FIG. 1. CHART OF COMPARATIVE INTELLIGENCE OF ANIMALS FROM MAN TO AMPHIBIANS

The Animal Mind

The Comparative Intelligence of Animals

By the late Dr. R. L. Garner

IT is difficult to find a common unit of measure by which to determine with precision the various horizons of the minds of different species of animals. Hitherto it has been chiefly a matter of guesswork, and most people let their fondness for a certain kind of animal bias their judgment. Upon surveying the whole range of animal intelligence, it is apparent that there are many levels, and by comparison it is possible to formulate a system by which they may be graded. The process of accomplishing this is by a study of the environments of a race, its physical development, its mode of life, and by interpreting the actions of its members and the motives which prompt them. In the animal kingdom as a whole there is a wide scope of intelligence, ranging from protozoa to man, in which certain obvious divisions must be made according to their disparity. Probably all minds are the same in quality and compass, and the degrees of difference constitute the problem to be solved.

At a glance it is evident that those forms of life which live under the most restricted conditions are the aquatic and amphibian forms. Shut in by the surrounding waters, aquatic animals have a poor medium through which to receive sense impressions. The element in which they live not only lessens their opportunities of experience, but likewise lessens their need for knowledge of their surroundings. These impressions are, therefore, comparatively few in number and dull in nature, and the resultant development of senses correspondingly less, which places aquatic forms far down the scale of comparative intelligence. For the same reasons amphibians are only a trifle higher in mental horizon.

The advantages of sense development through experience are chiefly with the terrestrial forms of life. Among these the most conspicuous divisions are between those of nocturnal and those of diurnal habits, of which the former suffer in much the same way as the aquatics in restriction of experience, although, obviously, to a much less extent. Diurnal animals, spending their waking hours as they do in the clear light of day, have the greatest opportunities for acquiring new and distinct impressions, and are logically those whose mental attainments stand the highest because of the advantages of frequent use and its consequent development. Aquatic and nocturnal animals receive a measure of protection from the media which restrict their perception of exterior things, and, therefore, have less need for alertness, skill and strategy as means of self-preservation. Many of them tend to develop but slug-

gish senses and often grow large bodies with comparatively small brains. The *carnivores*, the *pachyderms*, reptiles and lower forms, most of which lead isolated lives and therefore cultivate but little social intimacy with their kind, while their optics are more acute than those of diurnal animals, are yet far below them in the scale of intelligence. Their mental horizon in comparison to that of diurnal animals is as the distance and distinctness of their vision in the surrounding darkness to that of the diurnal animals in the light of day. The *ungulates*, or hooved animals, are of mixed habits and bear nearly the same relation between the nocturnal and diurnal animals that the amphibians do to aquatic and terrestrial forms. They are inclined, however, to live in herds, instead of family groups, and have only the rudiments of social life. They are strictly herbivorous. They are, perhaps, exposed to more danger from enemies than the carnivorous, but because they band together in greater numbers, their faculties of observation and alertness are less taxed, and their chances of survival upon being attacked are proportionately greater.

As the basis of comparison of animal intelligence, man as the highest type occupies the foreground of a perspective (see Fig. 1) of 100 units, the vanishing point of which is at zero, where protozoan life begins. Inasmuch as we find in man the most active and efficient faculties of mind, it is logical to assume that he possesses the means and qualities which promote the growth and development of all psychic activities. It also seems clear that *those animals which are most highly specialized and, therefore, most resemble man in their physical development likewise most nearly approach his mental horizon*. In the lines of investigation so far pursued, man obviously occupies the highest level, and it appears equally clear that other genera follow him in the same order and degree in their mental status and possess the greatest individual possibilities for advance beyond the normal stage of their kind, and in pursuing further the manifestations of these elusory forces, the validity of the foregoing premises become more and more evident.

According to these it would follow that the manlike apes possess higher mental powers than those of any other group of animals below man, and investigation amply substantiates this conclusion. Through twenty-five years of methodic study of animal life this fact has been borne in upon the writer by such force of evidence, that what was once a theory has long since become a conviction, and the same conclusion is being

reached by all scientists who have devoted sufficient time to the study of the subject with due respect to the weight and cogency of the evidence.

Of the ape group the highest level is occupied by the chimpanzee. This has been clearly demonstrated by the education of certain specimens of this genus. By means of such specimens, educated with laborious care to obtain the most reliable results—differentiating always between *education* and *training*—the writer has demonstrated that the chimpanzee mind is endowed with many powers formerly accorded to man alone. Among these, the perception of abstract values and their relation requires the highest form of mental capacity, and surely constitutes the crucial test of intelligence. Scientists had hitherto believed this power to be entirely above the range of any animal mentality. Yet a young chimpanzee learned to distinguish concrete geometrical forms and pick them out by word of command, in blocks of three dimensions, or upon a plane surface in relief or countersunk. The little ape learned by name and to distinguish between five different colors regardless of the forms they covered.

The crowning accomplishment which bore down all opposition was the ability to count any collection of small objects, such as beads, grapes, nuts, jackstones, or other things which she could handle easily. The chimpanzee did not guess at the numbers, but drew them from a pile, one by one, and counted them in any order up to four, obviously appreciating the numerical value of each number in exactly the same way as a human being does. This was accomplished in four months of teaching, beginning when the animal was one year old. During this period it was found that the difficulty of learning for the chimpanzee mind is not measured simply by the addition of the number of things to be learned. To add digit values to her repertory, for example, the difficulty incident to the process was equivalent to the powers of the number of distinct concepts. In other words, each single thing taught being regarded as one unit of difficulty, to teach her to count *three* was not simply the sum of three units of difficulty, but was *nine* times as difficult, or the square of the number of concepts.

$$C + C + C = 3(3D)$$

C = concept.

D = difficulty unit.

To cite another case, it was *four* times as difficult to teach the little ape to grasp the idea of *white cube* as it was to teach her the concept of either *white* or *cube*. To teach the idea of *big red cube* was *nine* times as difficult as to teach her any one of the three concepts alone. The difficulty of teaching the chimpanzee mind to perceive and appreciate abstract values advances thus, one-four-nine- and sixteen-fold. Compared with the simple addition, or thereabouts, of the human brain, this shows the relative capacity of the two types of mind.

No other genus below the human has ever accomplished anything to be compared with this chimpanzee. Other specimens of the same genus have displayed unmistakable ability in similar ways, which leads the writer to believe this one to be a fair standard of chimpanzee intelligence. Without betraying any trade secrets, I feel justified in stating here that the horses, dogs and other animals that are alleged to have learned to count, or select certain figures by word of command, are pure and simple products of expert fakery, so far as real education is concerned. I have been associated for many years with the best animal trainers in the profession, and most of them have kept no secrets from me; but it is no injustice to them to say that scientific methods of *teaching* and their methods of *training* are as different as the respective ends sought, the one being strictly scientific—and accurate—the other strictly commercial, without other considerations.

Investigation thus demonstrates that the chimpanzee is next to man in mental endowments, and it will be seen that this genus of ape most resembles him in physical structure, also. The general physical resemblance of the chimpanzee to man is

too obvious and too well known to dwell upon here; but in skeletal formation the similarity is still greater. In fact in only two sections does the skeleton of a chimpanzee differ in structure from that of man, viz., in the *sacrum* and the *sternum*, and neither of these discrepancies is very great. With these comparatively trifling exceptions, the skeletons of man and the chimpanzee may be truly said to be exact counterparts of each other, having the same number of bones, of the same general model, arranged in the same order, articulated in the same manner, and performing the same functions. In other words, the corresponding bone in each is the same in design and purposes. The gorilla, which has been found to be next to the chimpanzee in mentality, possesses a skeleton which is a counterpart of that of the chimpanzee in its general structure, save for the cranial ridges in the skull of the adult male. In some respects the gorilla skeleton is slightly less like that of man than the chimpanzee. Somewhat less like man is the orang-outang both in skeleton and soft anatomy; and his mental possibilities are correspondingly less than those of the gorilla. The gibbon is still more removed from man in these points. His mentality appears to be of a lower type than that of the orang-outang.

As investigation is carried farther the physical points in common and the variations corresponding approximately to their inferiority, multiply accordingly. Many persons shrink from the thought of man being allied to the ape because of the hirsute of the latter; and yet if a square inch of the skin of an ape be compared under the microscope with the corresponding area on the surface of the human skin, there will be found approximately the same number of hairs on each. Man has probably lost the heavy hair on his body primitive through ages of wearing clothes, just as he has lost the prehensile use of his foot probably from wearing shoes. It has even been found that apes are subject to many diseases of man to which other animals appear to be immune.

Dr. Reichert of the University of Pennsylvania has performed a vast series of experiments which demonstrate that the blood crystals of the chimpanzee and the gorilla are very much more like those of a human being than they are like any species of monkey known. The chief difference between the human and the ape crystals is a greater obtuseness of certain angles. The axes are almost the same, the geometrical forms are the same, with an equal number of similar facets and angles, and arranged in the same order. In fact they are of the same system.

The clavical, or collar bone, is more developed in apes than in other simians. In the lower species it becomes more and more primitive in form and less uniformly articulated in inverse proportion to the habit of erecting the body either habitually or occasionally, while in lower orders of animals it is hardly articulated at all, being quite rudimentary and probably useless.

In this way the physical resemblance to man may be traced with variations through the entire perspective of animal life, and it would be found to hold essentially true in relation to comparative intelligence.

The diet is another reliable index of the mental horizon of any genus of animals. Those forms which have the most varied diet and which are the most fastidious in selecting and preparing their food, are found to be more highly developed in mentality than those of more simple diet and less discrimination of taste. Multivorous man conforms to this rule even in the different races of his genus. In search of variety of food, animals necessarily range through a wider field of experience, expose themselves to more varied conditions, incur more dangers, which demand greater exercise of their wits to avoid and thus they get a more or less intensive mental training.

It is also an interesting sidelight upon the question of the search for food in relation to animal intelligence, that those animals which dwell in the vicinity of human beings, pitting their faculties against those of man, are mentally superior

FIGS. 2 TO 4. CRANIO-FACIAL ANGLE (A B C), GNATHIC ANGLE (A D E), FACIAL PLANE (F G) AND CERVICAL AXIS (H I) OF MAN, COMPARED WITH CHIMPANZEE (CENTER) AND LOWER ORDERS OF MONKEYS (RIGHT)

to any genus or species that dwells habitually in the sequestered depths of the jungle. Among the anthropoid apes, the chimpanzee has, perhaps, the most varied dietary of any other race, and is about the most fastidious in his choice of food and his manner of eating it. He makes his habitat in the purlieu of human habitations, and much of his food is the fruit of man's toil, which the ape procures by stealth. In company with his family, he makes frequent raids on the gardens and plantations of men, employing tactics which would do credit to the wits of prowling schoolboys intent upon similar adventures. They take narrow chances, often with surprising success. The gorilla also is an adept in this art. His dietary, however, is less varied than that of the chimpanzee. He leads a more retired life, seeking the inaccessible places in the forest for his nightly bivouac, while the chimpanzee often builds his bed in a tree within a few hundred yards of a village, relying upon his own shrewdness to escape harm in this rather dangerous locality. The chimpanzee actually seems to like the proximity of human beings. The ourang-outang, next to the gorilla in mental endowments, takes still fewer chances in procuring his food, lives upon a less varied diet, depends more upon the wild products of the forests, and is more easily satisfied with what he obtains. The gibbon, last and lowest of the ape group, is much more addicted to arboreal habits, is more limited in his dietary and more timid in procuring it. He is much less fastidious in his choice, and comes less frequently in contact with man. In descending the scale of the monkey species, their horizons of mind descend in about the same degrees as they lessen the variety of their diet and their proximity to the dwellings of man. Below the monkeys the same rule holds good of the lemurs, which gradually merge into the *procyonors*, including raccoons, civets, etc., which are allied in one direction with the *canidae* and in the other with the rodents.

In following out certain physical developments as coordinates of other faculties it appears that the movements of the digits also coincide with the mental development of all orders and genera. Man possesses some twenty-seven possible movements; the chimpanzee, twenty-three; other apes, twenty-one; monkeys, nineteen; lemurs, eleven; and so on down the scale to the reptiles, with only two, simply those of opening and closing the digits. The rodents, however, do not appear to conform strictly to this law, and in this may be the exception which is supposed to prove a rule, although in other ways they conform to the place to which they are assigned in the scale of nature, as shown in the diagram.

To man the use of the thumb is highly important, and to the ape only a little less so; but as we descend the scale it becomes more and more limited in its use and arrested or atrophied in development until, in forms below the lemurs it becomes a mere rudiment, or "dewclaw." In a few species of monkeys, however (usually of low levels) and prosimians, the thumb is entirely absent. In the *ungulates* it is absent, having been absorbed into the ankylosed carpal and tarsal bones.

The erect carriage of man is, undoubtedly, the result of slow development through the ages. This tendency toward the erect habit in the apes keeps pace with the development of intelligence along the scale of animal life, although it appears at a point above the stage reached by other genera. Through the whole range of simian races this coordination is traceable, although the close alliance of different species of monkeys makes it difficult to discern their exact relative standards of mentality.

In conjunction with this tendency is that of the glottic plane (or plane of the vocal cords) which, beginning with reptiles, occupies a position of approximately forty-five degrees from the axis of the larynx, tends toward the horizontal as we ascend the scale until in the apes it is approaching the horizontal, and in man it is still nearer to that position. The gamut of sounds, or scope of vocal products controlled by the glottis, undergoes similar variations. From man, whose gamut is the most varied of all animals, it is found that the chimpanzee has the most varied gamut of the lower animals, followed in order by the gorilla, gibbon and monkeys. The ourang-outang is possibly an exception. Continuing on down the scale, ultimately ending in the reptilian forms, we find the vocal powers more and more restricted in scope and degraded in quality, until in the lowest reptiles, they are lost in a mere hiss.

This scale of relative variety in gamut is of special importance here, inasmuch as it relates directly to the brain and its higher functions. Vocal sounds are, by their very nature, vehicles of expression, conveying definite concepts. A vocal sound emitted by an animal may or may not be intelligible to the hearer, but its source is not a vacuum, so to speak. In animal economy it is a *de facto* means of communication. The apes and monkeys have sounds which to their own species stand for ideas. Primitive wants and oft-repeated situation—each has its particular sound or word, which symbolizes it. Hunger, fear, love, aversion, danger, anger—all have their vocal symbols, many of which through years of

research the writer has become familiar with in several different simian and anthropoidal species. But as the animal brain is less and less complex, as we descend the scale, the reactions likewise become less and less complex, and the expression thereof becomes more and more primitive. Nature does not equip an animal with a faculty in a highly developed form unless it has a need for it in proportion to its complexity.

This brings us to one of the most interesting phases of the study of comparative intelligence of animals, and that is the *gnathic index*. In general the development of the chin of an animal is an index of the mental horizon of his genus. In the higher type of animals, such as man, the complexity of his being allows wide field of individual differences which are not possible in the lower and simpler forms. In the cranial types it is obvious that the human skull is more spherical and the face more nearly vertical than is the case with any other animal. The skull of the ape is more elongated and prognathic, and the facial plane is at a greater angle from the vertical.

In the scheme of nature there appears to be a fixed law of cranial projection, which coincides with other laws of anatomy and intelligence as indicated in the several scales above described. The cranio-facial angle in man, ABC (Fig. 2), is a right angle, and the gnathic angle ADE is approximately the same. The line FG represents the axis of the facial plane, and

FIG. 5. CRANIAL PROJECTION OF A REPTILE

the line HI is the cervical axis. Reckoned from the vertical line KL it will be seen that the angles formed by the facial axis FG and the cervical axis HI are about the same on opposite sides of the vertical line KL. It will be observed that these lines and angles are those of man whose posture is upright. In Fig. 3, which represents the chimpanzee, it will be seen that both the facial axis FG and the cervical axis HI form greater angles from the vertical line than in man. It will also be seen that the cranio-facial angle ABC is increased by about one-half the angle of the facial axis GML. The gnathic angle ADE is increased in about the same degree.

Fig. 4 illustrates the lines and angles of monkeys in which the angles are widened in a degree measured by the tendency of the animal to assume a horizontal posture like that of true quadrupeds. In Fig. 5 is reproduced a model of reptilian forms of life to which the cranial projection of practically all the remaining orders conforms in principle. The facial axis FG and the cervical axis HI are almost horizontal. The cranio-facial and gnathic angles have been correspondingly widened, and upon a comparison of genera it will be found that this angle widens in proportion to the place of each particular genus in the scale as indicated.

Concurrent with these variations, the longitudinal, transverse and vertical axes of the brain also change their proportion in like degree in accordance with the animalian life and mind as outlined in the chart, Fig. 6. From the lowest animal forms which possess brains of the most rudimentary sort, some of them little more than ganglionic centers, we find infinite gradations of type as we ascend the scale of animal forms, and all in exact coordination of parts. The

lower brains are long and narrow in shape. Reptilian brains are approximately four times as long as they are wide or high. That is to say their axes measure about 4 to 1; the *pachyderms* measure about 3 to 1; the *ungulates* about 3 to 1; the *carnivores* about $2\frac{1}{2}$ (or 3) to 1; the *lemurs* about $2\frac{1}{2}$ to 1; monkeys about 2 to 1; apes about $1\frac{1}{2}$ to 1; and human beings about 1 to 1. Thus ascending the scale we find that the higher the stage of development the shorter becomes the longitudinal axis of the brain in proportion to the vertical and the transverse axes. The hemispherical type of brain becomes more and more pronounced, the details better defined, terminating in the marvelous complex brain of man himself. In other words, the cephalic model undergoes a steady metamorphosis, growing shorter and higher as its length diminishes with higher development. The measurements of the human brain average about 1,400 cubic centimeters; that of archaic man, about 1,000 cubic centimeters; and that of the ape brain about 600 cubic centimeters.

It appears that in one or two respects nature exacts a penalty for progress. With the development of reason, the instincts appear to fade. Man has lost his instincts to such an extent that they are no longer reliable guides to action. The apes have likewise forfeited a large portion of this animal inheritance, about in proportion to the substitution of the reasoning faculties. But the lower forms have the main, if not all, activities of existence guided by instinct alone. The very lowest forms of animal life possess certain qualities which seem to disappear as we ascend the scale. In those orders of life where fission is the manner of reproduction the organism has the power within itself of self-restoration, of reproducing members or parts of its body that have been destroyed. Pseudopods restore themselves; when a limb is severed another grows in its place. But as the forms of life become more and more intricate in structure, the organs become more and more specialized, and their power of recuperation becomes more restricted, until in mammalian forms, and especially those of the higher levels of life, the individual cannot even restore or grow a digit that has been severed.

Investigation along the above and similar lines might be followed *ad infinitum*, correlating the various aspects of comparative anatomy and their arrangement in a fashion concurrent with the evolutionary scale, which in turn coincides with the scale of comparative intelligence in animal forms presented herewith; but it is obviously impossible in the space here allotted to present all the data available.

The coordination is apparent and it is possible to employ it in a material way in research. *Given the gnathic angle, or the ratio of the cerebral axes, or the angle of the glottic plane with the larynx, or the number of digit movements, or the vocal range, or the number and qualities of items in the dietary of an animal form, and from any one of these indices it is possible to determine the others with fair accuracy and thereby assign any animal to its place in the scale of nature, physically and mentally.*

The foregoing glances over the various fields of anatomy, physiology and psychics are but general views of their broad panoramas, but they are sufficient to show the principles which govern the development of nature's types. They serve to demonstrate further the psychic unity of all animal life, and to vanquish man's foolish arrogance in according himself exclusive rights to all mental processes above those that are automatic or instinctive. The facts afford ample scientific grounds for believing that the hiatus existing between modern man and the lower extinct types of humanity has been entirely filled during the progress of the race from that low stage to the present one. Likewise, in view of the multitude of data in support of the Darwinian theory, and supplemented by the above coordinations, the same conclusions hold good of the hiatus between archaic man and the anthropoid apes and of that between the latter and the majority of lower animals. The scale shown here is not put forward as an exact measure; nor does it prove capable of containing

FIG. 6. CHART OF ANIMAL INTELLIGENCE IN WHICH LETTERS A TO M ARE TANGENTS OR HORIZONS OF THE SPHERES OF MIND AND CONCOMITANT FACULTIES

all forms of life in their endless variation. It is merely an indication of the principles at work in the development of vitalized matter through the ages, manifested in the comparison of animal types. Not all specimens or species conform to this relationship because of variations due to causes distinct in themselves predominating. But from the whole scale of comparative animal life the deduction is clear that every order, family, genus and species of animal lives within a sphere of life, or cosmos, all its own. And these correctly arranged fit into a perspective the outlines of which are tangents to the circumference of every one of these spheres of life, from zero to its foreplane, occupied by the grand cosmos of man himself as the monarch of animalia.

Nature has its freaks which do not coincide with the general scheme, just as there are discrepancies in the mighty mechanism of the solar system. Science discovers anomalies in every field of research, but it does not abandon a principle because of them. The imbricating circles of animal life, the unity of plan and purpose, the inherent relationship of types, the foetal history of forms, the possession in common of the gifts of nature, stand out as cogent facts with stereopticon clearness in proof of the unity and continuity of design in the realm of vitalized matter. Mind is essentially one in kind, from the acme of human attainment to the protozoa; and it is as universal as the vital phenomena which we call life.

THE USE OF AUTO-SERUMS IN THE ART OF HEALING

ONE of the newest methods of treating certain infectious maladies is by means of a serum taken from the body of the patient himself. Two different processes are employed in this method, which is technically known as auto-serotherapy.

The first method was devised by Dr. Gilbert of Geneva for employment in cases of sero-fibrous-pleurisy of slow development. The operation consists in extracting by means of a puncture a small quantity, only a few cubic centimeters, of the liquid discharged, and then injecting this beneath the skin of the patient. In about half of the cases thus treated the development of the disease was suddenly accelerated and recovery was comparatively prompt. It must be noticed, however, that this effect is not produced, or but rarely, when the injection is made during the period while the pleurisy is augmenting. The explanation of this remains rather obscure. P. Courmont is of the opinion that when the pleural liquid has been maintained at its maximum level for several days the anti-toxins balance the toxins and that the absorption of the discharge is not definitely begun until the anti-toxins are in the ascendancy, so that as a result the *vaccination* is complete. But since this vaccination is sometimes very slow in establishing itself it may be of advantage to hasten it either mechanically by a simple explorative puncture or else by auto-

serotherapy. Other authorities suppose that the injection simply releases a diaphylactic reaction which modifies the colloidal state of the liquid so as to facilitate its absorption.

In the second process it is the serum of the blood of the patient which is employed instead of the discharged liquid. Vidal, Abrami and Brissaud have shown that it is possible to obtain by this means very valuable results in case of certain infections; it was thereupon employed in serious bronchopulmonary affections and in cases of grippe. The patient is bled and the serum is allowed to settle in a sterile place and the serum was then reinjected under the skin or into the veins. The intravenous injection is frequently followed by violent reactions on the patient's part (shivering, advance of temperature, curious thoughts of ill-feeling, etc.), and sometimes, indeed, by anaphylactic accidents; but after this the temperature falls and there is a general improvement in the condition of the patient, which may be definitive. The effects just mentioned are those which are invariably observed when foreign bodies are introduced into the circulation, whether directly or indirectly, such as peptone, sugar, colloidal metals, horse serum, emotions of bacilli, etc. But the serum of the patient has itself become the cause of the necessary manipulation of the blood, a foreign body, and this fact forms the explanation of the reaction and the therapeutic results described above. However, this process involves so many difficulties of technique in order to avoid the contamination of the serum that it is but rarely employed, it being considered preferable either to make an immediate injection of the blood of the patient, as is done by Artaud de Vevey or else to inject the citrated blood or plasma of the convalescent according to the methods followed by Grigaut and Moutier.

A BIRD THAT BUILDS AN INCUBATOR

A REMARKABLE example of a sort of artificial incubation is found, according to a writer in the *Naturw. Umschau v. Chem.-Ztg.* (Berlin) for November, 1920, in the brush turkey (*Talegallus*) which is a native of Australia and New Zealand. This bird prepares a sort of incubator for its eggs which relieves it of much of the labor of brooding over them, which other fowls find necessary. It scrapes together with its strong, muscular feet a great mass or mound of withered leaves and decaying vegetation in which the female lays her eggs, arranging them in a neat circle. The decomposing vegetation soon begins to produce the needful warmth for developing the eggs. Meanwhile the male bird visits this great compost heap from time to time to regulate the temperature, and when the time for hatching comes to assist the young birds in extricating themselves from the decaying mass in which the eggs are reposing. He does not permit his youngsters to leave their warm home, however, until they are fully fledged.