to-day the knife still bears the double character. Soon the artificial organs, in this form as weapons, began to play a part in men's mutual fight. In this way, world history became a history of wars; endless streams of blood have accompanied mankind's evolution. This was the first "progress" of man compared with the animal. Whereas with nearly all species of animal the struggle for life amongst their kind is no more than a competition as to which will survive in their opposition to the hostile forces of the surrounding world, with man this match has become a real fight, increasing to a battle of annihilation against his fellow man. Direct extermination of his kind as a mass form of the struggle for life only occurs with man. This is also a result of the use of tools, because provided with different, better weapons, he may count as a different species with superior organs. It means that in the evolution of mankind an even fiercer form of selection has been active than in the animal kingdom.

III THINKING

9. With the lower animals phenomena and behaviour are observed which imply feeling and sensitiveness with regard to the influence of environment. Considering the higher animals we conclude from their actions that they have a certain consciousness, as they display behaviour which we consider to be the result of deliberation and a certain intellectual faculty. However in man alone occurs that form of intelligence which we call abstract thinking, thinking by means of conceptions.

What use is thinking? "The nature of reason is to regard "things not as simply existing but as necessary", Spinoza wrote in his thesis 44 of the second part of his Ethics. "Thinking is "conscious comparison of acquired perceptions, collecting what "is similar into conceptions", thus Helmholtz (p. 341). In his booklet "*How we think*", a manual on pedagogics explaining how to teach children to think in the right way, Dewey says: "Reflection involves.... a consecutive ordering (of ideas) in "such a way that each determines the next as its proper outcome" (p. 2) "Thinking.... is defined as that operation in which present "facts suggest other facts (or truths) in such a way as to induce "belief in the latter upon the ground or warrant of the former"

(p. 8). "Demand for the solution of a perplexity is the steadying "and guiding factor in the entire process of reflection" (p. 11). Here is spoken of the kind of thinking which is concerned with facts of the past and future, and which orientates itself in the world by means of the regularity of phenomena. Such thinking acts as an organ of science and philosophy, its immediate aim being to find the truth about the world. This, however, is already a more developed stage of thinking which, although playing an important part in later centuries, particularly with the "thinkers", theorists and scientists, was preceded by the simple thinking of primitive man. Even now for the great majority of men, and even for all of them for much of their life, thinking has an immediate, practical purpose. It does not put or answer the question: "What is truth?" but the question: "What am I to do?" "Perplexity" is too strong a word for the state of mind produced by these daily recurrent problems. Besides much automatic habitual action there is a constant reflection and consideration; it does not involve abstruse problems or seek for "truth", but is a comparison of various possibilities of action from which a choice has to be made. This work of thinking forms a constant essential part of the total effort of keeping alive.

If one wishes to compare human and animal intelligence, in order to learn to understand their interconnection and continuity, one should not take, as the human example, the most recent and highest forms of development, involving the theoretical thought of scholarship and philosophy, but rather the simplest practical thought of the common man of today, and of primitive man. This latter does exhibit the sundry characteristics of abstract thought, though as yet confined to the immediate problems of existence [1]). Here lies the problem of anthropogenesis; further

[1]) This is a principle of methodology which also applies to other fields of science where interconnexion is sought, notwithstanding fundamental differences or even contrasts of character. Thus it is with regard to the problem of unity and connexion between life and non-life or between consciousness and the unconscious life of the lower organisms. Should one in this case — as is often done — place in juxtaposition the most extreme stages of development and oppose the highest form of human thinking to the automatic reactions of infusoria, or a higher animal to the simple atomic structure of a mineral crystal, this would only lead to a state of perplexed dismay in which the cleft would be seen as unfathomable, as an

development of the initial human mental activity to the modern level then becomes a series of gradual steps which do not offer any fundamental difficulties.

10. With man as with the animal, mental life starts from the sensation as the most simple element, the sensation being either corporeal, as with hunger and pain, or environmental, as with smell, sight, or hearing. These sensations are the stimuli to which the organism reacts by actions in a manner appropriate to life. The sensations combine into images: one sees an object, such as a fruit, or moving animal, or he hears something. In such an image a great number of successive impressions of colour and light, changing according to the examining movement of head and eyes, or a number of separate sounds rising in succession out of the surrounding noise, have been combined. This is possible because every impression, which does not truly exist but for one indivisible moment, does not disappear with it but continues to exist and fades only gradually. What is called, therefore, an image, an observation, or experience, is already an entire combination of many various impressions covering a certain period.

When ever a combination of the same kind is repeated the earlier impressions are evoked as memories. Memory is the connecting together of earlier and later impressions, a relation tying past with present experience. When certain parts of a complex repeat themselves (*e.g.* a sensation of hunger, or impressions of the environment) the other parts of the image, which earlier were connected with it, are called up — in accordance with the principle of connection-reflexes [1]) — so that they are completed and form the entire complex (*e.g.* food). It then effects the same appropriate reactions of movement, a

unbridgeable contrast, as an absolute difference of quality, where it is hopeless to search for scientific explanations. The way of science which looks for unity of the world, trying to find connexion and continuity, consists of the juxtaposition of different kinds of phenomena where they approach each other most nearly; in this case placing the dubious traces of life in virus matter with the chemistry of the highly complicated protein molecules. Here only there is a possibility of building a bridge by scientific research, or of establishing a connexion between life and non-life.

[1]) Pavlov uses this name as an alternative to "conditioned reflexes" (p. 25).

certain behaviour, the search for, or the taking of food. The increasingly definite stimulation of such behaviour by preceding sensations is of the greatest importance in the struggle for life, and is succinctly called "learning by experience".

From similar observations often repeated and analogous experience complexes, the image created by memory rises up again and again. Such images are not exact reproductions; they are more vague than the observations and experiences themselves. They are a kind of average in which that which is common has remained and the differences have been wiped out. In the struggle for life, what is of importance is not that which happened only once but that which may be expected normally, *i.e.* the recurrent common element in occurrences. This is, therefore, what is grasped by the imagination, what remains in the perception, and what determines expectation.

These perceptions which render present what has been in the past, form consciousness. Consciousness is conscious being [1]), knowledge of being, the most immediate and surest fact of experience. It is said that as to our fellow men we conclude from their actions that with them the same kind of consciousness exists as we experience ourselves. In reality the consciousness of our fellow-men and our own are equally a matter of direct, instinctive certainty to us, a basic fact, already present before we arrive at such conclusions, and is entirely independent of them. With the higher animals we similarly conclude consciousness from their appropriate actions and, even more so, from their active attention towards what approaches them as sensations; but here there is only partial similarity. We lack, of course, a clear idea of their perceptions and their consciousness, since we only know our own and have to take this as a model for others. We try to approach it by assuming that their consciousness is inferior in comprehension as well as in clarity, by comparing it with a state of passive dimness of mind in man which remains as a background when clear-cut conscious thought is lacking. It has been remarked that, if we do not know anything about the consciousness of animals with certainty, it is of no consequence as it is only their reactions and behaviour which are of impor-

[1]) In German: *Bewusstsein = bewusstes Sein.*

tance as the only observable psychical phenomena; an accompanying "consciousness" in this connection is juist as irrelevant as the light by which we learn the time from the clock is irrelevant to the time-piece. This may be true, but it omits that "consciousness" here is the name of a conception within which a great complex of acts of behaviour are appropriately combined. The same, moreover, would apply equally to man, in whom consciousness as a psychic phenomenon is certainly present.

11. What difference there is between man and animal must appear in the visible psychic penomena. With the higher animals we observe that the sensations are immediately connected with the actions and provoke them. The images of observation which blend with the memory of former sensations into a whole of perception, are connected directly with the practical reactions, forming a consecutive chain. Such a chain may be: sensation of hunger, scent and sight of plants, grazing, satiety; or in a more complex form with beasts of prey: scent or sight of prey, following of tracks, stalking, watching, attacking. That is how they maintain themselves in their natural habitat. The observations and perceptions form the introduction to the appropriate action and find their conclusion in it. With man, however, a separation takes place; the chain is broken. Perception and action are no longer consecutive, mutually supplementary parts of a developing complex but are apparently independent. Impressions, observations, and images influence him, but no action or reaction follows. Perceptions are formed but remain unused; they are laid up with the store already available; and new ones are repeatedly added and increase it. The actions of man are not immediate reactions to his last impressions; they appear to be autonomous creations, spontaneously produced at any moment from the total store of available perceptions.

This difference has further consequences. When — in animals — observation and perception find their conclusion in the action, their aim has been achieved, and they may disappear into the depths, as material only for a later memory. If — with man — no action follows, the perceptions, unused, are left to themselves. The vision of a fruit is not conducive to the picking of it; but the chain of perceptions of picking, eating, satiety is still formed.

The series continues to the end, but this end remains so to speak floating in the air without anything on which to fix. In the series of consecutive perceptions each preceding one evokes the succeeding one, but in the opposite direction each succeeding one evokes its predecessor. The series rebounds, one might say, from its freely floating end and may be run through several times. These series themselves become sensations and objects of observation. It is here that what is called thinking, takes place in a higher degree — indeed it is called re-flection — than in the simple presence of perceptions [1]). Here perceptions of perceptions appear, which denote a higher degree of consciousness, a knowledge of knowledge, self-consciousness. The perception, a product of preceding experience, becomes a perception of a future occurrence; as an unfinished perception it is a foreseeing of later action.

With man too, life is maintaining oneself as a part of the whole of nature by an interchange of matter and energy with that whole. With man too, action in the last resort is, roughly, determined by the sum-total of sensations, images, and perceptions; thought is an auxiliary to practical action. But there is no longer the simple direct way from the impression on the senses to the action; in its stead the stored-up perceptions form a network of diverging and converging ways, and from this store the inducement to later action is taken. Between sensation and action many links are inserted; various chains of linked-up perceptions form themselves spontaneously, each preceding one evoking the next one. In the process of conscious thinking they are connected into orderly series.

This means that from observation to action thought follows a detour. Linked up with the observation of the fruit are not the perception and the deed of actual eating and satiety, but other, more distantly connected perceptions, such as the change of seasons, a former shortage, the thought of planting and sowing, and the prospect of a future new harvest. Or again, with the detection of a bear or wolf, perceptions of other

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1) Pavlov mentions as Sechenov's, the Russian physiologist's, opinion: "Thoughts he regarded as reflexes in which the effector was inhibited" (Pavlov p. 5).

connected experiences link up, such as the fetching or preparing of a weapon, the lurking in wait, and the setting of a trap. The detour in thought corresponds to a detour of the action itself. Between the bodily need originally felt and the later deed of satisfying oneself, a series of actions inserts itself which only indirectly leads to the aim. They are preceded by a series of perceptions which consecutively indicate the way as an imagined whole before it is actually taken. In the later development of mankind these detours become wider and wider and more complicated as society becomes more complex.

Moreover, there is not one detour; there are many. According to the greater wealth of modes of life the action can take different ways. For this it is necessary that each series of possible actions exists beforehand as a series of perceptions; it is then possible to compare them and to make a choice. This weighing of the one against the other and this choosing of ways comes to the surface of consciousness as free will. Thought acquires the character of independent activity; the perceptions are not allowed any more to link up passively in producing each other; each one is called up and held attentively and deliberately fitted to the others, until the result of each consecutive action can be foreseen and the series has been carefully built up in all its links.

12. The process of thinking consists of the interconnexion of the perceptions. What at first was an automatic linking up is now a travelling up and down the series of connexions and as such a conscious process. Thoughts are not independent entities, not "*Wesenheiten*", but connexions and interrelations. They are not a being but a process of movement, of a continuous linking up and connecting. "Thinking is dynamical, thought is association" (Piéron, p. 28). Moreover, as we have already seen, the perceptions between which they form the relation, are not simple, static things either; each perception is an expansive structure of countless connexions between a number of dissimilar and non-simultaneous sensations. At the simplest thought, at the even simpler perception, *e.g.* of a fruit, consciousness darts rapidly over the most different remembered images of an earlier and a later date, visual impressions of colour and form, gustatory

impressions of appetite and satiety, experiences and desires, the one perception activating and provoking many others; it jumps from one image to another quite different one, each framed by and compared with others; it shoots through the whole world of the mind, hither and thither as the images flash up. Many pages would be needed to describe in detail what darts through the mind with one single thought.

Sensations come flowing into us in a continuous stream. By an automatic process acquired through learning and experience some of them are incorporated and organized into the existing store of images, so as to form an ever increasing wealth filling the consciousness. Others remain unnoticed, sinking away into subconsciousness, and heaping up in the dark depths, gradually smoothing out and amalgamating. They are always present as the basis of one's personal attitude towards life, determining his instinctive actions — until perhaps a new strong impression or a practical necessity suddenly calls them up, in the form of spontaneous deeds or intuitive judgments, into the daylight of consciousness, and they become conscious perceptions. In the process of thinking the perceptions are arranged, the related elements being assembled and fixed in concepts, and their relations and interconnexions laid down and expressed in rules.

The separation of perception and action brings about what we call autonomy of thought. From the mental stock of collected impressions and perceptions consecutive chains are built up, apparently spontaneously, starting from themselves, without external cause. They are, of course, not without cause; there always is some impulse or occasion which forms the beginning, but it may be so imperceptible that it is not recognized. All these chains of thoughts then form a personal spiritual life which is the source from which all conscious actions spring.

This separation is also the separation between theory and practice, theory becoming independent of practice. Theory is the independent weaving of chains of thoughts into conclusions applicable to practical actions. The observations are the material, and the theoretical rules form the result. The observations become proof and argument, consciously advanced, of the rule, — *e.g.* ever again after the cold of winter spring came with its growth of plants and animals. From that the rule was built up

as a summary and an expectation: the seasons follow each other in regular rotation. Observation and rule together form knowledge and science. The rules express what happens normally and what, therefore, may be expected, not being concerned with secondary and momentary occurrences but with their general being. They do not speak of the concrete fact, but of the abstract concept: winter is followed by spring. In any particular practical application, a given case is identified with the abstraction: after this winter another spring will come. By applying the rule to each separate case future action is determined.

13. In the abstract conception the general or common factor of a group of phenomena is expressed; the mind is the organ of the generality. "Through thinking things we make them into something general" (Hegel). The endless multiplicity of the phenomena we cannot retain; the mind selects what is permanent and common in it, holds on to it, and abstracts from what is peculiar and different. What is common and lasting is essential for life; it forms itself into a rule and is condensed into a conception. Each succeeding experience recognized as similar is inserted into this structure, or is arranged under the existing rule; by being acknowledged as a special case of the conception or rule already known, each is incorporated and classified, so that the well-known conclusions apply directly to it. Frequently, too, of course, cases of wrong application occur, when there is error by supposed but mistaken insertion, leading to an incorrect conclusion and inappropriate action, which in turn lead to a change in the conceptions, and to transformation and improvement of the rules, *i.e.* to the development of science.

The abstract character of thinking in conceptions which characterizes man lies not so much in their generality but chiefly in their independence. The former does, in a sense, hold for the animals too, but not the latter. As with man, so with animals images of memory or perceptions exist as the common factor of previous experience, and, similarly, not in the form of precise details of each case, but rather as a smoothed average. In the animal, however, the progression remains an unseparated whole from impression to action, and is not dissolved into its elements. In human thinking these elements acquire independence owing

to their being sharply determined as conceptions. As a conception the image is defined, separated from others, and maintained as an independent entity. Thus they are all separately manageable, and as separate links may be arranged, through short causal relations, into series of thoughts in various ways, until in forethought the most effective structure has been obtained.

The animal, too, in its behaviour often follows the indirect way. We speak of cunning with some beasts of prey; but here the detour, involving stealing, hiding, spying, has become a fixed habit, imprinted by the struggle for life. The animal also can make a certain choice, with regard to the moment and the place of attack. But this choice is limited within narrow margins owing to the limitation of the bodily organs, which impose certain habits of life. These special characteristics of human mental life are, therefore, also present in small traces in the animal. Man, again, has not got them in an unlimited degree, and he too is tied in his choice to the technical possibilities. These, however, owing to their continual development, create more and more varied forms of living, with the fulfilment of ever wider possibilities of life, which render possible an ever richer multiplicity of causal relations. Thus the spiritual world of conceptions grows. In the abstract conception as a substantial mental element lies the most special characteristic which distinguishes human thinking from that of the animal.

IV. BRAINS

14. Among the special characteristics distinguishing man from the animal the brains have not been mentioned. This may seem strange as man's superiority above the animal has to be attributed to his brain. The brains are the organ of the intellect, of the mind, and it is this which as the real basis, as the final factor determines man as the crown of creation, and master of the earth. The apparent contradiction is due to the fact that the difference between the brains of the higher animals and those of man appears as a quantitative one only, and that we cannot indicate a manifest qualitative difference.

The quantitative difference consists in the much higher weight

of the human brain (at an average of 1300—1400 grammes) as compared with that of the most highly developed animals, the anthropoids (400—500 grammes). Of course the mere weight of the brain cannot provide a sound criterion for the mental level, as this also depends on the bodysize. Dubois has shown that with closely related animals of different size the brain-weight changes in proportion to the 5/9th power of the body-weight, almost as the body-surface. By eliminating in this way the influence of the body-weight and by reducing all animals to the same body-weight, a factor known as the degree of "cephalization" remains, which can serve as a measure for the level of development of the brains. Thus Dubois found that, when comparing different animal species, the degree of cephalization for related species always differs by the factor 2. He could explain it by assuming that with the development of a lower animal into a higher a mutation takes place in which all braincells split in two, and thus double their number. Reduced to a body-weight of 100 kilogrammes the brain-weight for anthropoids would be 450, whilst that for man would be 1650, which is nearly four times as much.

It has been possible subsequently to show from a greater mass of data (R. Brummelkamp, Brainweight and Bodysize) that the real rate of increase is not 2 but $\sqrt{2}$, so that two small leaps take the place of Dubois' one leap. In order to explain this a more complicated sequence of processes has to be assumed. Generally speaking, what has been observed of the mental life of animals agrees rather well with the cephalization found, so that the further one descends in the orders of the mammals, the lower the cephalization (lungoor 306, lemur 183, wolf and fox 240, cat and lion 200, panther 425, bear 320, elephant 730, horse and ass 270, hippopotamus 120, hare and rabbit 110, mouse and rat 50, mole 47, anteater 170, armadillo 53, all these figures representing grammes reduced to a bodyweight of 100 kilogrammes). But there are also strange values amongst them: seal 630, sealion 870, dolphin 1070, which would place such animals well above the anthropoids — a thing one would not, notwithstanding their cunning, deduce from their behaviour. Although no satisfactory explanation of this has as yet been given, we may yet say that the cephalization theory for the

first time allows us to express in precise figures the superiority of the human brains as compared with those of the animals.

15. The structure of the brain, of course, is likely to show this too. In very low classes of animals, nervecells are already present, and these, owing to their remarkable length, serve to conduct the stimuli quickly from the one part of the body to the other, where the appropriate movement of reaction has to be carried out. With higher classes of animals centres are formed to which the stimuli received by the various sensory nerves are carried and where they are collected so that the movement necessitated by the collective result is despatched thence to the organs of movement by the motor nerves. With the vertebrates the brain forms the central organ serving this purpose. Here on top of the older, primitive systems new ones have been built so that a structure has come into being, so to speak, in storeys, (*une organisation à étages*, Piéron, p. 8). "The nerve centers of "the brain, spinal chord, and sympathetic ganglia scattered "throughout the body are arranged in 'levels' or hierarchies, each "higher level controlling those below it" (Judson Herrick, 24, p. 119). The lowest stage with the mammals and, therefore, with man too, is formed by the autonomous nervous system, a delicate network permeating all the internal organs, blood vessels, muscles, tissues and glands, controlling and regulating their activity, without any of it coming to the surface of consciousness. Through the nerve-bundles of the spinal cord it is connected to the brains, the central organ which keeps all life processes balanced in harmonious co-operation, receiving all outside stimuli from the senses, and setting the muscles in motion. Their oldest part, the oblongata and thalamus (brainstem), the cerebellum and olfactory centre, whilst forming the chief mass in the lowest vertebrates, the fishes and amphibians, comprise with the mammals less than half. This story is considered firstly to be the seat of the simplest sensations, such as pleasure and grief, pain and emotion, and secondly to perform the delicate regulation, the keeping in good order of the bodly functions, and the balancing in every movement, all usually being outside consciousness.

Superior to these are the new brains which cover the former,

like a mantle (pallium). These are barely existent with fishes, and are small with reptiles, becoming increasingly developed in the series of mammals, and with man forming the main part of the brains. They consist of a white nucleus surrounded by a gray cortex. With man this cortex consists of a grey layer of intertwined single nerve cells, which has an average thickness of 4 mm (0.16 in) with a total surface of about 1100 cm² (169 sq. in) and is folded up in a great many folds in the small space within the skull (internal surface about 700 cm² or 110 sq. in) like a piece of paper crumpled up in one's fist. The thickness of the cortex in the series of mammals is not systematically different and the surface increases equally with the cephalization. So with man it is four times as large as with an anthropoid of the same size; the external surface shows a much greater number of folds and much deeper ones, so that the external appearance gives the impression of a more complicated and, hence, higher organization. Within lies the white brain mass, the marrow-coverings of countless nerve fibres, which are thus separated from each other like insulated wires, and which connect the various parts of the cortex with each other and with the lower centres, the thalamus and the cerebellum. The cortex is the supreme organ which in the last resort dominates all the lower ones; here, via the lower centres, the stimuli of the senses converge, and are combined and integrated — as far as the lower centres have not already been able sufficiently to cope with them — and the result is conducted through the motor nerves to the organs of motion. The cortex is the organ of the deliberate body movements, that is to say, of conscious acting. These processes in the cortex are mostly accompanied by consciousness; they form the material background of mental life.

The structure in storeys appears to be the result of an evolutionary process in the animal world. The primitive mechanisms at higher stages of development have not been substituted by better ones; they remain in use, but on the top of them the more complicated mechanisms are formed as higher resorts, dealing with the more complicated cases of a richer life, which are beyond the control of the original ones. While the external influences reach the cortex via the lower centres and the motor impulses travel via the same paths in the opposite direction, the

central regulation of all actions in life rests on a co-operation in which the cortex chooses and decides on the execution or arresting of any action. "The thalamus supplies the emotional "coloring, the agreeable or disagreeable quality, and the simple "impulsive drives; the cortex supplies the intelligent guidance "and rational control" (Judson Herrick, 24, p. 118).

The cortex consists of a dense network of about 9000 million nerve-cells (neurons). From each nerve-cell emerge firstly a number of nerve-threads (dendrites), which at their ends branch out like trees and receive and conduct the stimuli, and secondly a single, sometimes very long, efferent nerve-thread (neurite or axon), similarly split up at the end into fine branches, which abduces the stimuli and nestles against another cell (nerve-dendrite, muscle- or organ-cell). Thus external stimuli (*e.g.* light falling on a nerve end in the retina, or touch affecting a nerve in the finger-tip) are conveyed to the successive nerve cells which collect them, combine and conduct their action, until via more or fewer intermediate stations they reach the cortex. The same obtains conversely, from the cerebral cortex to the muscles. Originally, there was within the cortex a layer of small nerve-cells (so-called granular cells) below an outer layer of nerve-fibres coming from elsewhere. These granular, or sensorial, cells receive the stimulus and pass it on via short axons to the next layer. This deeper layer of the cortex consists of larger nerve-cells (so-called pyramid cells), the motor cells conveying the motor-stimulus via axons, often very long, to the more deeply situated centres, and in this manner to the muscles. When fully developed, in human brains, there are usually two, and sometimes more of these alternative layers; instead of these simple up and down connections they form an innumerable mass of cross-connections linking together all parts of the cortex. The number of possible connections between 9000 million cells is so immensely large and totally beyond the powers of our imagination, that it can be regarded as being practically infinite. A single two by two connection already results in trillions of possibilities. Thus the total amount of possible connections can offer an adequate directive mechanism for the most complicated relations of life and a sufficient material basis for the most abundant and varied spiritual life. "The known complexity of

"the brain, and especially of the cerebral cortex, is adequate "for any theoretic explanation of cerebral function whatsoever. "There is no dearth of mechanism". (Judson Herrick, 23, p. 21).

16. The investigation of the whole structure of connections, and the laborious determining of the functions of each of the parts, in their relation to sensations, conciousness and thought, the subject of neurology, is the discovery and disclosure of a new and wellnigh unlimited world. Thereby it appeared that certain areas of the cerebral cortex performed specific functions. The impressions of light on the eyes are conducted by the optic nerves to the optic thalamus, and thence to the occipital lobes of the cortex, the organ of visual perception. The lobes lying against the left and right temples constitute the organ of hearing. Above them, in the side lobes between forehead and occiput, are the centres for the stimuli emanating from the whole body, the skin and muscles, for general bodily sensation; separate detailed sensory areas for the separate limbs, situated side by side can be distinguished here. In front of these and against the frontal lobes the motor centres are situated; these consist of large pyramid cells of which the stimuli control the motion of the various parts of the body.

Now and again one encounters the opinion, and especially in popular writings, that the specification goes still deeper, down to cell-groups and separate cells, and that these are the carriers of images, perceptions and conceptions.. Thus Rohracher (p. 60) states that "there seem to be special memory cells", and he speaks of a "reading centre" (p. 66) in which in the case of civilised persons the letters are fixed. However, he is not quite certain as to the consequences: are there cells particularly intended for combinations of conceptions, such as the quantum theory or housekeeping-money? Larger parts than simple cell-groups may be had in view by W. Hanna Thomson where he writes: ".... in a small patch of gray matter not larger than a "hazel nut .... is stored every word that can be spoken" (p. 94), and further on: "We think in words, and for that purpose "we register our word memories in their laboriously prepared "brain places" (p. 190). In another sentence, however, he compares "those speech areas to the shelves of a library with

"words arranged thereon like so many volumes" (p. 96). Conversely, Piéron states that "it is a childish idea to imagine that "the nerves constitute a warehouse in which little pictures, "photographic images of events which have effected the "sensation, can be stored" (l.c. p. 241). In actual fact the brain cells in the various cortex-areas are identical, composed of the same protoplasmic structure with similar nuclei. Their different functions are determined by their different connections. Mental processes are not distinguished in being borne by particular cells, but in having particular connections. In the same way that ideas are not entities but relations, the material substratum of thought is not the biological and chemical contents of the brain cells, but the structure of their relations, *i.e.* their connections. One may draw the analogy of a railway traffic apparatus the essence of which does not consist of the structure of wellnigh similar stations, but of the structure of the network of rail connections, and can be recognized by it. There are no special cells or groups of cells in the occipital lobe, in which the correlate of certain letters has been fixed. The visual image of one single letter stimulates many hundreds of thousands of the more than a hundred million cones and rods of the retina. Each of these undergoes changes of light, darkness, and colour during the rapid and involuntary movements of the eyeball and the head, and cause an unlimited whole of nerve-cells and nerve-fibres of the inward and outward tracks to come into action. The correlation of all these processes, determined by the structure of the connections, is projected outwards as the visual image recognised as such.

17. The conveying of the stimulus from one nerve-cell to another takes place in such a way that these cells are charged, as it were, or are under tension, and then are discharged, the tension being released, by the stimulus at the sensitive surface, whereby the potential energy (obtained from the chemical energy of food) is released and becomes available for conveying the message to the next nerve cell. Thus the nervous emotion progresses as a current. "The signal is a brief local depolarization "of the electrically polarized surface-layer of the nerve-thread, "and the signal involves freeing of energy and development of

"a temporary electrical leak which will travel along the fibre "or over the nerve net. By repolarization in the wake of the "signal the transmitting surface is repaired and made ready for "a second signal.... These junctional points are often con- "vergence points for several lines from several directions. Arrived "there signals convergent from several lines may coalesce and "may reinforce each other's exciting power. At such points too "appears a process which, instead of exciting, quells and "precludes excitation. This inhibition, like its opposite process, "excitation, does not travel. It is evoked, however, by travelling "signals not distinguishable from those which call forth ex- "citement.... These two opposed processes, excitation and "inhibition, co-operate at nodal point after nodal point in the "nerve circuits. Their joint operation at any moment settles "what will be the conduction pattern, and so the motor outcome, "of the signalling going forward in the brain." (Sherrington, p. 11—13).

The transmission of the nervous current often works as a relay, whereby a very feeble electric current opens the track for a stronger current. Each consecutive step in the connected track increases the available energy. Therefore the cerebral cortex does not only act as a switchboard with millions of fuses, but also as an amplifying apparatus through which almost imperceptible energy impulses coming from outside or from within the body are increased to great effects. "The whole "cortical apparatus is wound up and set on a trigger so that "its latent reserves of motor power and memory patterns may "be released by the slightest impulse set in motion by some "external event or some change in the interior of the body." (Judson Herrick, 24, p. 122). Herrick quotes the example of a man on a ship. When this man sees a faint spot of light in the distance (effecting perhaps only a millionth of an erg on to the retina) the whole of his brain apparatus comes into action and thereby the muscle apparatus of his body is set in efficient motion. This can even cause the great engines of the ship to function.

During each small fraction of a second the loading and unloading continually flashes through the innumerable nerve fibres, and the currents from the nervous reactions pass through

the conduction tracks, now halted, then amplified, flowing together or spreading out. It has previously been pointed out that the extent of the simplest thought would require many pages to be described. It can be added now that each line of this description signifies an immense quantity of brain processes and of specifically determined stimuli currents flowing via tracks consisting of millions of neurons. So the connection of mental life and brains surely cannot be described by way of these processes, but should be sought in the correlation between the structure of perceptions, conceptions and ideas, and the structure of the network of the nerve connections. Consciousness itself of course cannot be deduced from the structure and the processes of the brains.

The brains however do more. The impressions and the stimuli are not only transmitted and amplified, but are also collected and stored. The brains are the archives of the entire life-history of the individual, fixing all past experiences in structural formations. "This organ is a marvellous registration apparatus. Often a single "stimulus is sufficient to produce a lasting impression" (G. Bohn, p. 328). Surely man must manage with the nine milliard neurons with which he was born, as no new neurons are ever added. Those which he has, however, develop in a greater or lesser degree throughout his life. "The extension, the growth and the "multiplication of the appendices of the neurons, for that matter, "do not stop at birth, but continue after birth.... Excercise no "doubt is not foreign to these modifications, which probably "with cultured man are more marked in certain spheres. The "absence of exercise, on the contrary, must bring about, during "the period of growth and even at an adult age, in the inactive "spheres of an educated person as well as in the brain of "uneducated man these phenomena of resorption.... which here "betray themselves by forgetfulness." (Ramon y Cajal, p. 188). Certain connections developed in correlation with habits of life; in consequence of a more intensive use a larger quantity of branchings and a greater wealth of connections correspond to a greater plasticity in behaviour. "The newly created cellular "expansions do not proceed by chance; they must orientate "themselves according to the dominating nerve currents, or "again in the direction of the intercellular association, which

"is the object of the reiterated requests of the will" (ib. p. 189). The nerve-cells themselves also migrate in the direction towards the stimuli entering them (Ariëns Kappers, on neurobiotaxis, passim). Although not all the details are known of the mechanism causing new connections to be made and existing ones to be facilitated or strengthened, it is a fact that it does take place. This then is the basis for learning, for the constant acquiring of fresh knowledge, and also for the spontaneous memory processes, for the later reproduction of the images, and for the formation of conceptions. Since the brains are a plastic organ in which the billions of possible connections and intertwinings of nerve fibres are selected, effected, established and determined by the influences of life, all experiences gained in life can be fixed therein, and thus conduct further on the reactions and determine behaviour. The higher degree of cephalization of the higher mammals, compared with that of the lower ones, signifies a greater wealth of intercortical connections, and therefore more possibilities of reacting differently with regard to the more complicated conditions of life, as well as a greater capacity for learning, in short a greater intelligence.

18. Similarly the cerebral cortex functions with man. Here, however, when compared with the most highly developed animals, a qualitative difference of consciousness becomes apparent, in the form of the autonomy of abstract reasoning, which as the supreme instance controls the mental processes, and thereby the bodily actions. Is there also an organ in the brains corresponding to it, controlling the working of the rest of the cortex in the same manner?

From the earliest times it has been assumed, that the seat of human intelligence was in the forehead. A high forehead was taken to be a sign of a high spiritual level; the more sloping forehead of the lower and less intelligent races was accepted as an indication of an inferior development of the frontal brains, and the difference is still more pronounced in apes. This opinion is expressed in a more scientific form by leading neurologists. Thus Bianchi states: "I hold that abstract thought must of "necessity require particular organs and those I find in the "frontal brain." (p. 70). And further on: "The associative paths

"that unite the sensory cortex with the frontal lobes have a "twofold office: first, that of informing the higher consciousness "of the modifications of the kinaesthesis and of all the new "percepts acquired by the personality by means of the sensory "centres; second, that of permitting the higher consciousness to "select and recall those images registered in the sensory cortex "that, in the vicissitudes of mental and physical life, are reputed "necessary for the purposes of the struggle for existence and for "higher reasoning...." (p. 208). Likewise Tilney says: "The "frontal lobe.... is now credited with such functions as those "connected with the regulation of the higher faculties of the "mind, the development of personality, the formation of all the "associational memories which.... bespeak the degree of intel-"lectual development." (p. 789). Correspondingly, from ape-like and from primitive to later man this part of the brains has developed most of all. "Traced through all their intermediate "steps upward it is exactly these pre-frontal and frontal regions "which manifest the most conspicuous development." (ib. p. 935).

It is a curious thing, however, that the contention which regards the frontal brains as being the special organ of human intelligence, has not been explicitly supported by neurological research. In cases of disease, when certain other parts of the cortex were destroyed, the capacities of intelligence were lost. The removal of the frontal lobe of apes, on the other hand, produced no change in the effective connection of all actions; what did disappear was the active attentiveness, the careful investigating curiosity, the cunning shining of the eyes, and the control of impulses. Thus Bianchi, on account of these experiments, indicated the frontal lobes as the organ of attention. Goltz had previously stated that intelligence had no more to do with the frontal lobe than is contained in its association with other parts of the brain. Munk put it in this way that intelligence has its seat everywhere in the cerebral cortex and not in any particular part (cf. Bianchi, p. 74—77). Flechsig also held this opinion. He describes how there are certain cortex areas between and besides those for sight, hearing, and general sensations of the body, and that nerve-threads coming from all the surrounding areas meet here, intertwine, and in this manner interconnect those areas. "There are.... extended areas of the

"cortex whose purpose is essentially to associate the state of "excitation of the different sensorial spheres" (p. 60). And on the same subject Judson Herrick says: "The enormous increase "in the size of the human cortex is chiefly in the association "fields. Here, then, is to be sought the structural organization "upon which depend human culture and the progress of civili-"zation. The feature which most distinguishes these associational "fields from the rest of the cortex is their greater wealth of "strictly intercortical associational connections." (23, p. 265). Hence, he continues, the much larger wealth of structures in which previous forms of reaction are fixed and are at hand for assimilation into ever new combinations: which is capacity for learning. Hence, further the greater dynamic effect of the stored tension in the neurons, which is now placed under a deliberate control of spontaneous thought.

Flechsig considers the function of the large association centre situated behind the side lobes to be "the forming and collecting "of perceptions of exterior objects and of sound images, the "connecting of the one with the other, hence the actual positive "knowledge, and not less the fantastic activity of imagination..... "briefly the essential contents of what language denotes as "intelligence ("*Geist*") (l.c. p. 62). Regarding the frontal lobes themselves, he says: "It seems to be a fact that positive know-"ledge does not suffer directly when the frontal lobe is "destroyed — what does suffer is the adequate use of it, in that "eventually a complete lack of interest.... asserts itself" (ib. p. 63).

The growth of the frontal brains from the lower mammals to the apes corresponds to an increasingly active attentiveness in all their actions. This is most striking already now and again with dogs; but "in dogs the frontal lobe has not assumed control "of the mental life, which revolves mostly in the sensory cortex" (Bianchi, p. 80). In the case of apes who, just as man, through the concerted action of their eyes are enabled to see stereoscopically and thereby to distinguish position in space, this results in a much more constant control of actions. The development culminates in human thinking which is a process of uninterrupted intensive attention. "Consciousness is active "attentiveness over a passive course of perceptions" (Clay, p. 22).

It wellnigh follows, therefore, that the mental processes of linking together and ordering the series of perceptions in a designed sequence, of surveying them up- and downward and automatically commencing or terminating them, and organising them into conceptions, must link up with the processes of active attentiveness, and thus have their organ in the frontal brains. It should also be noted that what Flechsig calls positive knowledge, the combining of different sorts of sensations into images and perceptions, is not the essential and special property of the human mind. Such a body of facts is also possessed by higher animals, though they do not have it in our form of conscious knowing. One can call this "intelligence", but it must then be distinguished from "reason", the capacity of forming free and abstract conceptions, which as the organ of theory is characteristic of the human mind.

One might therefore expect that the human frontal brains would show a stronger development than the rest, when compared with the higher apes. Tilney actually asserts that the human frontal area amounts to 47 % of the entire side surface (83 out of 178 sq. cm.), whereas this is 33 % with the chimpanzee, and 32 % with the gorilla. "It is, therefore, in the expansion of "the frontal lobe, both in the area covered by it and the great "increase in the complexity of its convolutions, that the human "brain stands in striking contrast to the anthropoids" (l.c. p. 783—784). This, however, is contradicted by the accurate measurements of the surface of the cortex with all its windings and folds (by Brodman, by Leboucq, and by Brummelkamp). These measurements (cf. Brummelkamp, 7, p. 26) show that the proportion between the frontal part and the other parts is identical for anthropoids and for human beings, *viz* 1 : 2.5, according to the latter. Here "frontal" includes all that is situated in front of the "central fissure" and therefore also the motor area. Further there is still the uncertainty as to how much of the surface within a fold belongs to the one, and how much to the other part. If we assume this result to be correct, then the strong growth of the frontal brains relative to the rest did not accompany the genesis of man, but that of apes or anthropoids from lower mammals. It follows too that the quadrupling of the cerebral cortex at the genesis of man to the

same extent holds good for both the association fields situated more to the rear, in which the combined images and perceptions form themselves and constitute the immense material of practical knowledge, and for the frontal organ where this material is grouped into a world of abstract conceptions, the world of theoretical knowledge.

There is something contradictory in that the qualitative leap in thinking from animal to man should have nothing which corresponds in the organ of thinking, the brains undergoing a merely quantitative enlargement. This then would have to be understood in such a way that the enlargement is to be regarded as a condition, but not as a sufficient or decisive cause for the qualitative leap; it did not necessarily bring with it the new character of human thinking. Besides the biological growth of the brains there must have been other causes through which specifically human thought came into existence.

V. SPEECH

19. Speech is one of the most essential characteristics of man, distinguishing him most strikingly from the animals. This is so true that it is sometimes regarded as the only determining characteristic, in that by definition man starts with the coming of speech.

Speech consists of active production and passive understanding of sounds for mutual communication and understanding. Such sounds, however, also exist in animal communities, with their effects on their fellows. Most of the higher animals are capable of producing throat sounds as expressions of their emotions. These also exist with solitary living animals, and are normally related to their sexual emotions or they may be a means of terrifying a prey. With gregarious animals these sounds likewise are expressions of emotions, of fear in case of danger, of anger, or of contentment. Since the other members of a group react by nature to such sounds, they acquire the character of warning or assurance and become a means of understanding and co-operation which is valuable in their struggle for life.

If sometimes such sounds, in their highest state of development, are called animal language, this term certainly is

improperly used, as the comparison is very remote. Human speech differs from animal sounds in that it consists of words. Words are names for things, actions or properties. Words are sound-symbols, sounds serving as a symbol for something else, and signifying something else. Language is an organised system of conventional sounds, serving as symbols for realities. "Language is a purely human and non-instinctive method of "communicating ideas, emotions and desires by means of a "system of voluntarily produced symbols.... the essence of "language consists in the assigning of conventional, voluntarily "articulated sounds.... to the diverse elements of experience." (Sapir, p. 6 sqq). The similarity of animal sound and human speech as an instrument of communication and mutual intercourse makes it conceivable that the one has developed from the other through a natural process. However, the not only great, but essential difference, and the not merely quantitative but qualitative distinction makes it that human speech must be an entirely new creation. As such an explanation will have to be sought, as part of the entire problem of the origin of man.

The characteristic element in language as a complex of symbols is the arbitrariness. There is no clear connection between the object or phenomenon and its name — apart from occasional examples of onomatopoeia, such as cuckoo. The sound "horse" designates a certain type of animal, but it only has this meaning for those speaking the same language. For that reason language is not innate, but has to be learned by means of imitating. Only the disposition, the ability and the organ of speech are inborn. It is precisely this necessity for learning, for being initiated in the complex of symbols, that demonstrates the artificiality of language. The same thing, for example the same species of animal, will be designated by different peoples by entirely different words: horse, cheval, pferd, equus, hippos, loshadj, kooda.

This does not mean that they are arbitrary fancies. Language has developed and grown according to its own rules, which are an object of investigation in comparative linguistics. Language has been called a creation of the human mind. That does not mean, however, that its rules are products of intelligence and judgment. The curious origin of the German word "Pferd" from