the struggle for life, and that the general course of development corresponds with the satisfaction of these successive needs.

<sup>2</sup> It is an essential property of the nervous system to form associations, and any higher development of that system must exalt the power of association. When an action has been performed by a part of the nervous system, the restoration by nutrition of the force expended in the action seems to adjust itself to the then condition of the organ, so that when the action is performed again the organ in recovering its equilibrium after the action tends to be thrown into that same condition. And if on the first occasion the action was followed immediately by another action which quickened the life of the organ, as when an action gives pleasure, then the renewal of the first action will tend to throw the organ into a condition which is at the same time one of exalted life and one which it is natural for the organ to assume after the performance of the two actions in succession. The organ will then not only be quickened by the first action, but in the effort to attain equilibrium will tend to perform the second. And thus the sequence of two acts, of which the second gives pleasure, produces a twofold effect. It combines a degree of pleasure with the first act in its next performance, and it associates the second with it in a similar degree. Moreover, when the immediate effect of any action is to promote the life of the nervous system, as when an action gives pleasure, it seems by a general law of life to attract the force of the system while it is being performed, and to stimulate its nutrition afterwards. The disturbance caused by it in the first instance will be the greater, and when afterwards induced by an antecedent associated action will have the more force in eliciting it again to attain equilibrium; and the subsequent nutrition being accomplished more quickly while the one condition of the organ lasts, will correspond more closely to that condition, and cause it to be reproduced afterwards more faithfully. Thus an attractive action will have a special tendency to be associated with another

The intelligence requisite for the attainment of desirable ends consists of knowledge of the ends and knowledge of the means; but this degree of intelligence is only gradually attained. We find that in some animals which have no cerebrum certain sensations have become associated with the origination of certain muscular movements, so as to direct the actions of the body in accordance with the notices of external things which sensation gives. We must suppose that in these animals when a new sensation of a pleasurable kind has been imparted by an object, the presence of a similar object again will tend to recall that sensation. A mental state thus elicited by association follows that which calls it forth; and the obscure sensation thus recalled by the recurrence of the object will follow the impression which the object makes directly on the senses. Now the pleasure of the recalled sensation must be combined with the direct impressions made by the object, instead of only following them, in order that the present object, and not the mere past sensation, may be the object of desire. A pleasurable sensation thus awakened by association tends gradually to coalesce with that which often calls it forth. But this process is too slow for the prompt recognition of desirable objects; and the demand for development therefore will be the want of an organ to combine the successive impressions made by objects on sense, so as more rapidly to select by experience those objects which are desirable as ends for action. Accordingly the first function of the cerebrum should be to enable the mind to combine the impressions of sense into perceptions of sensible things, adding each new impression to the idea of the thing, as a quality inhering in it. Connected with this perception of desirable objects a power of thinking those objects in their absence is needed in order that they may effectively guide action by continuing to be the ends towards which it is directed. This need would be supplied by an action of the cerebrum on the sensorium, whereby the cerebral states which are produced by the impressions of sense may afterwards renew those impressions in the centres of sense, so as to supply ideas of absent objects; and accordingly the function action which preceded it, and will also tend to infuse into that other action a portion of its own attractiveness. A painful action arouses the life of the nervous system to resist it, so that it too has a special tendency to form an association; but here the association is negative of the action.



of the first lobe of the cerebrum in connection with thought should be to act with the sensorium in the perception of sensible things, and afterwards in the renewal of the idea of them.

If we analyse our own consciousness we find that there is in every perception or idea of external things an element of thought which is the centre or nucleus of our idea of the thing. This element of thought, though it has no mental image, can be distinguished by the human mind as substance; and the thought of substance therefore in a more or less indistinct and rudimentary form is probably what corresponds to the first contribution which the cerebrum gives to the powers of thought. In this element the sensations are combined into unities; for to substance they are all referred as qualities inhering in it, and constituting with it sensible things. And the first rudiments of position and dimension are probably added to the ideas of things from the series of muscular sensations associated with the sight of them during the motion to them or about them. As the cerebrum grows in the vertebrate series of animals and thought gets subdivided, the comparative attributes of things and the relations of things are thought; new emotions, desires and aversions grow out of the associations of ideas of things with the pleasures and pains which are essentially involved in various modes of nervous action; and possibly that reaction of the cerebrum, whereby after one thought has been conceived another is elicited in the mind, may become localized in different parts and specialized as different powers for ordering the successions of thought, so as to compare, combine, observe relations, and awaken emotions; the cerebrum and sensorium being both probably in action whenever an idea or mental image is before the mind. The cerebrum is also connected with the centres of motion, combining into unities groups of muscular actions as it combines into unities groups of impressions of sense, and extending and facilitating the associations between thought and action. Simultaneously with the cerebrum the cerebellum also makes its appearance in vertebrate animals. It is believed to coordinate the actions of the muscles with one another; and as its connections are principally with the spinal chord, it probably serves as a store of force, which having been set in action by the contracted muscles through the posterior nerves, continues to

maintain through the anterior nerves the stimulus to muscular action. Thus the cerebellum probably keeps up the activity of the groups of muscles which have been set in motion, that the momentary impulses which come from the brain may carry on with steadiness the progress of the action. For volition acts at each moment in producing slight changes in the existing action of the muscles, or directing that that action shall be unchanged or suspended.

Now after the power of thinking the ends of action the next development which is needed in the furthering of attainment is the power of thinking the means. For though the various steps in the process of attaining an end may be joined one to the other by association, action will not be moved to take those steps till the desire inspired by the end has been transferred to them, and this transference by association is, as has been said before, a gradual process. The same necessity therefore for a new power of combination which demanded the first development of the cerebrum in order to combine sensations into a perception of a sensible thing, will demand a fresh development of that power in order that the mind may think means in combination with their end, as leading to it. The desire inspired by the end will then combine with the means so as to prompt their adoption; and the idea of the means as such, that is as leading to the end, will be formed, and may be renewed in their absence so as to maintain the guidance of action.

Thus the middle lobe would be developed to act along with the anterior lobe so as to give a sense of the series leading to the end; though there can be no idea or mental image except of that part of the series with which the cerebrum is impressing the sensorium. To the middle lobe thus acting with the anterior would belong on this supposition the power of thinking acts with a view to their end, the power of thinking a series of occurrences, the distinct sense of time, a fuller development of that idea of space which springs from the sense of a series of muscular movements, the thought of action or fact as part of a series, and therefore involving time; and as substance is the special thought corresponding to the action of the anterior lobe, so fact or occurrence in time would be the special thought corresponding to that of the middle lobe, combining into a unity

the series comprehended within the time of occurrence, and inhering in a subject which is thought by means of the anterior lobe and sensorium. As the cerebrum grew in the development of the vertebrate series and thought was subdivided, the relations and the comparative attributes of facts and actions would be thought, and new emotions, desires and aversions would be formed in connection with them. Particular powers of combining them and comparing them, and thinking them with an emotional sense of them, might possibly be located in different parts of that region of the cerebrum which consists of the anterior and the middle lobe, and it would be the seat of all moral judgments on action which are formed by association with facts. To that region would belong whatever is expressed in language by the verb, including its infinitive, gerund and participles; and it is some confirmation of this view, that, among the strange effects of cerebral disease producing Aphasia or loss of correct speech, it is found that sometimes the nouns are lost while the use of verbs is unimpaired, and sometimes the contrary; as if the verb belonged to a different part of the brain from the noun. With muscular action the middle lobe would have indirect connection through the anterior, and in consequence of its immediate union with the anterior it might conceivably acquire direct connections of its own.

Now if such be indeed the course of development, each lobe carries forward by one step the power of directing action to the attainment of its object. Through the anterior lobe the mind combines with the ideas of things the sense of desirable impressions as qualities inhering in them, so as to think things as desirable ends of action; and through the middle lobe it combines with the end of action steps in the process of attainment so as to think these as means leading to it. But another power is needed for the secure guidance of action towards attainment. A desirable quality may be erroneously attributed to an object which does not possess it. Means may be thought as leading to an end which they have no real tendency to secure. In order that action may be directed rightly a further development of intelligence is needed. Not only must there be the *thought* of ends and of means, but the *knowledge* of ends and of means—the power of judging by past experience whether the object really

has the quality, and whether the means are really conducive to the end. There may arise from association with the past experience of similar cases a suggestion of the quality, as belonging to the present object, or of the means as conducive to the present end; and this suggestion will be more or less strong according to the frequency and uniformity and interest of the past experience. But the strength or weakness of the suggestion is not sufficient guide to the reality or unreality of that which is suggested. The idea of it may be weak because the experience of it was scanty though quite uniform. And the idea of it may be strong because the experience of it was accompanied by special interest, though there were many cases in which it was not realised. What is needed is a sense of the degree of uniformity of occurrence in cases similar to the present, and the extension of that degree of uniformity to the present case; in other words, a power of thinking the degree of uniformity of past experience in combination with the present case, so as to impart to the present case a belief in the presence of the element proportioned to that uniformity. This should be the next development; and accordingly the posterior lobe should act along with the middle and anterior lobes in such a way, that when by the associations which they form the thought of a fact or thing awakens the thoughts of other like facts or things, then the posterior lobe shall receive the impressions of those other ideas, so as to strengthen the sense of an additional element in which they agree, and strengthening that element in proportion to the uniformity of the agreement, to combine it in a corresponding strength of apprehended fact with the object which is before the mind. This would be in a more or less rudimentary form, according to the degree of development, the power of thinking a fact as a case of a principle. It is the physiological expression of the first obscure beginning of syllogistic reasoning. To the posterior lobe thus acting with the middle and anterior lobes would belong, according to this view, reasoning and principle and all the tendency to generalise in the sphere of fact and in the sphere of morality. As the cerebrum grew in the course of vertebrate development and thought was subdivided the relations and comparative attributes of general principles would be thought, and possibly

special powers of dealing with general principles and seeing emotional aspects of them might be localised in the cerebrum. The associations of action with reward and punishment, approval and disapproval, already formed by the instrumentality of the middle and anterior lobes, would be generalised by that of the developed cerebrum into universal principles of morality inherent in the nature of things, and the constraining influence which such associations exert on conduct would be elevated into natural obligation. And in the unity of all perfect law referred to its source and author the human mind would at length attain to its highest idea of God.

Thus the hypothesis with regard to the functions of the three lobes of the cerebrum which is suggested by the natural order of development as determined by the great requirements of life, is that which the closest analysis of the degrees of intelligence in vertebrate animals seems also to indicate. So that though each class of facts is so intricate and obscure, as scarcely to afford a solid footing for investigation, yet their agreement may perhaps be considered to give a degree of positive probability to the general views here given of the mechanism of thought in the brain. And if it be objected that considerable portions of the cerebrum may be removed without any apparent mutilation of the powers of thought, shewing that no part of the cerebrum is specially connected with any act of the mind, it is to be observed that the acts of the mind become by association so connected with each other, that in each thought there are many associated elements, and the corresponding seat of cerebral activity would be not in one but in many localities throughout the brain. Even if some of these were removed, the action of the others would still by association elicit and be elicited by the accustomed impressions of the sensorium and stimulation of the centres of muscular action.