Intelligence,
Power and Personality

Intelligence, Power and Personality

by George Crile

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THE PROBLEM

One of the mysteries of the human race is the fact that civilized man is subject to certain diseases that rarely attack primitive man and never appear in wild and domestic animals. These are various nervous and mental disorders, exophthalmic goiter, neurocirculatory asthenia, Raynaud's disease, diabetes, peptic ulcer, essential hypertension, and coronary disease. Each of these diseases is related to the expenditure of energy. It would appear that this fact alone offers a biological cue to the mechanism of the energy characteristics of man and animals.

It is well known that only certain organs and tissues control the expenditure of energy in all animals, including man. These are the brain, the heart and the blood, the thyroid gland, the adrenal glands, the celiac ganglia, and the sympathetic system.

I postulated that if we were to analyze, measure, and compare the organs of this energy-controlling system in fish, reptiles, birds and mammals and then compare the influence of the heat of the tropics and the cold of the arctic upon the size of these organs—heat and cold and struggle and survival being the most potent of all environmental influences—we should be able to account for the varying intelligence, power, and personality among the different species of animals and the races of man. We should be able to find for man an energy formula distinct from that for wild and domestic animals and, further, an energy formula for civilized man. This became our quest.

THE QUEST

While Mrs. Crile and I were hunting in Africa in 1927, two phenomena well known to hunters of big game excited our attention.

The first was that an antelope, a lion, or any high-powered animal, when shot through the heart in such a way that the circulation of the blood is immediately arrested, may continue to run at top speed for a distance of a hundred or more yards before he falls dead. This fact challenged credulity, for, from my observations in war, I had found that death results instantly from a comparable shot through the heart in man.

The second phenomenon was the explosive outburst of speed seen in the long leaps of the impala in escape and the incredibly high and long bound of the lion in attack.

In contrast, we observed that if an animal is shot through the brain or high in the brachial plexus near the spinal column, it will never move again; if shot through the heart, it may run a hundred yards or more and even complete its attack; if shot so that the energy of the bullet suspends momentarily the action of the brain or "creases" the animal, the animal may fall, then jump up, and bound away or complete its charge.

When a comparison was made of the effect of a shot through the brain of a zebra, a lion, or an elephant with the effect of a shot through the brain of a turtle, a crocodile, or a python, a great difference was noted. In the warm-blooded group death was instantaneous. In the cold-blooded group there was more or less muscular activity for varying periods of time, up to several hours.

Why one animal behaves like a high-powered motor, set in high gear, exhausting itself by a high expenditure of energy, and another behaves like a low-powered motor, set in low gear, and therefore capable of carrying on indefinitely at a moderate expenditure of energy, has long been an enigma. This became our problem.

Crude dissections with a hunting knife, made in the field in 1927, had disclosed a striking difference in the size of the energy-controlling organs in the various species of animals. It was therefore believed that a study of the evolution of the energy or oxidation-controlling system—

namely, the brain, the heart and blood volume, the thyroid gland, the adrenal-sympathetic system, and the celiac ganglia in the various species of animals in their wild state—might account for the variation in the intelligence, power, and personality of animals and perhaps elucidate the nature of certain energy diseases in man. To that end we embarked on a research in comparative anatomy and physiology during the course of which we collected the energy-controlling organs of 3,734 animals from many parts of the world.

The first field collection was made in 1931 by the Crile-Bole-Fuller expedition to Arizona,[1] when Robert Crile collected and preserved the thyroid and adrenal glands and determined the size of the brains of animals ranging from small rodents to the mountain lion.

The preponderance of the adrenal glands, which govern emergency energy, over the thyroid gland, which governs the level of constant energy, was shown in all the animals that were collected.

This expedition also yielded the significant fact that in a pursuing animal, such as a coyote, and in a fleeing animal, such as a deer, the weight of the thyroid gland and the weight of the adrenal glands are more nearly equal, the adrenal glands being but slightly heavier than the thyroid gland.

The research was extended to include the thyroid and adrenal glands from wild animals and birds in northern Ohio and from various species of domestic animals and of animals taken from zoological gardens, but the latter studies showed the presence of goiter in varying degrees in a large proportion of the domestic and zoo animals.

We next studied the wild life of the beautiful Cumberland Island, off Georgia, where there is no goiter and where alligators, Florida deer, and sea turtles are abundant.

[1] Crile, Robert, "The Comparative Anatomy of the Thyroid and Adrenal Glands in Wild Animals," *Ohio Journal of Science*, Vol. XXXVII, No. I, 1937.

Through the courtesy of Mr. Morrison Carnegie, the opportunity to collect animals on Cumberland Island was afforded us. This research was extended to include the organs of eighteen bulls and steers that were collected in Jacksonville, Florida. These animals were found to be free from goiter and more nearly like animals in the wild state than were the domestic animals in Ohio that we have also studied.

Dr. Herbert C. Clark, director of the Gorgas Memorial Laboratories in Panama, sent a large amount of material and data from Panama to Cleveland, including memoranda on 525 monkeys, sloths, tapirs, armadillos, ant-eaters and collared peccaries, as well as on small rodents and many domestic animals. This material was studied in the Research Laboratories of the Cleveland Clinic Foundation in collaboration with Daniel P. Quiring, Ph.D., director of the Division of Anatomy.

In the course of these researches there were brought alive to the laboratory alligators, crocodiles, lions, tigers, bears, chimpanzees, some from zoological gardens and others imported directly.

It was because we believed that the source of the many so-called "energy diseases" of civilized man lay in the pathologic physiology of the energy-controlling system, in particular that sector designated the "abdominal brain" or "power station" of the sympathetic system—that is, the celiac ganglia—that an expedition to Africa was organized in 1935.

The members of this expedition were Dr. Daniel P. Quiring, Mr. Arthur B. Fuller, Dr. W. Harrison Carr, of England—a guest, Mrs. Crile, and I.

Through Captain J. Raymond Hewlett, our hunter, and Mr. Bryan Cooper, a laboratory was established in the Rift Valley, in Tanganyika, at a latitude 2° south of the equator. Here perhaps a greater concentration of wild life abounds than in any other known region of the earth, and here in the field we weighed not only each of the 220 animals that we studied but also every organ of each animal and sometimes the skins and the skeletons.

Routinely, all animals except the largest were brought into our field laboratory, where they were weighed. The skin and every organ of the body were weighed separately. In large animals that had to be weighed in sections, an allowance of 5 per cent was made for the blood. In all instances we collected the brain and pituitary gland, the eyes, the thyroid gland, the adrenal glands, the celiac ganglia and sympathetic complex, the heart, the kidneys, the lungs, the liver, the genitalia, often the spleen, and a section of the larynx and trachea.

In the case of large animals such as the buffalo, the rhinoceros, the giraffe, the hippopotamus, and the elephant, we set up scales in the field, where we carried out the dissections on the same plan that we followed in the field laboratory. In the case of the elephant it was necessary to weigh 176 different parcels in the course of the dissection in order to determine the entire weight of 14,640 pounds.

In the Museum of Intelligence, Power, and Personality of the Cleveland Clinic Foundation the heads of these animals and, in some cases, the whole animals have been mounted, and grouped about them are models of their energy-controlling organs.

Since the striking difference between the energy release of the cold-blooded alligator or crocodile and the warm-blooded lion or tiger of the same weight, of the fish and of the warm-blooded bird was still to be explained, during the winter of 1937 we set up a field laboratory in a *cabaña* on the beach at Key West, Florida.

Here, besides studying many varieties of birds and small mammals, Dr. Quiring, Mrs. Crile, and I studied various species of fish, those that prey and those that are preyed upon. We contrasted the cold-blooded shark with the warm-blooded porpoise of the same weight. We discussed the needs of such a cold-blooded animal as the shark, which breathes the oxygen in the water in a 1 per cent concentration, as contrasted with the needs of the porpoise, which breathes the oxygen in the air in a 20 per cent concentration.

The porpoise was the only warm-blooded animal that we had studied to that time, save man, in which the normal thyroid gland was notably larger than the adrenal glands.

Naturally the question next arose as to the energy-controlling systems of other cetacea.

Professor E. M. K. Geiling, of the University of Chicago, for some years has been collecting and studying pituitary glands from whales at the Queen Charlotte Islands. Through his courtesy and the cooperation of one of his assistants, Dr. Lewis L. Robbins, we were able to secure the energy-controlling organs of a blue whale, whose total weight was calculated to be 122,000 pounds.

Since our collections had been made largely in tropical Africa or subtropical and temperate America, where the effect of habitat temperature alone could not be estimated, we next organized an expedition to the subarctic regions. In Churchill, on Hudson Bay, at 58° North latitude, and around Chesterfield Inlet, at 63° North latitude, at the edge of the Arctic Circle, we compared the effect of cold per se upon the size of the energy-controlling organs of the warm-blooded animals on the land and in the sea. This expedition consisted of Dr. Quiring, Mr. Fuller, Mrs. Crile, and me.

Interest and cooperation were shown by Mr. W. E. Brown, the manager of the Nelson River district, of the Hudson's Bay Company, Mr. R. H. Cook, manager of the Hudson's Bay post at Churchill, and Dr. Alvin Cohen, in charge of the small hospital at Churchill. The office of the district manager, a small house situated on the beach at Churchill, was turned over to us to serve as a laboratory and cookhouse. Dr. Thomas Melling was the medical health officer at Chesterfield Inlet. He was in charge of the district of Keewatin, Northwest Territory, and had had wide experience among the Eskimos. Dr. and Mrs. Melling not only had a young walrus in cache for us but had turned their storehouse into a laboratory and had arranged for our quarters with them.

On this subarctic expedition, besides making studies of the energy-controlling systems of cold-blooded and warm-blooded animals, we also made studies of the metabolism of the Cree and Chippewyan Indians[1]; and, through the cooperation of Dr. Melling, we were able to make studies of the metabolism of Eskimos.

These studies of metabolism led to further inquiries into the effect of varying altitudes upon the energy-controlling systems of animals and the metabolism of man. Accordingly, in 1938, an expedition to Guatemala was undertaken by Dr. Quiring, Mrs. Crile and me to study the metabolism of the Maya-Quiché Indian soldiers at Totonicapan, Guatemala, at an altitude of 8,100 feet and of Indian laborers serving on a coffee plantation at Samayac, 800 feet above the sea.[2]

For aid in these studies we are much indebted to our medical colleagues Dr. Ramiro Galvez, dean of the Medical School of the University of Guatemala; Dr. Mario J. Wunderlich; Dr. Julio Bianchi; Dr. Mariano Lopez-Herrarte; Dr. Ezequiel Soza; and, in particular, to Dr. Estévez, the minister of public health, and to Mr. Antonio Goubaud, who assisted us in our work.

At Totonicapan, under the efficient organization of Colonel Cipriani, every facility was placed at our disposal, and we found the most cordial interest in the study of the metabolism of the Maya-Quiché soldiers in that district.

[1] Crile, George W., and Daniel P. Quiring, "Indian and Eskimo Metabolisms," *Journal of Nutrition*, Vol. 18, No. 4, Oct. 10, 1939.

[2] Crile, George W., and Daniel P. Quiring, "A Study of the Metabolism of the Maya-Quiché Indian," *Journal of Nutrition*, Vol. 18, No. 4, Oct. 10, 1939.

Since we wished to make a further study of the influence of climate upon the races of man, we made an expedition to the Hawaiian Islands in 1939. In Dr. Nils P. Larsen, who has himself made valuable contributions to the study of man, we found a most cooperative collaborator. To Dr. Larsen we are indebted for much valuable human material from Hawaii.

In our dissections in the subarctic we were impressed by the large brain, the large thyroid gland, and the large blood volume found in the warm-blooded animals of the north in contrast with the smaller brain, smaller thyroid gland, and smaller blood volume found in comparable species in the tropics.

These observations suggested to me a study of the potential gradients of the brain and the blood under the influence of the thyroid hormone. A long series of experiments conducted by Otto Glasser, Ph.D., director of the Department of Biophysics of the Cleveland Clinic Foundation, Dr. Quiring, and me, showed that the thyroid hormone specifically increases the potential gradients, that is to say, the thyroid hormone increases the rate of oxidation or metabolism and is a fundamental adaptation against cold.

As a corollary, animals in the tropics, as an adaptation against heatstroke, possess the smallest thyroid glands.

The results of this research were reported by me, in collaboration with Dr. Glasser and Dr. Quiring, before the American Association for the Advancement of Science in June, 1940. In 1941, when we found that we lacked that unique animal the manatee and certain fish, a supplementary expedition to Florida was made.

The data from our various expeditions, as presented in the following pages, show that the intelligence, power, and personality of animals are indicated by the absolute and relative size of the brain, the heart and blood volume, the thyroid gland, and the adrenal-sympathetic system. Whether in the sea, on the land, or in the air; whether in the tropics or in the arctic; whether warm-blooded or cold-blooded, it would appear that each animal has its own energy formula or pattern.

Special mention should be made of the collaboration of Mrs. Crile in these expeditions. She attended to the infinite details of preparation. She kept the field notes, weighed all specimens, and prepared them for shipment, and has assumed a large part in the preparation of the material for publication.

Part I

ENERGY

1. ANIMAL ENERGY

The earth and its atmosphere are constantly subjected to two universal forces, gravitation and radiant and electric energy from the sun. Gravitation brought the fluid part of the earth—the water—into final equilibrium in the great oceans. Gravitation brought soluble soil to the ocean as a basis upon which the radiant and electric energy from the sun produced organic life.

Gravitation is so constant, so powerful that cold-blooded animals on the land are scarcely able to lift their bodies from the ground. This same force, universal and continuous, has been a factor in the high development of the brain, heart, thyroid, and adrenal-sympathetic system, enabling the warm-blooded animals of the earth and the birds of the air to raise their bodies against gravity and to move at various speeds.

The second universal force essential to the genesis and the work of protoplasm is solar energy. Solar energy pours down upon the earth, and lightning and terrestrial electricity passing through the air fix nitrogen, thereby producing a continual stream of fixed nitrogen, the basis of protoplasm.

The intensity of the energy put into the nitrogen fraction by lightning endows the nitrogen fraction with the highest energy known; hence, generally speaking, the nitrogen fraction becomes the positive element, and the carbon fraction becomes the negative element in the synthesis of life. These nitrogen and carbon fractions with their positive and negative signs of charge are continuously coalescing in every part of the earth, on the land, in the air, and in the sea, each plant and each animal growing in accordance with its use of energy. Each form rises as far as its food supply and energy will carry it and then breaks down with dispersion of the energy that it received, thus entering dissolution and death.

The source of all plant energy being the radiant and electric energy of the sun, the plants taken as fuel into animals and there oxidized or burned reradiate solar energy. The solar energy held within the plant, when taken into the animal as food, is oxidized or burned in infinitesimal quanta within the billions of cells of animals. Thus plants capture and build up solar energy; furnaces and animals reradiate solar energy; the reradiation of energy comes from the burning of coal, wood, oil, or gas and from oxidation within the cells of a fish, an eagle, a lion, or a man.

This universal principle applies equally to the burning of fuel in the cells of the animal body. Oxidation in the brain cells releases radiant and electric energy, which enables the brain to think. Oxidation in the countless billions of the voluntary and involuntary muscle fibers provides body warmth and muscular action.

The Energy Control of the Living

Plants have the equivalent of a bony skeleton in their cellulose. Plants have the equivalent of tendons and fasciae. They have a skin, they have lungs (leaves) and circulation of sap, and the protoplasm of plants is analogous to the protoplasm of animals.

In one fundamental respect animals differ from plants: animals can adaptively alter the speed of oxidation in their various organs and tissues and increase the speed of this energy output in one of a number of organs and tissues or in combinations of these organs and tissues. That is, animals can run or walk or swim; and plants cannot.

In animals the special senses are highly developed. Only the Venus's-flytrap and a few other plants have special senses. The special senses in animals facilitate the release of energy to promote their welfare. Animals and plants alike have a basic metabolism. The basic metabolism of plants and animals is required to maintain their structure. As animals evolved and searched for food and protection against enemies, better energy-releasing systems developed. The demands of the plant for energy are constant, but the demands of the animal for energy are not constant.

To establish adaptive control of energy, special mechanisms for the control of the speed of oxidation have been evolved in animals. These mechanisms are the special senses, the brain and communicating nerves, the heart, the blood volume, the thyroid gland, the adrenal glands, and the sympathetic system. These energy-controlling organs and tissues are the means whereby energy is released in this or that gland and in this or that combination of muscles to enable the animal to secure food, to escape, and to procreate.

The transmitting system of animals includes the sensory nerves of the organism, the nerves that control the voluntary muscles, and the sympathetic nerves that supply the great network of blood vessels, which, in turn, are supplied to each of the hundreds of millions of cells of the liver, the thyroid gland, and the digestive system. These energy-controlling systems constitute a network so vast and so intricate that, were all the tissues of the body removed except these nerve mechanisms, there would remain an effigy of the body as a whole. Standing alone, without accelerators or controllers, these nerve mechanisms would work all day, all night, in danger, in hunger, in the presence of prey or in the presence of mates but would not be able to vary their speed and power. Little benefit would accrue to an animal such as a man, a lion, or a zebra, if, having a perfect mechanism for generating and distributing electricity, it had no mechanism by which speed could be adaptively altered. Man would not be able to adapt his mechanism to his changing requirements. The lion would not be able to rush its prey. The zebra would not be able to meet the energy requirements for escape. All animals would exist at a constant energy level; they would be operated at a given speed. The energy of these animals would be as changeless as the energy of the protoplasm of a tree. The mating season would be identical with every other season. There would be no rhythms of adaptation to cold and for reproduction. Thus, if every animal had the same speed of energy transformation or basic metabolism, everything would be alike and predictable. There would be only basic oxidation, not adaptive oxidation. The ovaries, the testes, the mammary glands, the hypophysis, the muscles, the bones, the tendous, the fat, the connective tissues—none of these can of itself change the rate of basic oxidation or metabolism. The brain can supply the spark that produces oxidation, but it cannot, without the heart and the red blood cells, the thyroid gland, the adrenal-sympathetic system, and the special senses, adaptively regulate the speed of oxidation.

The brain-heart-thyroid-adrenal-sympathetic system, then, is the distinguishing feature of higher animals. The brain, the heart, the thyroid gland, and the adrenal-sympathetic system adaptively control muscular action, glandular secretion, and emotional expression, thereby generating and controlling the intelligence, power, and personality of the animal. Therefore, we should expect to find variations in the size of the brain, the heart, the volume of the blood, the thyroid and adrenal glands, the celiac ganglia, and the sympathetic system in warm-blooded animals in contrast to cold-blooded animals. Among the warm-blooded animals we should expect to find variations in energy characteristics and in the size of the brain, the heart, the thyroid gland, the adrenal glands, the celiac ganglia, and the sympathetic system in such animals as the protected group, on the one hand, which possess carapace, sting, barb, and color protection, and the pure-energy group, on the other hand, which depend solely upon their power of attack and escape, such as the tiger and the antelope. In these two groups there are intermittent energy requirements.

The third group consists of the master animals in the sea and on the land. This group is characterized by the possession of a higher level of activity than is seen in any other group. The representatives of this group in the sea are the warm-blooded land animals that returned to the sea but continued to breathe the rich oxygen concentration of the air, namely, the whale and the porpoise. The sole master on the land is man.

No animal, including man, possesses any organ or any power that does not have survival value. Evolution is a strict economist. Therefore, we should expect that an animal that depends on carapace, inaccessibility, sting, or poison would possess a smaller brain, a smaller heart, a smaller thyroid gland, and a more primitive sympathetic system and celiac glanglia than an animal without such protective devices.

If, on the other hand, in attack or escape, an animal depends upon high speed over long distances—such as the wild dog or the wolf that pursues the antelope or caribou—one would expect to find a thyroid gland nearly as large as the adrenal glands in both the pursuers and the pursued, since a high rate of oxidation must be maintained over long periods of time.

If an animal depends upon a sudden rushing attack, as do the members of the cat family, one would expect the adrenal glands to be larger than the thyroid gland, and, as a corollary, the animals that the smaller cats rush, namely, the rodents, would be endowed with correspondingly large adrenal glands.

Since the greatest energy requirement in warm-blooded animals is the maintenance of the warm-blooded state, we should expect to find the brain, the heart, the volume of blood, and the thyroid gland larger in the cold arctic than in the warm tropics. It is constant energy expenditure, not outburst energy expenditure, that constitutes adaptation against cold. Therefore, we should expect to find the adrenal glands of animals in the north to be smaller in relation to the thyroid gland than the adrenal glands of animals in the tropics.

Since the warm-blooded animals owe their superiority to the operation of van't Hoff's law, that with each degree centigrade of rise of temperature the speed of chemical activity is increased 10 per cent, the question arises, why were not the warm-blooded animals evolved to a still higher temperature? The answer is that protoplasm would be destroyed by detonation or heatstroke.

Heatstroke

Since the brain controls the oxidation of the animal and the thyroid and adrenal glands control the oxidation of the brain, why have not larger brains, larger hearts, greater blood volume, and larger thyroid and adrenal glands been evolved? Why has not the elephant a brain bearing the same relation to its body weight as the brain of the mouse? Why, instead of a temperature of 98.6° as a normal temperature for man and animals, did not evolution establish a temperature of 120°* as a normal, thereby greatly increasing the intelligence, power, and personality of animals? To answer these questions it is necessary to consider again the nature and some of the properties of protoplasm.

As previously stated, the universal base of protoplasm is its nitrogen and its carbohydrate fractions. These fractions also constitute the base of nitroexplosives. Thus protoplasm and the nitroexplosives possess certain properties in common. Both are normally in the state of constant disintegration. The rate of disintegration is accelerated specifically by heat. The relation of chemical disintegration of nitroexplosives is expressed by the mathematical equation of Berthelot. This law expresses the fact that nitroexplosives are continually disintegrating unless they are at

* It has been reported that under excitement the temperature of a bird may reach 116°F.

zero temperature and in absolute darkness. From this low level of temperature, with each degree of rise a certain increasing rate of chemical disintegration follows to instantaneous oxidation or explosion.

This corresponds to the changes in metabolism that have been observed in patients who have been subjected to artificial fever. Likewise it corresponds to the changes that occur in a mass of nitrocellulose films or in such a mass of protoplasm as an elephant, a horse, a plant, or a tree, in all of which, under normal conditions, a continuous disintegration takes place. This continuous disintegration is attended by the production of heat. Van't Hoff's law of chemical reaction, that a rise of 1°C. in temperature speeds the chemical reaction 10 per cent, applies to living and nonliving systems alike. According to A. V. Hill, in the case of nitrocellulose this increase in speed may be four times as great as is expressed by van't Hoff's law. If the heat loss is insufficient to balance the heat gain and if heat is increased continuously, a spontaneous explosion becomes a certainty in the case of the nitroexplosives, and heatstroke becomes a certainty in the case of animals.

Obviously, since protoplasm contains a nitrogen fraction and is in continuous disintegration, there must be a universal ceiling of temperature for plants and animals above which heatstroke takes place, just as there is a universal ceiling of temperature in nitroexplosives above which spontaneous combustion takes place.

If protoplasm consisted of carbon compounds only, such as starch, cellulose, and fats, the temperature would be safe at almost any range of heat, and heatstroke would occur only at kindling temperature. But animals constructed of such protoplasm would be as immobile as marble statues.

The extreme sensitivity and mobility of animals are due to the nitrogen compounds in chemical combination with the carbon compounds. It is the nitrogen fraction in protoplasm that is exquisitely sensitive to all stimuli, is easily disintegrated by heat, and is the mechanism by which heatstroke is produced.

Animals take into their bodies large amounts of solar energy in the form of plant food or the flesh of other animals. This energy constitutes a liability as well as an asset, for the nitro fraction thus taken in the food is the fraction of protoplasm that governs the chemical decomposition that leads to heatstroke. Added to the heat produced by this continuous disintegration is that produced by the oxidation induced by the brain and controlled by the thyroid and adrenal glands. It is clear, then, that each animal could be provided with only as large a brain, heart, volume of blood, thyroid gland, and adrenal-sympathetic system as would maintain the body temperature at a safe level below heatstroke.

The level of heatstroke, however, is not dependent alone upon the size of the brain, the heart, the volume of blood, the thyroid gland, and the adrenal-sympathetic system, that is, it is not dependent solely upon metabolism. It is also dependent upon the facility for cooling, which, in turn, depends on the size of the animal, the presence of sweat glands, fur, thickness and vascularization of the skin, and the size of the lungs.

The ratio of the surface of a small animal to its weight is greater than the ratio of the surface of a large animal to its weight. Consider the mouse and the elephant. The mouse and the elephant exist at different levels of oxidation per unit of surface. Therefore, not only does the relative size of the organs that control the rate of oxidation in these two animals prevent rapid disintegration of protoplasm under excess heat, but also and equally it controls the facility for cooling the animal. In animals, just as in motors, not only is combustion essential, but so also is the cooling system. Since the loss of heat in animals is essentially at the surface, the greater the ratio of the surface to the body weight the greater the facility for cooling, and the greater the facility for heat dissipation the greater the bodily activity a given animal can endure. The great activity of an insect would quickly destroy an elephant.

An examination of insects with respect to heat elimination shows the insect to have the advantage of a large ratio of body surface to body mass. If, in addition, we take into consideration the added surface area for cooling in the respiratory tubules of the insect, there is a greatly increased facility for heat elimination. Add to this the constant swift flow of air from the wings and from flight, and we see in the insect the most perfect of cooling mechanisms.

That the metabolism of the muscles of insects is at a high level is obvious from the fact that the wings of a housefly may move 19,800 times in a minute. A large animal would be able to increase the metabolism of its entire body were it ventilated as completely as an insect.

Since heat elimination occurs only in the lungs and on the surface of an animal, animals were evolved in such a manner that the maximum elimination of heat could be effected. Many expedients were evolved in the process. We see the long legs and the slender bodies of monkeys and of man. Evolution took the direction of cooling, not only by means of the absorption of heat by colder water and colder air, but equally by evaporation of water by the cooling device of sweating. In man evolution set up a mechanism by which much of the blood from the warmer internal part could be shifted by dilation of the blood vessels in the skin, thus further facilitating the loss of heat, and in certain hunting animals, such as the dog and the wolf, evolution seized upon rapid respiration and upon the large moist surface of the tongue as an additional means for facilitating the loss of heat.

So fundamental is this balance between the production of energy and the elimination of heat that evolution adapted animals of larger size to spend much time in the water, in swamps, in the cool shade of forests, and on the high mountain sides. Throughout all ages large animals have been inhabitants of swamps or of the ocean.

In the warm-blooded animals in the sea there was no problem of heatstroke. Instead, the problem in the cold polar seas was that of too much heat loss. Thus, in the adaptation to the cold sea, nonconductors of heat, such as oil, blubber, and fat, were evolved. The warm-blooded land animals in the arctic evolved such devices for the prevention of the loss of heat and death from freezing as fur, feathers, wool, and fat, all of which are inert, insulating materials.

In the tropics the temperature of the air may daily rise higher than the temperature that causes disintegration of protoplasm, or heatstroke. If the animals in the tropics were ensheathed in a skin of copper or any heat conductor, they would acquire an internal temperature that would cause heatstroke.

The greatest protector against the loss of heat is water. The composition of animals is approximately three-fourths water. Since water exhibits the highest known specific heat, water gives the greatest protection against the adverse effect of rapid changes in temperature.

Protoplasm may be disintegrated as well as frozen. It is a significant fact that the animals in the tropics are as completely covered with hair for protection against too much external heat as the animals in the north are covered with fur for protection against too little external heat. A Thermos bottle serves to keep its contents cold as well as hot.

The eland, the giraffe, the zebra, the kongoni, the wildebeest, the oryx, the impala, the Thomson's gazelle, the dik-dik, the reedbuck, and the steinbok of the tropics are all high-speed Herbivora. So also are the musk ox, the caribou, the reindeer, the elk, and the moose of the north. All are covered with hair, and when they run their internal heat mounts so rapidly as to threaten heatstroke.

The attacking animals, the Carnivora, such as the lion, the leopard, the cheetah, the wild dog, the wolf, the fox, the coyote, the mountain lion, have a light covering of hair. All these animals maintain their protoplasm, whether in a hot or cold climate, at a safe temperature level.

Some animals, such as the elephant and the rhinoceros, which are usually considered to be hairless, have a skin that is actually a semisolid mass of hair or wool. It is as if nature produced the compounds of which hair is made and then ensheathed the animals in a layer of plastics of hair rather than in hair itself. This great envelope of plastic hair has the same property of being as low a conductor of heat as hair. So, in reality, the elephant, the rhinoceros, and the hippopotamus are encased in a comparatively heatproof layer of plastic hair. These animals increase their heat loss by spraying water over their backs, as in the case of the elephant, or by seeking the damp of the cool jungle and wallowing in the swamps and streams.

It would appear, then, that heatstroke is a fundamental fact in determining the intelligence, power, and personality of animals and that the size of the brain, the heart and the blood volume, the thyroid gland, and the adrenal glands is related to the surface area of the animal and to its mass.

It might be suggested that instead of the size of the brain, the heart, the thyroid gland, and the adrenal-sympathetic system being limited by the tolerance of protoplasm to heat, the size of the energy system of a given animal is related to the supply of oxygen to the muscles. In support of this suggestion might be cited the so-called "oxygen deficit" that occurs as the result of vigorous muscular exercise, such as running and fighting.

We must, however, take into account two facts. (1) Each fiber of the muscle of the heart, which has the highest metabolism among the muscles of the body, is supplied with capillaries in close apposition to it so as to prevent oxygen deficit in that fiber as it performs its maximum work. (2) The voluntary muscles have a capillary supply far less abundant than that of the fibers of the heart muscle. If oxygen deficiency in the great mass of voluntary muscles were the cause of the limitation of the size of the brain, then the process of evolution would have supplied a larger amount of blood to the great mass of voluntary muscles, as in the case of the whale.

If a fever due to an infection of any kind has reached a temperature of approximately 108°, heatstroke will develop. There is no oxygen deficit in the muscles of such a patient, since he is relaxed in bed. We took the temperature of the winning horse at the end of a trotting race in July and found it to be 104°. It is clear enough that an oxygen deficit may be coincident with the limitation of the speed of a race horse. Considering the fact that even in a short race the temperature of this horse rose to 104°, it is more probable that the oxygen deficit is a protection against death from heatstroke. If in this horse there had been more capillaries supplying more oxygen and nutrition to the muscle, the oxidation in the muscles and hence the amount of heat would have been increased, let us say, 4° further, and this winning racing stallion would have died on the track of heatstroke.

It is significant that in the application of heat therapy the temperature of the patient can be safely increased only to 108°. In such a case, when the source of heat is removed, the temperature of the patient returns to the original level. If the temperature is increased to 108.5° heat stroke occurs.

The brain contains the greatest percentage of the most sensitive of the nitro compounds. This fact explains why the brain is the first point of the organism to succumb to heatstroke. The first symptoms of heatstroke are mental confusion and stupor, followed by coma; or the disintegration of the brain may be so abrupt as to be equivalent to detonation. Thus the chemical picture is in accord with our postulate. When the internal temperature of a plant or animal has risen to a certain point, disintegration of the protoplasm is so accelerated that the excess heat cannot be eliminated, and internal temperature accumulates until the universal ceiling of heat tolerance is reached. Heat-stroke then occurs, followed by the death of the plant or animal.

2. ANIMAL BEHAVIOR

OXIDATION is the only source of animal energy. "Struggle" among animals is largely competiton of rates of oxidation.

While we were hunting in Africa, the rush of the lion in attack and the swiftness of the zebra in escape exhibited such lightning speed and power that the feeble action of enzymes and catalysts seemed to me inadequate to account for the genesis of this fulminating energy.

Let us compare the oxygen-controlling mechanism of these high-powered animals with the oxygen-controlling mechanism of the amoeba, for these may represent different oxygen-controlling systems.

In unicellular organisms the positive nucleus and the negative cytoplasm maintain their electric strain through oxidation controlled by enzymes and catalysts. The rate of oxidation being higher in the nucleus than in the cytoplasm, there is maintained between the nucleus and the cytoplasm a difference in electrolytic concentration that establishes a difference in electric potential. This is adequate for the low and more constant level of the basic energy of the amoeba. One would suppose that this energy formula of the amoeba would apply equally to the nucleated cells in the organs of the higher animals.

In the nucleated cells in the organs of the higher animals a similar energy pattern is seen. These nucleated cells are found in the organs and in the structures of the digestive tract, the genito-urinary tract, the pulmonary tract, the liver, the pancreas, the spleen, the skeleton, the skin, the lymph glands, the bone marrow, the thyroid and adrenal glands, and the brain.

The nucleated cells of all these organs take the energy pattern of the amoeba, but these nucleated cells form the minor part of the higher animals, both as to mass and as to the generation of energy. The cells constituting the greatest mass and almost the exclusive generation of the energy of the higher animals do not follow the energy pattern of the amoeba or of the nucleated cells in the organs of the higher animals.

The voluntary muscle cells and the red blood cells have an energy pattern different from that of the nucleated cells. The red blood cells have no nucleus, therefore generate no electric strain within themselves. The voluntary muscle cells, though multinuclear, possess such small nucleuses that functionally they might be considered "anucleated."

We have already seen that the unicellulars, such as the amoeba, and the nucleated cells of the higher animals depend upon electric strain for performing their work and for maintaining their structure. What, then, could be the source of the electric strain that enables the red blood cells and the voluntary muscle fibers to perform their work and to maintain their structure?

Let us first examine the evidence in the case of the voluntary muscles. The voluntary muscles are adapted to high-speed action in attack and defense, for the expression of the emotions and for the maintenance of the warm-blooded state. This requires high-speed oxidation in comparison to the low-speed oxidation required by the amoeba and by the nucleated cells in the organs of the higher animals.

It has long been known that when the nerve communication between the brain and a voluntary muscle is severed, even though the muscle possesses a normal blood supply and enzymes and catalysts, the electric stimulation generated by the brain cells and upon which the muscle fiber depends for structure and function is lost.

Of still greater significance is the fact that the severance of the nerve communication between the brain and a voluntary muscle instantly paralyzes the muscle. The structure of the muscle fibers then breaks down and is replaced by fibrous tissue. This indicates that the universal pattern of the nerve-muscle unit of energy transformation is the nucleus-cytoplasm pattern of the amoeba.

There could have been no interruption between the pattern of the unicellular and the pattern of the higher animals, or death and dissolution would have followed, thus stopping the progress of the evolution of the unicellulars to the higher animals.

Logically it would appear, although it has not been proved, that the brain cell is the descendant of the nucleus of the ancestral unicellular organism. From this point of view, it would be understandable why the brain cells from a distance send electric impulses over the communicating nerve fibers and thus maintain the function and the structural integrity of the muscle fibers. This would indicate that not only the function but also the physical structure of the voluntary muscle depends upon impulses from the brain and not upon enzymes and catalysts.

Of equal fundamental significance is the fact that both oxidation and muscular contraction and the maintenance of the protoplasmic structure of the voluntary muscle fiber whose nerve supply has been severed can be maintained by electrical stimulation from without.

What about the red blood cells? Unlike all other cells of the body, the red blood cells of the higher Mammalia and man possess no nucleus. Red blood cells are as essential to life as are the brain cells. In a human being there are about twenty-five trillion red blood cells.

Although these red blood cells generate no electric strain by means of oxidation within themselves, they carry as powerful an electric charge as do the brain cells. The positive electric charge of the brain cells is derived from oxidation within each cell. The electrically powerful red blood cell bears a negative sign of charge.

From what source does the red blood cell derive its high negative electric charge? Logically it would appear, although it has not been proved, that the red blood cell, like the voluntary muscle cell, is a descendant from the ancestral unicellular cytoplasm whose negative charge was accumulated at its surface.

The first fact that emerged from my study of this problem was the determination of Hugo Fricke, in the biophysics laboratory of the Cleveland Clinic Foundation, that the envelope surrounding the red blood cell is on the order of 1/2,500,000 centimeter in thickness, or about the thickness of a molecule of oil or of 30 carbon atoms. This extreme thinness endows the red blood cell with a high capacity for holding electric charge, and the peculiar biconcave shape of the red blood cell, which is ideally adapted for tumbling and friction, increases the surface area of its covering membrane.

In order to account for the electric charge-up of the twenty-five trillion red blood cells in the human being, we turned to the well-known electrophysical principle that a particle moving in air or in fluid takes on static charge, the amount of charge being related to the intensity of friction. This is the principle on which particles floating in the air through friction take on negative or static charge and, being of like sign of charge, repel each other and float as dust.

I postulated that this electrophysical principle could be applied to the origin of the electric charge on red blood cells, since the heart, with its powerful contraction, causes such violent agitation among the red blood cells that the red blood cells would become charged with static electricity and repel each other and not agglutinate.

In collaboration with me, Dr. Otto Glasser and Dr. D. P. Quiring, of the Research Laboratories of the Cleveland Clinic Foundation, tested this principle[1] for the charge-up of the red blood cells through the action of the heart and

[1] "A Study of the Potential Gradients of the Blood and the Organs of Certain Mammals," paper presented before the Society for Experimental Biology and Medicine, at the meeting of the American Association for the Advancement of Science, in Seattle, June 20, 1940. To be published.

found that the highest charge on the red blood cell is in the left ventricle, where agitation is most violent. We found that as the speed of the red blood cell decreases in the course of its slow circulation through the capillaries, each red blood cell contributes its electric charge on certain electrostatic collectors in the area of oxidation, thus building up a voltage. The left ventricle and the arterial tree may be considered a condenser system that contributes the negative energy of the metabolic arc.

When the high-tempered zebra perceives a lion by sight, smell, or sound, the brain cells flare in oxidation, at once increasing the positive potential. Instantly impulses pass from the brain over the motor nerves to the running muscles; instantly impulses pass from the brain over the two sympathetic nerve trunks, namely, the major, minor, and lesser splanchnic nerves. At their terminal these two nerve trunks divide into two branches, one of which supplies the adrenal medulla, stimulating the output of adrenalin, and the other supplies the celiac ganglion and plexus, stimulating the output of sympathin. These two hormones, sympathin and adrenalin, cause an instantaneous increase in the power of the heartbeat and circulation of the blood, hence raise the negative potential.

From the celiac ganglion and plexus, the sympathetic nerve fibers pass along the arterial blood vessels down to the capillaries, delivering positive electric charges to the blood-vessel walls. The negative charge is supplied by the red blood cells within the arteries and capillaries. The involuntary muscle fibers of the arterial wall lie between the positive charge delivered by the sympathetic nerve fibers and the negative charge delivered by the red blood cells.

It is clear, then, that a single capillary with its continuous stream of negatively charged red blood cells may serve both as a negative pole to the sympathetic nerve fiber on its wall and as the negative pole to the positive end plate of the voluntary muscle fibers.

Thus, in man the 62,000 miles of capillaries receive positive electric stimulation not only from the great executive brain but also from the abdominal brain, namely, the adrenal medulla, the celiac ganglia and plexuses. When the thinking brain is asleep or under anesthesia, the abdominal brain continues to control the vascular system.

We can now glimpse the homologue of the nucleus of the amoeba in the vast nervous system of the higher animals. Equally can we glimpse the homologue of the cytoplasm of the amoeba in the muscles, glands, and blood of the higher animals. Kofoid has illustrated this in the appearance of elements akin to a nervous system in a unicellular diplodinium. Thus the dominating positive nucleus of the unicellular was evolved to see, to hear, to touch, and to smell in the higher animals, that is, the forces that give the positive charge to the nucleus of the unicellulars also determined a similar positive charge in the eye, the ear, the touch corpuscle, and the nose of the higher animals.

From these simple principles we see that the thyroid gland, whose hormone, acting as a catalyst, increases the rate of oxidation in the billions of brain cells and in the cells of the sympathetic system, produces electric charges only, hence influences the activity of the brain in training and education and in maintaining the warm-blooded state. The increase in the rate of oxidation in the brain cells and in the cells of the sympathetic system alone would not affect the body temperature; but the increased potential of the brain, controlled by the thyroid hormone, provides the constant electric stimulation of the vast mass of muscles and thus maintains the warm-blooded state against cold. This constitutes the first great oxidation or metabolic arc in man and animals.

Just as the nucleus of the ancestral amoeba was the universal executive, so the brain in the higher animals is the universal executive. In addition to a constant executive stimulation for temperature, for muscular work, and for intellectual work, the brain is equally the executive for crisis energy. In combating an infection with a fever, in fighting or fleeing from an enemy, in the expression of the emotions, the adrenal glands and the sympathetic system inhibit the thinking or new brain and violently stimulate the old or energy brain that executes fighting, escaping and emotion.

Thus two types of energy can be discerned among animals. In each the brain is the executive. In one synthesis the brain is the executive and the adrenal glands are the excitants of outburst oxidation. The brain cells mobilize executive energy, the pounding heart increases the negative electric potential of the trillions of red blood cells, the respiration is accelerated, and the entire energy mechanism for executing violence is mobilized.

The adrenal glands play a lesser role in the mobilization of constant energy. The constant energy necessary for adaptation to cold or to constant muscular work, such as is required for a long migration, a long chase or by the porpoise and the whale for rising at frequent intervals day and night to the surface of water to breathe or by man in his daily task, is established by a synthesis of the brain and the thyroid gland, the heart and the blood volume.

Evolution of the higher animals centered in muscular power. Muscular power is controlled by the joint action of the positive side of the metabolic arc, the brain, and the negative side of the metabolic arc, the heart and the red blood cells.

The constant tempo of the brain and the heart is controlled by the hormone thyroxin, the product of the thyroid gland. The emergency tempo of the brain and the heart is controlled by the hormone adrenalin, the product of the medulla of the adrenal gland, and the hormone sympathin, the product of the celiac ganglia and sympathetic plexuses. The energy of the whole is derived from oxidation that completes the trillions of metabolic arcs within the animal.

Basal metabolism includes not only the metabolism of all the nucleated cells of the organs and tissues of the body but also the oxidation in the voluntary muscles required to maintain the warm-blooded state. Adaptive metabolism is the oxidation response from mere awareness to outburst energy in fight or flight or in the expression of the emotions.

From the foregoing it would seem that in man and animals there are two kinds of mechanism for the control of oxidation. One system possesses the mechanism of the amoeba, in which oxidation is controlled by enzymes and catalysts. This system applies equally to all the nucleated cells in man and animals.

In the other system, which is constructed on the principle of the carbon lamp, the brain furnishes the positive charge, and the red blood cells, through the mechanical energy given by the contraction of the heart, supply the negative charge. Thus are provided the quick and powerful variations in the speed of oxidation, hence in the speed of muscular contraction from a mere muscle tone to the rush of the lion or the escape of the zebra.

Thus the intelligence, power, and personality of man and animals would seem to be dependent on the absolute and the relative sizes of the brain, the heart and blood volume, the thyroid gland, and the adrenal-sympathetic system.

Part II

COMPARATIVE ANATOMY AND PHYSIOLOGY

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3. THE AFRICAN FRONT

In the civilized part of the world the soil, the plants, and the animals are so completely under the domination of man that one can scarcely see the play of the great natural forces, free from the modifications made by man.

In the First World War I attempted an interpretation of man at war in France[1]—rich, beautiful France, for ages modified by a brilliant, industrious, artistic people, a land of terraced vineyards and trained trees, a land of metaled highways and model villages, a land where the cycle of fertilizing, sowing, reaping, and fertilizing again keeps a part of the surface of the earth in ceaseless rotation.

It was from this territory, at an intensely human stage, that I viewed the Great War. On this land masses of French, German, English, Italian, American, Australian, New Zealand, East Indian, Canadian, and Portuguese troops were crowded in dense concentration. On this land was also the greatest massing of human mechanisms ever seen. There were mules, horses, dogs and pigeons, bred and trained by man. There were such nonliving mechanisms of energy as motor cars, tanks and tractors, airplanes and balloons, shells and bullets, bombs and mines, firebrands and poison gas; there were bayonets and trench mortars, radio and telegraph, Red Cross nurses, surgeons, priests, prayers, and oaths.

In our expeditions to equatorial Africa I visited a front that civilized man has not dominated; a front in many respects as intensive as the French front of the First World War, though devoid of civilized elements; a front that derived its driving energy from the equatorial sun and some of its rich soil energy from one of the greatest events in geologic time, namely, the formation of the great rift between Africa and Asia.

[1] "A Mechanistic View of War and Peace," The Macmillan Company, New York, 1915.

In the First World War the struggle among rival nations was for dominance. On the African front the struggle is for food and against a natural prey. On the French front there were no women and children. On the African front young are born and raised, and each member of the family spends his life struggle on the front.

On the French front a casual observer could see nothing —no gun, no soldier. The nearer the fighting front the more peaceful and quiet it seemed when no "kill" was on. It is likewise with the African front. The African front is in every blade of grass. It is in the water and in the air. It is behind every sheltering tree or rock. It is in the burrows, in the deepest jungle, and on the open plain.

In France the front existed for several years, only. The African front began when life began. As many soldiers populated the French front as animals the African front. On the French front raids were common. On the African front no night passes without raids. In war camouflage is utilized. In Africa animals are born camouflaged.

In Africa each day the native kills many animals with poison arrow, spear, or trap, and each day a number of natives are killed by poison fangs, teeth, or claws. Each day, also, lions, leopards, cheetahs, civet cats, jackals, ostriches, secretary birds, and the greater and lesser bustards kill thousands of mammals, birds, snakes, and scorpions. Birds kill thousands of insects, and insects, in turn, kill myriads of birds and animals; and the countless billions of living things revealed only by the microscope—the greater world of bacteria—take the largest toll.

Not only is the animal world in constant struggle in Africa, but, on an even wider front, plant warfare is extended. Many animals attack plants, and plants, in turn, defend themselves against the animals by thorns, by poison, by bitter acrid taste, by climbing heights, by delving into swamps, and by forming jungles. Just as the most relentless warfare of animals is animal against animal, and just as man's warfare against man is the most bitter, so in the plant world the most relentless warfare is that of plant against plant. A plant fights for sunshine, for moisture, and for soil, and to this bitter struggle plants draw many animals. The nectar of flowers entices the insect to fertilize distant plants and trees. To exact payment for the fruit, which bears energy to the animals, trees subsidize animals to spread their kind by carrying their seeds.

Thus the plant sustains and kills the animal; the animal sustains and kills the plant; billions of plants and animals are killed, and millions are born every day in this age-long struggle; in fact, a day on the African front is a day of countless deaths, countless births, countless conflicts, countless victories, and countless defeats.

4. MAJI MOTO CAMP

At Maji Moto Camp in the Rift Valley, Tanganyika, Africa, 2° south of the equator, theoretically and practically we were engulfed in energy. Here titanic forces, past and present, nonliving and living, have been at play during geologic ages, creating, destroying, advancing, regressing. Our camp was in the midst of a dense tropical forest that hugged the base of the high west escarpment of the East African Rift Valley and was only a mile away from Lake Manyara. The little rains had just ended. The grass was green and in rapid growth. During the day the sun poured down its energy.

A short trek from our camp were the Maji Moto hot springs. In the distance, to the east, was the highest of all African mountains, the snow-covered Mount Kilimanjaro, and a hundred miles away was Mount Meru. To the south was the beautiful Oldonyo-lengai, the Mountain of God, and to the west was the enormous crater Ngorongoro.

Besides these giant volcanoes, one towering 19,000 feet and more into the skies, there were also volcanoes of lesser size, down to mere potholes. It was as if every giant had its progeny.

The great crater of Ngorongoro is 12 miles in diameter. It is surrounded by a rim or escarpment 1,500 feet high. The soil of this crater affords a high yield of life energy; the deep volcanic ash, the rainfall, and the tropical sun produce a luxuriant growth of sweet clover. This supports about 50,000 head of animals, the wildebeest predominating, and this unbelievable mass of Herbivora, in turn, supports large numbers of lions, leopards, hyenas, and vultures.

For centuries, within this crater, the soil and the sun's energy have been producing cycles of clover, wildebeest, and soil again. A constant stream of innumerable insects, flowers, scorpions, spiders, snakes, birds, ants, Herbivora, predatory animals, and native men go in—and all return to it again!

Through this endless cycle of change, life has moved on, sometimes as a hyena, sometimes as a flower, sometimes as a snake, sometimes as a man—every living thing has once been something else; every living thing will return to the universe in some other form.

Obviously, it is identical energy that creates and energizes them all—all that is under the clover, in the clover, and above the clover—identical nucleus and cytoplasm of the living cell; identical electrolytes; identical water; identical sunlight; in fact, in all essentials life is identical. It is the many forms of life only—the many forms, the many colors, the many sizes—that appear to be unrelated.

What a romance could be written of the adventures of a single electron, one that was born in the endless abyss of space, perhaps of the great fire mist from which our earth was condensed, aeons old, yet beginning its new life today in the body of a young gazelle just born in the clover fields of Ngorongoro! How significant that the structure of the living cells in this sequestered treasure island of life remains the same as that of the cells of the animals of the far-away ocean or in the arctic! How significant it is that, despite their instability, living cells remain constant in dynamic pattern and constant whether in man or wildebeest or clover!

This constancy of the living form is due to the constancy of the laws of physics and chemistry. Life is constructed by their interplay. When the nature of one beam of light is discovered, we shall know the nature of all light; when the nature of one atom is discovered, we shall know the nature of all matter; when the nature of one living cell is discovered, we shall know the nature of life.

It was this theater of Vulcan in the greatest rift in the earth's surface, where there exists the largest aggregation of volcanoes in the world as well as the greatest aggregation of animal life, that we entered. What could be the relation between the cataclysm that caused this enormous rift and the existence of most abundant animal and vegetable life known?

Under this rift, probably a hundred miles deep, are masses of tumbled rock that still generate heat at millions of points of contact. Hot springs and earthquakes—examples of injury and repair of the earth—are frequent in this region.

The friction in this pile of upheaved rock causes a melting and vaporization of rocks, and the eruption of volcanoes, great and small, spreads ash over thousands of square miles. This volcanic ash is a mixture of all the elements in the rocks. Chemically, it is a perfectly mixed soil, so uniformly pulverized that rain is absorbed and held, so light that oxygen enters into it easily; therefore roots may stretch out in any direction, and the result is the abundant vegetation that supports abundant animal life.

Thus Maji Moto camp had a setting of plentiful grass, ample water, great swamps, vast forests yielding every kind of vegetation from grass and flowers to scrub growth and dense jungles. Among the trees were mimosa and acacia, which supported the long-necked giraffe, dense bush and open plains where the rhino roamed, enormous forests in which elephants fed, swamps of coarse grass that hid buffalo, and impenetrable marsh, the habitat of the hippopotamus.

In plains near by were giraffe, eland, kongoni, impala, gerenuk, hartebeest, kudu, zebra, wildebeest, oryx, steinbok, Thomson's and Grant's gazelles, dik-dik, and warthog. Patrolling the plains like sanitary police were ostriches, greater and lesser bustards, and crested cranes, all of which derived their living from locusts, lizards, toads, and the many small animals found on the plains.

On the shores of the lake fed many varieties of ducks, marabou, and European storks and the beautiful pink flamingoes. On the edge of the forest, high in the spreading branches of the great trees, baboons, Sykes's monkeys and gray monkeys chattered, hyraxes and big-eyed lemurs

FIG. 1.—Elephants in the forest.

called, and in the shadow lurked stealthy pythons, mambas, and agile lizards.

Preying on this great concourse of animal life were many carnivorous mammals such as lions, leopards, cheetahs, hyenas, serval and civet cats, jackals, wild dogs, and foxes, as well as such large carnivorous birds as eagles, vultures, and hawks. In the midst of this concentration of plant and animal life our camp was located, yet in the midst of all this seeming drama there appeared to be only peace.

As if in obedience to unseen forces, this animal on the plain, that in the jungle, the great and the small, adjusted themselves with relation to each other, much as colloids are spaced by electric charge.

But the quiet about Maji Moto camp was like the quiet before a great battle, because, like the ether that is permeated with ether waves, the air in which these myriads of animals were enveloped carried sound waves of various lengths, chemical emanations of various kinds, and light waves.

As sound and odor constantly pervade the air that passes through myriads of ears and nostrils and as the senses of hearing and smelling by day and night vary with the movements of animals here and there, our camp was known to thousands of our great and little neighbors and to the native Masai with their herds of cattle. These animals, meat eaters and grass eaters, all know each other well.

The native Masai is the top animal. In cooperation with his fellow men, he can spear a lion. He can trap a leopard and build a boma to protect his hut. None of the other animals can do more than secure their food. The grass eaters merely crop the grass. The meat eaters secure food by killing the grass eaters. The grass and the trees take their life from the soil and the water and the sun.

All the parts of this living picture—insects, animals, and plants—are mechanisms of energy. The Masai native is the most highly specialized energy mechanism of them all.

5. RHINOCEROS AND BUFFALO

LIFE in Africa is sensitively balanced. Among the grass eaters there is cooperation for defense. A kongoni, posted on an anthill, serves as a sentinel for herds of grazing antelope and zebra. When a baboon or small monkey, stationed high in a tree, sees a nearly submerged crocodile, he will, through his own alarm, signal danger to animals coming to drink. The beautiful buff-backed egrets and white herons, suddenly rising from the high reeds and dense papyrus, cause the near-by elephant and buffalo to be wary.

As we trekked out to Lake Manyara one morning, we saw a solitary rhinoceros in the high grass at the edge of the sandy beach. Passing some fifty yards downwind of him, we noticed small brown birds rising from his back. Immediately sensing danger, he whirled and, catching the scent, started in our direction; but when within 50 feet of us, he as suddenly stopped, circled once or twice, then trotted off into the bush.

The insignificant ears of the rhinoceros testify to his lack of enemies. The piglike eyes show that sight is not a paramount factor in his survival. The rhinoceros depends upon the small, red-beaked birds that perch upon his back to serve as a warning to him. When these tickbirds fly from him, the simple memory mechanism of the rhinoceros associates danger. Thus the rhino bird and the rhinoceros are in cooperation.

Although the eyesight of the elephant and the hippopotamus is poor also, the elephant, the hippopotamus, and the buffalo, having used their senses of sight and hearing to detect danger, have evolved a greater intricacy of action patterns than the rhinoceros.

Wearing a heavy armored skin, the rhinoceros pushes noisily along among the shrubs and bush, through thorns and high grass, crushing everything before him. He sees little until he bumps into it. Whatever he meets, within reason, he eats. Had the rhinoceros no foe worthy to contest with him for the best stand of heavy grass and bush, he would need to have only sufficient muscle to carry his ample paunch and to procreate; and, being a vegetarian, he could always find food. But the rhinoceros has formidable rivals that eat from the same abundant table. Even though these powerful beasts are apparently at peace in the same area, it does not follow that they do not fight each other.

The rhinoceros has a powerful muscular machine behind a peculiar belly-tearing horn and has evolved a swift charge at the first scent of a possible enemy, but he does not spend his time in killing other animals. His is a defense mechanism, passive and active at the same time.

Since the rhinoceros eats noisily, his sense of hearing, although of more value to him in the bush than his sight, is not adequate. It is his sense of smell that discloses the approach of his rivals, and in the dense bush the sense of smell can serve the rhinoceros when his eyes and ears cannot.

Since the body of the rhinoceros is massive and near the ground and since his horns are poised vertically on the platform of his extended snout, it is to his advantage to make a sudden mass attack before giving his opponents opportunity to maneuver.

Clearly, this great bush mechanism has no pattern for jumping or for long-distance running. The rhinoceros is not geared for a long chase. His effort is always a short attack. His mechanism is patterned like a heavy tractor.

Each morning fresh tracks could be seen near the camp at Maji Moto, and each afternoon near sundown rhinoceroses could be seen rolling in the sand near the shore of the lake to rid their skins of ticks and to enjoy the warm sunshine on the beach.

Early one morning, Mr. Fuller shot for our Museum of Intelligence, Power, and Personality an adult male that weighed 1,683 pounds. Raising a tarpaulin over him and suspending our 600-pound scales on a limb, we made our dissection where he fell.

Dissection showed that the distribution of the muscles of the rhinoceros differs greatly from that found in antelopes or in the lion. There were five principal masses of muscles: one for the powerful head and one for each of the four stocky legs. The muscles of the back were not comparable to those of the antelope or of the horse family. The rest of the body exhibited but relatively little muscle, which suggested a mechanism adapted to straightforward progression with powerful action of the head and little or no power of jumping.

The bones of the vertebral column were soft and contained much blood and cancellous tissue, the skull and the ribs were exceedingly hard, and the muscles of the neck, which operated the great horn, were more massive than those which operated the legs.

The dimensions of the heart were 12 inches from base to apex and 8 inches transversely. The heart weighed 4,800 grams. The wall of the left ventricle was 2 inches thick. The aorta measured 2 inches in diameter, and its wall was 5/16 inch thick. The coronary artery was so large that it admitted the forefinger.

The brain weighed 655 grams or a little less than one-seventh of the weight of the heart. The convolutions of the brain were small as compared with those of the brain of an antelope. The olfactory lobes were especially prominent, being projected forward in bony cavities leading toward the snout, somewhat as in the case of the alligator and crocodile. The pituitary gland was relatively large.

The eyes of the rhino weighed 22.56 grams; the eyes of a 55-pound Thomson's gazelle weighed 26.9 grams.

The major, minor, and lesser splanchnic nerves (sympathetic system), contrasted with those of man, were heavy, and the sympathetic complexes and celiac ganglia were massive, showing that the rhinoceros is equipped for explosive attack.

The adrenal glands were elongated. They weighed 88 grams. Incising one adrenal gland, we found that the medulla was approximately half the total volume of the gland. In man the medulla is one-tenth the total volume of the gland.

The thyroid gland was elongated vertically and weighed 53.05 grams. There was no isthmus.

This dissection showed that the rhinoceros possesses the equipment of a high-powered, flexibly armored mechanism adapted to bush life. Through the high development of the adrenal-sympathetic system and the heavy muscles massed in five areas and vascularized and oxygenated by a large heart, a large vascular tree, and large lungs, this old-world beast is geared for powerful attack. This dissection showed that the rhinoceros possesses a mechanism adapted for instantaneous mobilization of energy. As indicated by the prominent development in the brain of the olfactory lobe and a lesser development of the ophthalmic area, it is obvious that a rhinoceros apprehends danger primarily through the sense of smell. Since the rhinoceros is unpredictable and implusive in behavior, the association tract of the brain was, as we expected, small, indicating a low order of intelligence; but the high development of the adrenal-sympathetic system indicated an unstable temperament. The rhinoceros exhibits curiosity and indifference or curiosity and attack. By reason of the relatively small brain and the small thyroid gland, in contrast to the relatively large brain and large thyroid gland of man, it is inconceivable that this great pachyderm could either develop exophthalmic goiter or intelligence.

Inasmuch as there are many conflicting opinions as to the prowess of the rhinoceros and the African buffalo, it is interesting to compare the energy-controlling organs of these two animals. The table that follows shows that, although the male rhinoceros and the male buffalo that we collected were of approximately equal weight, the brain of the rhinoceros was 1⅙ times heavier than that of the buffalo, the adrenal glands of the rhinoceros were nearly 1¾ times heavier than those of the buffalo, and the thyroid gland of the rhinoceros was 1⅓ times heavier than the thyroid gland of the buffalo.

Animal	Body weight, pounds	Brain weight, grams	Thyroid weight, grams	Adrenal weight, grams	Heart weight, grams
Buffalo	1,676	560	38.05	50.4	3,628
Rhinoceros	1,683	655	53.05	88.	4,800

The weights of the energy-controlling organs of these two great animals seem to indicate that the rhinoceros can execute a more formidable immediate attack than the buffalo.

6. EAGLE AND VULTURE

WHETHER the soaring vulture locates carrion by the sense of smell or the sense of sight is often a subject of speculation. During the day one almost never sees a vulture in Africa except when an animal is brought down; then vultures drop from the sky in numbers. They come apparently from long distances, with and against the wind, as if they had been spread above the earth like a net.

The collaboration of vultures is a fine example of cooperation, since the carcass of one animal provides food for many. Were there no cooperation, vultures would fare badly because of the rapid disintegration of the dead. By soaring in the cool air, spaced apart, a network of vultures could form an air patrol over most of the land in Africa.

The valiant eagle does not thus organize, for he kills no animal larger than he can eat alone. The eagle is an individualist. Speed with him is a prime necessity. He must work fast and near the ground. Vultures and eagles represent two principles in nature, the cooperative and the individualistic.

By reason of cooperation the vulture spends little energy for finding his food, since the telltale actions of those that are descending serve as the signal to those still stationed in the skies, and little energy is used in the actual process of gorging. Thus the vulture is operated at a lower kilowatt cost than the eagle, and vulture cooperation and economy of operation enable the land to support more vultures than eagles.

Inasmuch as the eagle is adapted to soaring passively and to flying vigorously and the vulture is adapted to soaring passively and is not adapted to flying vigorously, we should expect the vulture and the eagle to exhibit a distinct difference in their adrenal-thyroid relation and in the size of their brains.

The eagle must first overtake its prey, then seize and lift it from the ground, or capture it in mid-air. The vulture, constantly soaring, scans the ground for food, which, being dead, cannot run away. Since it is soft no unusual energy is required to devour it. Theoretically, therefore, one would expect to find that the eagle possesses larger celiac ganglia and plexuses than the vulture.

The energy requirements of the vulture are on the order of the long-pursuit animals, such as the wolf, whereas the energy requirements of the eagle are on the order of the cat family that rush their prey.

If it is through the sense of sight that the vulture and the eagle detect their food, then the eye and the optic lobes of the brain would be not only highly developed but also comparable in size, and the eye itself would show telescopic properties and a high ratio to the body weight. On the other hand, should it be through the sense of smell that the vulture detects food, then the olfactory lobes of the brain would be prominent, as in the case of the dog family.

On the same day that we dissected eagles we dissected vultures. The brains of the eagles were all relatively larger than the brains of the vultures. The olfactory lobe of neither the eagles nor the vultures indicated that they detect their food through the sense of smell. On the contrary, the optic lobes in both the vultures and the eagles were highly developed. In the eagles the two eyes weighed more than twice as much as the brain. In the vultures the eyes weighed slightly less than the brain.

In the eagles the adrenal glands were 1½ times as large as the thyroid gland, following the pattern of the cat family; in the vultures the thyroid glands were nearly equal to the adrenal glands in size, as in the dog family. These facts interpret definitely the contrasting behavior characteristics of these two great birds.

Let us now compare the energy-controlling organs of birds that are both larger and smaller than the vulture and the eagle and that are neither scavengers nor birds of prey.

The beautiful egrets are largely insectivorous. They follow the herds of buffalo and elephant through the dense swamps of reeds and feathery papyrus, often lighting on the backs of these large animals. Their habit of darting after swift-flying insects, taking them on the wing, as the elephants and buffalo force their way through the thick reeds, or searching out worms and larvae as the feet of these animals uncover them in the marshy ground suggest that the egret bird possesses a preponderance of adrenal glands over thyroid gland, as compared with the ratio found in the passively soaring vulture or in birds such as the stately crested crane that quietly pick up their food while they walk on the veldt.

The adrenal glands in the African yellow-billed egret showed a preponderance over the thyroid gland of 14 to 7, and in the great white egret, of 21 to 13; in the crested crane the preponderance was 30 to 26 and in the guinea fowl, 36 to 29. The greatest preponderance of adrenal glands over thyroid gland, hence of flash energy over constant energy, that we found among the birds in Africa, was in the eagle, which is a bird of prey.

Another interesting contrast in the energy characteristics of birds is seen between the European stork and the adjutant or marabou stork. Each year the European stork makes its migration from Northern Europe to the Rift Valley, where locusts drop at its feet. Such a long migration would necessitate sustained energy. The European stork exhibits an adrenal-thyroid energy pattern of 49 to 43.

The marabou stork of Africa is not a migrating bird. Like the vultures, it is a scavenger. Its flight is powerful and reaches incredible heights. But the marabou stork is pugnacious. It dominates the vultures at the kill. The adrenal glands of the marabou stork are more than three times larger than the thyroid gland.

The pink flamingo, one of the goose tribe, lazily feeds on aquatic invertebrates and seems to make no special energy effort in bending its neck to scoop into its capacious bill small Crustacea, then tilting its head to filter the brackish water through the lamellae of its lower jaw.

The flamingoes in thousands may leave one brackish volcanic lake to search out food in another. One night in Maji Moto we heard the whir of the untold numbers of their wings and saw them for hours silhouetted in graceful flight across the pale face of the moon. But the flamingo of Africa is not a migratory bird.

As one would expect from a life of such easy feeding, the adrenal and thyroid glands of the flamingo are nearly equal in size (0.51 to 0.50).

The Egyptian goose, in contrast, has to search out its food. It frequents streams and pools and small lakes, where it feeds on grass, algae, and minute animal life. In contrast to the flamingo, the Egyptian goose is "quarrelsome." It bears an adrenal-thyroid pattern of 42 to 34.

7. WARM-BLOODED VERSUS COLD-BLOODED

Two great energy divisions of the animal kingdom are the warm-blooded animals and the cold-blooded animals.

The energy advantage of the warm-blooded state over the cold-blooded state is expressed by van't Hoff's law that with each degree centigrade of rise in temperature the speed of chemical activity is increased 10 per cent. This law applies equally to living and to nonliving systems.

In accordance with such a law it would follow that a cold-blooded animal having a temperature of 22°C. would be at a disadvantage in a fight with a warm-blooded animal having a temperature of 37°C., for the warm-blooded animal, being 15° warmer than the cold-blooded animal, would be endowed with a speed of chemical activity 150 per cent greater than that of the cold-blooded animal.

Cold-blooded animals, with their low order of intelligence, power, and personality, occupy a less favored place on the earth. Many devices to protect them from the keener, more alert, and powerful warm-blooded animals have evolved. Snakes had to accept a life on their bellies. Other animals were obliged to resort to color protection, as in the case of certain lizards, or to a carapace, as in the case of the turtle. The alligator and crocodile took to the swamps. Since they are armored, it is unnecessary for them to build up mechanisms for fighting. Like biologic traps, they lie in wait for their prey and require but slight effort to find their food, while energy is supplied to them directly through their carapaces as they bask on the sunny bank.

It may be urged that reptiles such as the alligator, the crocodile, and the turtle breathe the same air, with its 20 per cent of available oxygen, that the lion and the porpoise breathe, yet the alligator and the crocodile are energized at a lower level than the lion or the porpoise. Therefore, there must be some other factor than oxygen tension that determines the relatively small size of the energy-controlling organs and the low level of the energy of the alligator and the crocodile.

The kind of habitat in which an animal lives is always a factor for consideration. In the still waters of the swamps and sluggish rivers, with their low oxygen tension, we find cold-blooded sluggish fish, sluggish turtles, and sluggish reptiles. In such waters hunting is not necessary.

The territory available to the warm-blooded animals is the greater part of the earth's surface. The lion, the hawk, the fox employ their keen eyes, ears, and noses and their 150 per cent higher power of chemical activity in hunting. Should the Herbivora be decimated, the Carnivora would starve. The Carnivora could never exterminate the grass and leaf eaters, since the Carnivora would be exterminated first. They cannot eat grass or leaves.

What about the reptiles? The reptile, in the midst of abundant oxygen, remains cold-blooded. As an adaptation of safety, with no energy required for keeping warm, with little muscular power needed for defense or to secure food, and with a minimum of food requirements, the alligator and the crocodile are literally fed by their prey. The passive state of these two reptiles protects the level of their food supply, and they are so formidable that they can destroy any other food-competing animal, thus further protecting their food supply.

Were the alligator and the crocodile warm-blooded, endowed with keen eyes and ears, and empowered with a vigorous nervous system on the order of that of the porpoise, they would quickly exterminate their own food supply.

Thus the competition among reptiles is toward negativity, and the struggle among warm-blooded animals is toward positivity. Competition for negativity takes the form of the development of the most effective armor, the most effective concealment, the most effective sting and poison. In the case of the alligator and the crocodile we have a negativity of the greatest degree, a negativity below that of the cold-blooded fish.

This point may be illustrated by a comparison between an alligator captured in Florida, weighing 450 pounds, and a white whale captured in the subarctic, weighing 472 pounds. The white whale, a warm-blooded mammal, was an occupant of the cold arctic sea. The white whale requires a large amount of food to maintain its warm-blooded state and to enable it to come to the surface once a minute to breathe.

The contrast in the behavior characteristics of these two animals of approximately equal weight is seen in the striking difference in their energy-controlling organs. The brain of the white whale weighed 2,390 grams; the brain of the alligator weighed 14.08 grams. The heart of the white whale weighed 1,370 grams; the heart of the alligator, 318 grams. The contrast in weight between the adrenal glands of the white whale (19.13 grams) and those of the alligator (11.96 grams) was negligible, but the contrast in weight between the thyroid gland of the white whale (65.32 grams) and the thyroid gland of the alligator (13.32 grams) is a striking example of the mechanism of constant energy, which is controlled by the brain and the thyroid gland and not by the adrenal glands.

Compared with the white whale, the alligator possesses an extremely low level of intelligence, power, and personality.

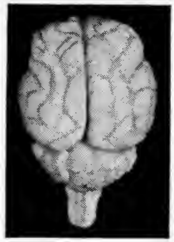
In the course of our researches we brought alive to the laboratory of the Cleveland Clinic Foundation alligators, crocodiles, lions, and tigers and administered lethal doses of chloroform or ether. The contrasting speed, power, and alertness were strikingly different in the alligator and crocodile as compared with the lion and tiger. When roped, an alligator and a crocodile, each about 11 feet long, weighing 450 and 295 pounds, respectively, were easily held by hand. Separated from their water and mud environment, they were more or less helpless creatures. In contrast was the fearful power of the lion and the tiger as it was partially revealed while they were being chloroformed.

In contrasting lions and tigers with alligators and crocodiles, we are considering animals equal in mass of muscle but wholly unequal in muscular power and in length of life. An alligator or a crocodile may live a hundred or more years, whereas a lion or tiger in the wild seldom attains an age of fifteen years. At first one wonders why evolution could not have made an alligator or crocodile as powerful as a lion or tiger. The answer is that evolution exploited all the possibilities of power for animals constructed on the cold-blooded principle.

Warm-blooded animals, cold-blooded animals, fish, reptiles, birds, carnivores, grass eaters, and leaf eaters are each as large and as powerful as they can be. Since growth, function, and work relate solely to energy, it is clear that the fundamental principle of evolution is the play of energy. Evolution, therefore, centers on the organs controlling the rate of oxidation, namely, the brain, the heart, the blood volume, the thyroid gland, and the adrenal-sympathetic nervous system. This energy system in animals has the power to endow warm-blooded animals with all the energy they can utilize to the level of heatstroke. A cold-blooded alligator weighing 204 kilograms (450 pounds) has a brain and a metabolism only approximately equal to that of a hare weighing 2 kilograms (4.41 pounds). Thus the comparative size of the brain, the thyroid gland, the adrenal-sympathetic nervous system, the heart and the volume of the blood, in relation to the weight of the animal, tells the story of the evolution of energy in the various species.

The difference in energy characteristics between such a somnolent animal as an alligator, which does not have to

LION



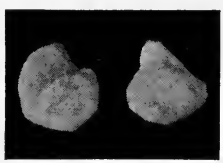
Brain—261 grams.

ALLIGATOR

Brain—14.08 grams.

Thyroid gland—22.52 grams.

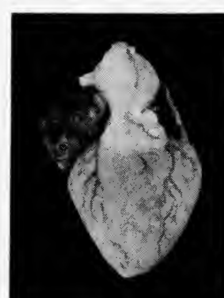
Thyroid gland—13.32 grams.



Adrenal glands—34.64 grams.

Adrenal glands—11.96 grams.

Heart—1,175 grams.



Heart—318.4 grams.

FIG. 2.

bear its own weight in the mud-water medium as it lies in wait to entrap its prey, and a lion, an animal possessing the most fulminating energy known, is seen in the contrast of the energy-controlling organs of these two animals. The weight of these two animals was approximately the same, the weight of the lion being 430 pounds and that of the alligator, 450 pounds. Both animals are carnivorous. Note the brain of the lion. It weighs 261 grams, whereas the brain of the alligator weighs only 14.08 grams (Fig. 2). Note, also, the thyroid glands that maintain the constant level of oxidation. The thyroid gland of the lion weighs 22.52 grams; the thyroid gland of the alligator weighs 13.32 grams.

Note the adrenal glands that execute crisis energy. The adrenal glands of the lion weigh 34.64 grams; the adrenal glands of the alligator weigh 11.96 grams. The heart of the lion weighs 1,175 grams; the heart of the alligator weighs 318.4 grams.

In Fig. 3 note the striking contrast between the complicated network, the mass of interlacing nerves, the large celiac ganglia and plexuses of the adrenal-sympathetic system of the lion and the simplicity of this mechanism and the absence of the celiac ganglia and aortic plexuses in the alligator. In the lion, on each side, eighty-two nerves extend from this mass; in the alligator but three.

No one could fail to see the difference in power that is generated by these two mechanisms. The blueprints of a tractor engine and an airplane engine could be no more enlightening. Both the alligator and the crocodile are master animals in their limited environment, but the master cold-blooded animal shows a marked contrast to the master warm-blooded animal.

Another striking contrast between a cold-blooded animal and a warm-blooded animal is seen in a comparison of the energy-controlling organs of a python that we collected in Africa with a sparrow that we collected in Cleveland.

The habitat of the python is the swamp and the damp, but not too thick, forest. The python—a cold, slippery mechanism—a living rope, equipped with strong teeth at

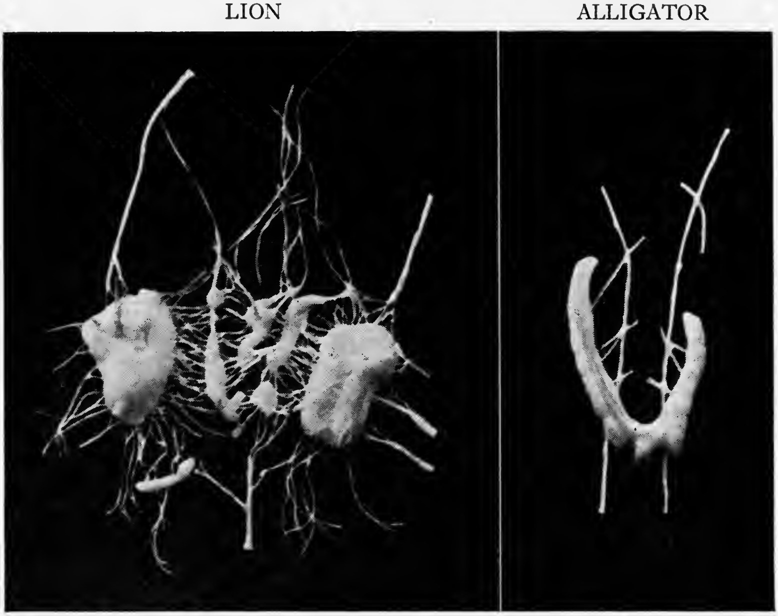


Fig. 3.—The adrenal-sympathetic complexes of the lion and of the alligator.

one end and two strong hooks at the other, has been evolved to encircle the chest of its warm-blooded victims so tightly as to deprive them of oxygen. The python possesses a small brain, a small heart, small thyroid and adrenal glands and requires a minimum of food. How is this low-power mechanism adapted to kill? The special act of the python is to produce asphyxia. Warm-blooded animals are endowed with powerful and sensitive energy systems and require an abundance of oxygen to maintain their warm-blooded state. Under danger they rush into a raging metabolism and require accordingly a greater respiratory exchange.

From the viewpoint of a fair fight or a fair getaway, nature seems to have evolved in the python the technique of killing at its worst. But from the viewpoint of the needs of the python, the steady pressure around the chest of its victim until asphyxiation produces death leaves the maximum of nourishment in the flesh of its prey.

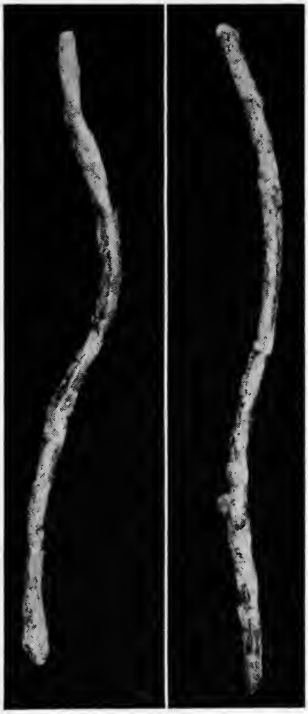


Fig. 4.—The adrenal glands of a python.

Why should not the python itself suffer in this deadly embrace? The adrenal glands of all animals are soft and easily crushed. The blood vessels in the adrenal glands and the gland tissue itself are almost as vulnerable as brain tissue. Yet the python puts pressure on every part of his own body in his ropelike coil. In the terms of the spherical adrenal glands found in most warm-blooded animals, the python would have crushed his own adrenal glands as easily as the body of his victim. The adrenal glands of the python follow the pattern of a shoestring and are tucked away effectively from the pressure of a tight embrace.

The bird has to feed its furnace continuously in order to maintain its warm-blooded state. The python gorges, then lies in a semicomatose state until hunger requires that it feed again. A comparison of a cold-blooded python weighing 6,140 grams with a warm-blooded sparrow weighing 24.03 grams shows that the weight of the brain of the python (1.123 grams) barely exceeds the weight of the brain of the sparrow (1.031 grams). As a corollary, the heat production or metabolism of the cold-blooded python and that of the warm-blooded sparrow are approximately equal.

8. INTELLIGENCE OF BIRD AND REPTILE

THE outstanding characteristics of the ostrich, as one first sees it on the veldt, are the large muscular legs that are developed to an extraordinary degree and the pole-like neck, at the top of which is a small, flat head that seems little larger than is necessary to carry a pair of eyes. The cocks stand as high as 5 feet at the shoulder and may weigh 275 pounds or more.

The ostrich is a powerful animal, whose kick can foil his enemies, whose speed compares with that of the fleetest of mammals, whose habitat is exclusively the open plains or the bare desert, and whose eyes, placed high in a watch-tower position, make him wary and difficult to approach. Ostriches usually are seen in pairs or small groups, such as an old cock with his harem of hens, but often one sees larger groups of twenty or more males and females. Although the ostrich is omnivorous, it belongs to the group of birds that diligently police the veldt, picking up snakes and lizards as well as berries and gravel.

Let us analyze this largest of all birds to see how, without the use of wings, it can successfully meet its competitors and its enemies, the most powerful and cunning of the Carnivora, such as the lion, the leopard, the cheetah, and the serval cat.

The ostrich is an eye-controlled mechanism with a simple pattern of action. The ostrich needs only to see, to run, to court, to mate, to brood, to eat. The long, heavily muscled legs provide stable support, a long stride, and a powerful kick. Having but two legs and wings that are not adapted for flight, the ostrich requires less brain than a mammal of the same weight.

On the Kiteti Plains we collected a cock ostrich that weighed 272 pounds. The brain that directed that mechanism weighed only 42.11 grams. The contrasting behavior characteristics of the ostrich and the antelope were strikingly illustrated by the fact that the brain of a 295-pound kongoni that we collected the same day weighed 275 grams. The brain of the ostrich consisted almost entirely of the optic and auditory lobes and thalamus. There was only slight development of the olfactory lobe and of the association centers, whereas the auditory and olfactory areas as well as the optic and association centers in the kongoni are well developed. Since the ostrich is eye-controlled, it is not surprising that a single eye weighed more than the brain or that the two eyes were equal in weight to the eyes of a zebra, whose body weight was twice that of the ostrich.

The long, stringlike adrenal glands of the ostrich followed the pattern of the adrenal glands found in the crocodile and the alligator. The thyroid gland of the ostrich, dumbbell in form, located in the chest, was similar in pattern and position to the thyroid gland of the crocodile and the alligator.

The lungs of the ostrich were adherent to the rib, which is the bird pattern; hence flapping of the wings when the ostrich runs is an aid to respiration. Were the ostrich equipped in energy to lift himself in flight, he would be overcome by heatstroke.

Birds and their cousins the reptiles provide clear-cut examples of the differing influences of the warm-blooded and the cold-blooded state with respect to the size of the brain, the heart, and the thyroid and the adrenal glands.

Let us compare an ostrich that weighed 272 pounds with a crocodile that weighed 295 pounds, bearing in mind the fact that about 75 per cent of the food intake of warm-blooded animals is used to maintain the warm-blooded state and, as a corollary, the fact that the actual energy of a warm-blooded animal is used for maintaining the warm-blooded state rather than for the work of running, fighting, mating. In contrasting the energy systems of these two animals, let us keep in mind the high speed and kicking force of an ostrich compared with the lethargy and somnolence of a crocodile. Let us recall the large, bright eye of the ostrich and the small, dull eye of the crocodile. Dissection of the crocodile showed the weight of the brain to be 15.6 grams. The weight of the brain of the warm-blooded ostrich was 42.11 grams—nearly three times the weight of the brain of the crocodile.

The brain of the crocodile consisted largely of olfactory and optic lobes. It is principally through smelling that the crocodile senses its prey. "Thinking" plays little part in this great reptile. Whereas the ostrich appears to be eye-controlled, studies of the brains of both crocodiles and alligators show the crocodile and the alligator to be largely smell-controlled mechanisms. The greater part of the entire brain of both the crocodile and the alligator consists of olfactory receptors, olfactory nerves, and the olfactory lobe. Therefore, in both the crocodile and the alligator we have a mechanism that is largely driven by the sense of smell. The bird has little or no sense of smell, and its olfactory lobes are slightly developed. The sense of smell is highly important to the crocodile but practically unimportant to the bird.

Throughout nature we frequently see compensation. If an organ such as the eye is very highly developed, as it is in the case of the bird, the sense of smell is accordingly diminished. If, on the other hand, the sense of smell is highly developed, as it is in the case of the reptile, the sense of sight is diminished. In evolution the sense having the greatest survival value is paramount.

The most important characteristic of the brains of these large reptiles is the almost complete absence of the association tracts or "thinking brain." To a certain extent the simple pattern of the brain found in the crocodile and the alligator is seen in all the reptiles. The reptile, being cold-blooded, has correspondingly a lack of energy for performing more than the simplest acts required for securing food. Since its habitat is the swamp or the long grass, the reptile depends largely upon concealment for survival. The energy equipment of the ostrich, like the energy equipment of the reptiles, shows little development of intelligence or association centers. It would take little intelligence to pick up the small snakes and lizards on the wide plain. Were the reptile warm-blooded, it could perform many acts to its advantage, but to perform such acts the reptile would require a corresponding mass of brain for "thinking."

Since, by virtue of the large ratio of surface to mass, the smaller the animal the greater its protection against heatstroke, a sparrow can support a body temperature as high as 112° without heatstroke. Were the ostrich to attain such a degree of temperature, it would die of heatstroke. The sparrow's advantage in having a temperature 12° higher than that of the ostrich is that in its mental and muscular actions the sparrow can be 120 per cent quicker than the ostrich.

Between the high intelligence of the sparrow and the low intelligence of the crocodile or the alligator there intervenes the intermediate intelligence of the ostrich. The mechanism of intelligence will be discussed in a later chapter.

The brain of a robin or a crow, like the brain of a sparrow, shows a well developed mechanism for "thinking." What seems to be instinct in the bird is more likely an ability for quick thinking, an awareness of an end or object to be gained. Before there are leaves on a tree in the spring a robin flits from limb to limb, looking this way and that until it decides where to build its nest. The robin, meantime, must prevision the leaves that have not yet appeared. It must perform an accurate job of engineering in placing the nest in a safe position with regard to the wind and storm, to snakes and marauding land animals, and to its enemies of the air. This accurate piece of engineering is done by the robin's sense of sight, the impulses of which fall upon its "thinking" brain, where they are sorted and sifted until decision is made. This is the same process by which a human being locates his house. The bird, with its high metabolism, its highly organized "thinking" brain, its keen sense of sight, thinks through its intricate problems in relation to the seasons, to the night and the day, to rain and to storm, in regard to food supply, in regard to placing its nest in a safe position, in regard to combating other birds, and in regard to bringing up its young and migrating in the autumn. In all these acts, it would seem that the bird surveys, judges, and makes decisions. In other words, the destiny of the bird is determined by what is called "instinct" but which might be considered "thinking"—the exercise of an inherited mechanism fixed in the protoplasm of its species, as in the case of man.

9. THE GIRAFFE

THE lights, shadows, and colors of Africa conceal a world of animals, partly by passive color protection, partly through the intelligence of the animals. A tawny lion may be concealed even in short grass. At the slightest suspicion of danger all animals "freeze" in the sea of color that engulfs them. Even the giant giraffe blends into the landscape of soft greens and dull browns.

In the Rift Valley the wealth of game is almost equal to the density of game in an animal park, yet to our unaccustomed eyes the veldt seemed inanimate until suddenly the outline of a giraffe topped a tree, and then groups of giraffes came into view.

During the midday heat many varieties of animals seek shade under the umbrellalike mimosa and acacia trees. It is at early dawn and at sunset that animals move about.

It was after a day of sizzling heat that we sought the cool breezes of the lake at sundown. As we neared the crusted margin of the beach our attention was arrested by the gaze of a beautiful dark-skinned giraffe from over a mimosa tree. He was the big bull that lived up near Maji Moto hot springs, whose habitat we had often hoped to find—and now, just at sundown, he had come to us.

Night falls like a curtain near the equator and allows no twilight or lingering sunset. As this great beast fell on an island of white sand, encircled with high bush, his massive body was silhouetted against the white ground. Flares and a full moon lighted our dissection, and the shining eyes of lemurs and baboons and the cough of the ever-hungry hyena assured us of an audience.

According to Lydekker,[1] fossils show that the giraffe once roamed the plains of Europe and Asia, but giraffes now

[1] LYDEKKER, RICHARD, B.A., F.G.S., F.Z.S., "The Game Animals of Africa," Rowland Ward, Ld., London, 1926.

exist only in Africa. In our collection of African animals the weight of this tallest of all mammals was next in size to that of the hippopotamus and the elephant. The giraffe has the unique advantage of browsing on the foliage and young shoots of the scattered mimosa and acacia trees. In height, these trees seem to fit exactly the giraffe's size and needs.

Since these large ruminants browse exclusively on the tops of the trees and since they may reach 18 feet in height, they have so wide a vision that they cannot be lost, and since they remain largely in a given area, the young cannot fail to see their parents. Therefore, the evolution of a voice in the giraffe would have had no survival value.

The giraffe is among the most peaceful and harmless of African animals. Its enemies are the lion, the leopard, and man. It is said to be seldom that a full-grown, healthy giraffe is attacked or killed by a lion or a leopard. The calves at times are victims, but usually the mother is able to beat off enemies with her powerful forelegs. The greatest problem of the giraffe, then, seems to be the physical process of moving from one tree to the other, the maintenance of its balance, and the protection of its young from lions.

In its dignified walk the giraffe moves with the caution of a man on stilts, the racklike action of the legs being similar to that of the camel. Living in a type of country in which there is little opportunity for running, the only other gait the giraffe possesses is a lumbering gallop, which, as Maxwell[1] states, "by reason of their long legs and comparatively short body, results in a characteristic flourishing of the limbs, although in reality when seen from the rear, with so little effort do these great ruminants move that they seem to be sailing over the veldt."

The extreme wariness of the giraffe is probably due to the fact that its watchtower position affords it an opportunity

[1] Maxwell, Marius, "Stalking Big Game with a Camera in Equatorial Africa," with a monograph on The African Elephant, William Heinemann, Ltd., London, 1925.

to apprehend danger. When danger is sighted, an entire herd, with seeming concerted action, moves quietly away. If taken by surprise at close quarters, the giraffe makes its escape in an apparently effortless gallop, its neck and head extended and its tail twisted like a corkscrew high over its back. Theoretically, one can see little basis for the development of fear, worry, anxiety, or anger in this great animal.

Formerly the giraffe was ruthlessly hunted by the native for his hide, which exceeds that of any other animal in durability. Now, protected as he is from man in Tanganyika, the giraffe searches inquiringly with his gentle gaze as to the reason for man's approach.

The big bull that we collected weighed 2,689 pounds, 340 pounds of which was skin; 501 pounds, carcass; 285 pounds, stomach and intestine. The fore and hind limbs, although appearing unequal in length, were almost equal in length and weight. The heart weighed nearly 11 pounds. The shoulder and neck muscles that held erect the 400-pound neck and head were more massive than those of the lion, the buffalo, the rhinoceros, or the hippopotamus.

The head of the giraffe, as one looks up at it, appears small, but, viewed from an airplane or from above, when the great beast is lying on the ground, the head exhibits its large relative size. From the horns to the tip of the nose, the face of our specimen measured 3 feet. The forehead was beautifully symmetrical. The eyes were large and prominent and bore a gentle expression. The delicate, mobile ears were 6 inches long. The lips were long and flexible; the prehensile upper lip was covered with thick bristles.

The trachea was 8 feet long. The larynx gave no evidence of vocal cords, but above the larynx the hyoid bone and other bony structure completely protected the larynx and pharyngeal space, forming a framework, as it were, for the soft tissue that is related to swallowing and breathing. The rough thornlike tongue was over 18 inches in length and, like the upper lip, was prehensile. With this grasping tongue and mobile lips the giraffe plucks his meals from the thorny mimosa. The currycomb appearance of the tongue made us wonder if it is cleaning the body of offensive dust or debris that makes licking each other a pastime with these animals.

The energy-controlling organs of the giraffe, compared with its body weight, were small. The adrenal glands were only 20 per cent larger than the thyroid gland, about the same relationship that is found in most of the antelopes.

In the giraffe, horns are present in both sexes and make their appearance even before birth. At first they are entirely separate from the bones of the skull, but in later life they become united with the skull and are invested with skin. Although one can see no present-day use for horns in the giraffe, when one considers his long phylogeny, an adequate explanation for his keen eyes, keen ears, and keen nose is seen; so possibly, when the giraffe was a smaller animal with a shorter neck, the naked horns that now appear to be slowly retrogressing had survival value.

10. THE HIPPOPOTAMUS

INASMUCH as the giraffe belongs to the first family of even-toed ungulates and the hippopotamus belongs to the ninth family, a comparison of the energy organs of these "cousins," with their many contrasting energy characteristics, may throw light upon our theme.

The hippopotamus is a streamlined animal that has the advantage of not having to bear its own weight in the mud and water that are its habitat, and the giraffe is a land animal that has to support its own weight against gravity.

The hippopotamus floats in the water during much of his life, spending a relatively small amount of his time foraging on the land. He lives in a tropical swamp amidst luxuriant vegetation, and his bountiful table floats to him. Since his habitat is mud and water, no land animal save man approaches him, and since there is no open water except in the lakes and stretches of the Nile, crocodiles and fish do not share his surroundings, for although the hippopotamus may inhabit the grassy marshes of the lake, he is adapted to the swamp rather than to the water or the land.

Since the weight of the hippopotamus is usually borne by the buoyancy of the water and the fluid mud, the hippopotamus requires less energy than the giraffe, and, like the rhinoceros and the elephant, has little to fear save man. Even when the hippopotamus moves out of his swamp habitat to forage on the land, he does not need to carry his entire weight, as do land animals, for he establishes runways along the fresh water leading into the swamps and chooses soft soil in which his short legs need only slide him along on his great belly. Often between the footprints of these great beasts may be seen the groove that their huge bulk has rubbed along the ground. So averse is the hippopotamus to stepping over an obstacle that a slight impediment is often sufficient to cause this lethargic animal to change its course.

Since the rapidly growing vegetation of the swamp is made up largely of water, the energy value of the food of the hippopotamus per mass of intake is low. The hippopotamus must, therefore, take in a vast quantity of fodder to produce enough energy for growth, reproduction, and the securing of food.

Since the hippopotamus must provide for an enormous storage space for rough food and since he must be streamlined in order to maneuver sufficiently through the mud to secure his food, he would have to be such an animal as, figuratively speaking, lives in a houseboat. propelled by its own motor.

Having no important competitors among the grass eaters to share his vegetarian diet and having no carnivorous enemies to attack him for his flesh, the hippopotamus fights only his own kind. Therefore, this self-building, self-repairing houseboat requires only a limited number of signals or lookouts to guide him.

We should expect that the brain of the hippopotamus would be simpler in pattern than that of the giraffe. As in other marsh animals, the sense of smell would be the most highly developed sense. In the giraffe, as in the buffalo and the antelope, the senses of hearing, sight, and smell would be fairly equal. Having such a vast receptacle for fuel storage, the hippopotamus, in order to maintain buoyancy in his swamp habitat, would have a bony skeleton that is not compact, in contrast to the long tibias of the giraffe, which are as hard and dense as ivory.

The hippopotamus that Dr. Quiring and Captain Hewlett collected was a female. She weighed 2,978 pounds and was still nursing her mtoto, or calf, which weighed 1,200 pounds. The giraffe weighed 2,689 pounds. The thyroid gland of the nursing hippopotamus weighed 118.79 grams; the thyroid gland of the bull giraffe weighed only 64.70 grams.

Since the hippopotamus is the most placid and least aggressive of the African pachyderms, we should have expected a *bull* hippopotamus, had we collected one, to have a smaller thyroid gland than a giraffe of approximately the same weight. On the other hand, rapid extraction of body heat by water environment requires a large thyroid gland to maintain the body temperature. But nursing a 1,200-pound mtoto is a work phenomenon, and since the thyroid gland of animals enlarges during pregnancy and with the production of milk, it was not surprising to find the weight of the thyroid gland of the nursing hippopotamus much greater than that of the bull giraffe.

Of great significance is the fact that the standard-bred milk cows, such as the Jersey, the Holstein, and the Guernsey, show a larger thyroid gland than adrenal glands.

The adrenal glands of the hippopotamus weighed 61.10 grams, whereas the adrenal glands of the giraffe weighed 78.12 grams. The smaller adrenal gland of the hippopotamus expresses the lesser activity of the hippopotamus in comparison with that of the giraffe.

The fact that the heart of the giraffe weighed 4,990 grams and the heart of the hippopotamus 4,536 grams may be ascribed to the greater amount of energy required by the giraffe to maintain his weight against gravity in comparison with the hippopotamus, whose weight is partly sustained by the buoyancy of his part-water medium.

In the tropics, the size of the energy-controlling organs, the brain, and the thyroid gland, in particular, is limited by the ceiling of heatstroke.

Because warm-bloodedness increases the speed of chemical activity, the warm-blooded animals have a great advantage over the cold-blooded animals. Since heat elimination is at the surface, the larger the animal the less is its facility for heat loss.

Through natural selection, as the warm-blooded animals became larger, the size of their brains and thyroid glands, relative to their body weights, became smaller. Therefore, it is not surprising to find, in the case of the giraffe and the hippopotamus, relatively small brains, namely, 700 grams for the giraffe and 723 grams for the hippopotamus. Since the hippopotamus has no enemy there would be but little provision in the brain for sight and hearing, but the hippopotamus, in its swamp and water environment, would find the sense of smell important. Therefore, as we expected, the olfactory region of the brain was more prominent in the hippopotamus than the ophthalmic or acoustic region. Of such little biologic value is sight to this placid pachyderm that the eyes of the hippopotamus weighed only 42.70 grams, which is less than the weight of the eyes in a 94-pound impala. The eyes of the giraffe weighed 127 grams.

We are fortunate in having for comparison with our 1,200-pound young female hippopotamus a warm-blooded animal from the cold arctic sea.

In the arctic the walrus has the same relative status as the hippopotamus in the tropics. Like the hippopotamus the walrus spends much of its time in the water. It does not need to support its weight against gravity and therefore needs less energy. Like the hippopotamus the walrus has no formidable enemies. Like the hippopotamus the walrus has stationary food and engages neither in the hunt nor in the chase

Animal	Sex	Body weight, pounds	Brain weight, grams	Thyroid weight, grams	Adrenal weight, grams	Heart weight, grams
Hippopotamus (mtoto)..........	Female	1197.3	540	32	53.35	1610
Walrus.............	Male	1471.11	1126.5	70.04	27.07	4536

These two animals, with so many factors in common, have one important factor in variance, namely, the habitat temperature. The hippopotamus in the tropics requires little oxidation for maintaining its body temperature at 98.6°. The walrus, in the cold of the arctic, requires a large amount of oxidation to maintain the temperature of its body at 98.6°. We therefore expected to find a larger brain and a larger thyroid gland in the walrus than in the hippopotamus. We also expected to find in the walrus a larger volume of blood and a larger heart than in the hippopotamus. The weight of the brain and the weight of the heart are accurate criteria of the metabolism of these two animals.

11. THE MERCY SHOT

A Lion at 196 *Yards.* "I dropped a zebra in a small volcanic crater and, after dissecting it, left it as bait. The next morning I started before dawn for lion. With loaded gun, I crept along over the stony ground until I was at the edge of the crater and could look over the rim. A huge black-maned lion filled my eye. He was lying 196 yards distant and was near the zebra upon which he had been feeding. At 196 yards, I shot that lion nine times with a Sauer Mauser .30–06, using steel-jacketed bullets, and on dissecting I found no bullet had penetrated a vital organ. The animal was killed by traumatic shock."

A Lion at 18 *Feet.* "I was tracking a lioness and two cubs when the track turned abruptly into a dense growth of thorn bush. Suddenly I came upon them lying in the thicket just eighteen feet away. Making a quick calculation, based on my dissection of a lion the evening before, I made 'the shoulder shot' with a Holland & Holland .465. The lioness did not move, nor did she make a sound. The large soft-nosed bullet had entered the middle of the shoulder, just below the level of the spinal column, in the midst of the great nerve trunks and within concussion distance of the spinal cord."[1]

Of all the animals shot in this manner in our collecting expeditions in 1927 and in 1935, not one escaped wounded.

The brain and the nervous system control every movement of the animal. It is the brain that drives every muscle in escape or attack. Like a battery, the brain is wired to every muscle and gland of the body. The brain of a lion is to that lion what the power plant is to the electric lighting system of a city. If the brain is hit the power of the entire animal is instantly turned off. Therefore, a shot through the brain causes instant death. The spinal cord is

[1] Excerpt from George Crile's unpublished African diary, 1927.

a cable that carries thousands of connecting wires, and the nerve trunks are lesser cables. A shot in the spinal cord or in a nerve trunk of a leg will at once paralyze the muscles supplied by those nerves but will not kill the animal. The shoulder shot is, in effect, a nerve shot, for either the bullet passing through the shoulder will sever the great nerves or the concussion will disable or kill the animal.

The nerve cells of the brain and their extensions, the nerve fibers, are the most delicate structures known. The membrane surrounding a nerve cell is 1/2,500,000 centimeter thick, only the thickness of 1 molecule of oil: it is much thinner, for instance, than the film of a soap bubble. The films surrounding these cells hold electric charges. The brain is a semisolid mass of jellylike consistency. It is 85 per cent water. Little wonder it is so securely encased in bone.

It is obvious that these delicate structures are easily disturbed. A blow on the head or the concussion of a high-velocity bullet, striking the neighborhood of these infinitely delicate nerve cells, may cause such violent agitation as to suspend their function temporarily. Therefore, a shot that does not penetrate the brain or the spinal cord but that sends into it an overwhelming molecular vibration may temporarily suspend its function. If an animal drops instantly when shot it is impossible to say at the first moment whether it is dead or only in temporary concussion. A high-powered bullet merely grazing the base of a horn or the top of the skull may lead the unwary to think he has delivered a fatal shot, for the animal may instantly drop; but the apparently dead animal, immobile sometimes for a long moment, may be charging or escaping the next moment.

Contrasting the impotence of the nine long-distance shots with steel-jacketed bullets from a Sauer Mauser rifle .30-06 with the overwhelming effect of a single shot at 18 feet with a soft-nosed bullet from a Holland & Holland .465, we have a striking example of the mechanics of killing by shooting. In neither instance did the bullet penetrate a vital organ of the lion.

In the case of the first lion, the total concussion effects of nine shots were required to discharge completely the hundreds of millions of brain cells. The second lion was killed instantly at 18 feet by the powerful concussion waves that spread from the shoulder nerves and the adjacent spinal cord to the brain and entire nervous system, completely detonating the hundreds of millions of brain cells.

Above all things, the hunter endeavors to place his shot so that the animal cannot escape wounded. Therefore, the shot high in the center of the shoulder, just below the level of the spinal column, is the "mercy shot."

The vigorous activity of an animal after the circulation of the blood has been arrested by a heart shot has an interesting scientific aspect. Mr. Leslie Tarlton, a famous big-game hunter in Africa, told me that the vigor of the getaway or the vigor of the charge, after the destruction of the heart, was, to his mind, explained largely by the animal's state of excitement when shot. If the animal was quiet and not roused or startled, he would move little when shot through the heart and would go down readily, but if he was on the alert, frightened, or chased, he might bound away. In the case of a lion, however, he might charge vigorously.

Mr. Tarlton made a practice of not firing immediately at a lion that was coming toward him. His procedure was to freeze and, with rifle pointed, to wait until the lion had made his decision. Then, he said, the lion, though wounded, will continue the intention established in his mind before he received the shot.

Two facts are important. (1) The complete heart shot in an unsuspecting quiet animal will not be followed by the violent bounding away or the vigorous charge of the animal that is first roused or startled, then shot. (2) When an animal has made a decision as to running away or charging before he is shot, he may carry out that decision, even though the complete heart shot has been delivered. The same is true of the boa constrictor. If its action pattern at the moment of decapitation is to coil and crush a man, then the headless body will continue that intent. The headless body could not alter the intent, since the pattern of action had been established. It is just as if the gear of a motor car were shifted and then the driver met instantaneous death; the motor car would execute the pattern of action, and it could not change that pattern of action. The mechanism, by means of which the animal is endowed with this last superpower is the instantaneous output of adrenalin that steps up the oxidation, hence the power of the brain, the heart, and the sympathetic nervous system.

12. THE CAT FAMILY

For their size the lion and the tiger exhibit a greater outburst of energy than any other known animals. Taking their food fresh, the lion and the tiger derive the maximum energy content of the flesh of their kill. After the gorge both the lion and the tiger sleep and loaf until hunger drives them to kill again (Fig. 5).

The lion and the tiger, being dependent upon flesh, must kill within certain intervals or starve. Therefore, the carnivore that is the most powerful, that has the best scent, the most stealthy stalk, the best calculated spring is the one that will survive when food becomes scarce. The less fit lions and tigers will finally be taken by the hyenas; the more fit will reproduce their kind.

The total number of lions or tigers in a given area is determined by the number of Herbivora, the stock of which the lions and tigers are constantly improving through elimination of the less fit.

On the other hand, the herd, through perfect line breeding from only the fittest male, is continually raising the qualities of its enemy by starving the less fit lions and tigers. Thus the fiercest interaction is established between the herd and the carnivores, resulting in a gradual stepping up to a maximum of physical fitness in all.

If our conception of the respective roles of the brain-heart-thyroid-adrenal-sympathetic system is correct, then we should find that in the lion and in the tiger the brain, the heart, and the thyroid gland are not larger than in an antelope of equal weight.

In the supreme energy effort of both the lion and the tiger, all the available energy is mobilized. Adrenalin, circulating through the blood stream, causes a flash of oxidation not only in the millions of brain cells but in the entire sympathetic nervous system. The celiac ganglia and the celiac plexuses of the sympathetic nervous system are coincidentally stimulated to their maximum activity. This simultaneous stimulation of the adrenal glands, the

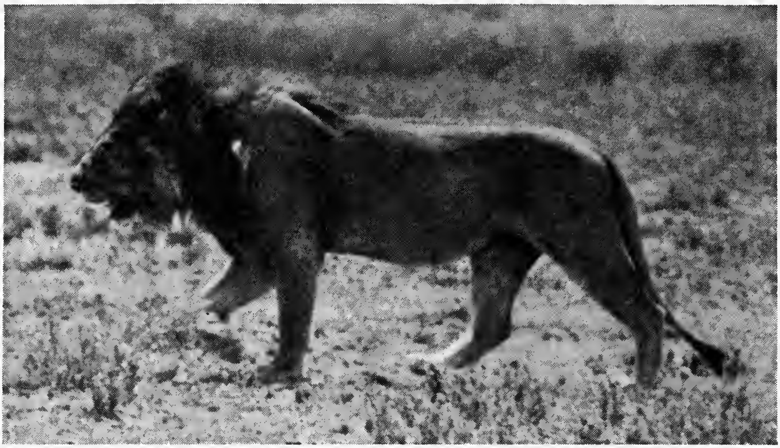


FIG. 5.—A lion in the wild. Rasha Rasha, Tanganyika. (*Courtesy of Frank and Pat Anderson.*)

celiac ganglia and plexuses, and the entire sympathetic nervous system causes a powerful beat of the heart, a speeding of the circulation of the blood, a mobilization and transference of the sugar from the liver to the blood stream, and a speeding of the respiration. The result is a stupendous output of energy for attack that more nearly resembles an explosion than a physiological act. Following such a convulsion of activity, there is rapid exhaustion.

On this premise, we should expect to find that the adrenal glands, celiac ganglia and plexuses would bear a higher ratio to the body weight in the lion and in the tiger than in any other animal, wild or domestic, of comparable size. Let us now turn to the record.

In man, in the wolf, and in the dog there are two celiac ganglia. In the lion and the tiger there are clusters of celiac ganglia. In the lion and the tiger the celiac ganglia equal the weight of the adrenal glands. This does not occur in any other animal that we have dissected. On each side there are eighty-two inter-communicating nerve fibers between the medulla of the adrenal gland and the celiac ganglia and plexuses in the lion and an equal number in the tiger. In no other animal—the whale, porpoise, elephant, buffalo, wolf, caribou, zebra, or thoroughbred horse among the 3,734 animals that we have dissected—have we found the size and complexity of this mechanism to be comparable to that found in the lion and the tiger.

Another point of interest is that most of the wild animals have formidable enemies and, therefore, have built up various types of muscular mechanisms for running away, but the lion and the tiger, having no enemies, have developed no mechanism for running away. Their equipment is for attack only. It is inconceivable that these two animals that possess only an explosive energy mechanism could be adapted to a long pursuit.

Let us see if there is a difference between the energy equipment of the lion and the tiger.

Of the fifteen lions that we studied, nine were bred in captivity and six were collected in the wild state. This gives us the opportunity of comparing the brain-heart-thyroid-adrenal-sympathetic system of a lion bred in captivity with that of a lion in the wild state. With the exception of the lions taken in the wild state, all the lions that we studied, whether bred in a semiwild state, as in one from Mr. William Randolph Hearst's lion farm in California, or in a zoo, showed goiter. This fact alone throws light upon the effect of captivity.

Prince, a lion from the Philadelphia Zoo, was born in captivity in 1917. The Bengal tiger, an adult middle-aged male, was the largest tiger in America. It was jungle-bred, imported when young, and, aside from an injury to an eye, was in excellent condition, although, like practically all animals in captivity, dissection revealed a goiter. Prince's goiter weighed 2 pounds.

On the basis of their energy-controlling organs, we can throw light on the personalities and mode of attack of the lion and the tiger. The more highly specialized an animal is for a rushing attack the more the adrenal glands and celiac ganglia will dominate. On the other hand, in proportion to adaptation for pursuit, the less will be the preponderance of the adrenal glands and celiac ganglia.

Applied to the comparison between the lion and the tiger, we have the following studies of individual animals of comparable weight, which suggest that the lion is more highly equipped for a rushing attack than the tiger.

Animal	Body weight, pounds	Adrenal weight, grams
Tiger from zoo	352	16
Lion from zoo	356	24.90
Lion taken in wild	430	34.64
Tiger from circus	461	20.80

The Heart of a Lion

There is a current opinion that the lion possesses a heart of unusual size. This is not supported by facts, as may be seen in the table that follows.

Animal	Body weight, pounds	Heart weight, grams
Ostrich taken in wild	272	1,205
Caribou taken in wild	329	1,247
Horse	411	1,230
Lion taken in wild	430	1,175
Wildebeest taken in wild	475	1,325

It will be seen that the heart of the rushing lion in the wild state is not so large as the heart of many of the long-endurance running animals.

The adrenal glands of a lion in the wild state are 25 per cent heavier than those of a lion of approximately the same body weight in captivity.

Bearing on the high incidence of heart disease in civilized man compared with that in primitive man, there is the significant comparison between the size of the heart in a "civilized" lion taken from the Philadelphia Zoological Garden and another lion taken in the wild state.

Animal	Body weight, pounds	Heart weight, grams
Lion from Philadelphia zoo........	356	1,614
Lion taken in wild...............	410	860

This suggests the effect of recurring frustrations and irritations upon the heart muscle of the lion in captivity, comparable to the effect of the frustrations and irritations on the heart muscle in civilized man in his autocaptivity.

If the size and power of the heart were the symbol of the qualities implied in the term "lion-hearted," of all the animals in the world of comparable size the heart of the thoroughbred horse should be chosen. It would seem that what is implied by the term "lion-hearted" is the bravery of the lion, which, as we have seen, is due to the size and complexity of its adrenal-sympathetic system. The adrenal-sympathetic system, however, cannot be counted upon to furnish bravery in all animals, because the adrenal-sympathetic system and the quality of the action patterns of the brain or "mind" furnishes energy to run away as well as energy to attack.

Since there is nothing characteristic in the size of the brain and in the size of the heart of the lion as compared with other animals, what, then, is meant by "lion-hearted?" The mechanism possessed by the lion, which has endowed the lion with the qualities that "lion-hearted" implies, is the mechanism of action patterns in the brain, which, through millions of years of supremacy among the animals, has characterized the demeanor of the lion.

The Smaller Cats

The leopard is a stealthy and cunning hunter, usually seeking his prey alone at night. A careful stalk, a lightning rush and spring are the leopard's method of attack. The animals that he prefers are the monkey and baboon, the native's dog, and the smaller antelopes and ostrich chicks. If animals are too large for the leopard to kill, he takes their young.

Next in size to the leopard in Africa is the cheetah, which, unlike the leopard, is geared for a swift pursuit. For a distance of 200 yards the cheetah can outrun the ostrich or the swiftest mammal. The cheetah is taller than the leopard. In form it resembles the dog family rather than the cat family and frequents the open plains.

The serval cat is the handsomest of the smaller African cats. It weighs up to 24 pounds and stands about 18 inches at the shoulder. It nests in anthills or in the dense bush, and its favorite food are small mammals and such game birds as guinea fowl and spur fowl.

The puma or cougar, popularly called the "mountain lion," is next to the largest of New World cats, resembling the female lion in appearance. Like all cats, the puma stalks and rushes its prey, unless, like the leopard, it can spring upon it from an elevation.

The jaguar is the largest, the strongest, and the most dangerous of the New World cats, resembling the leopard in its spotted skin. The jaguar is not a fastidious feeder. It takes whatever comes its way.

The following table shows significant contrasts in the size of the energy-controlling organs of an impala from Africa with a member of the cat and dog family, namely, a jaguar and a timber wolf.

The principle that attack in the cat family depends on a large adrenal-sympathetic system for crisis energy and that there is less need for constant energy, hence less need for high-sustained activity of the heart is here clearly illustrated in the supremacy of the adrenal gland in the rushing jaguar as compared with the smaller adrenal gland in the long-distance-running impala and timber wolf. Note the small heart of the rushing jaguar in comparison with the large heart of the long-distance-running wolf and antelope. Note, also, the slightly larger brain of the timber wolf taken in the cold north as contrasted with the brain of the impala and the jaguar collected in the tropics.

Animal	Sex	Body weight, pounds	Brain weight, grams	Thyroid weight, grams	Adrenal weight, grams	Heart weight, grams
Timber wolf...........	Male	66	152.4	3.49	3.37	314.5
Impala................	Male	72	140	4.04	3.82	250.
Jaguar................	Male	76	147	1.72	7.46	185.8

In the cat family the energy equipment is centered upon the brain-adrenal-sympathetic system in order that energy may be mobilized quickly for a rush attack. This requires a large brain and a large adrenal-sympathetic system.

In the dog family, for example, the wolf and, among the grass eaters, for example, the impala, both the pursuers and the pursued meet their fate in the run of destiny. Therefore, their equipment must be one that will produce long-continued energy. This requires a large brain, a large heart, a large thyroid gland, and a lesser sized adrenal gland.

These are the blueprints of the energy-controlling organs in the wild state of the cat family, the dog family, the grass eaters and the leaf eaters.

13. THE HERD AND ITS ENEMIES

THE grass eaters and the leaf eaters, being primary animals, are naturally the most numerous. The grass and the leaf eaters, in turn, constitute the food for the flesh eaters.

At first thought, it would seem that the flesh eaters would tend to exterminate the grass and the leaf eaters, but on closer analysis we find that the flesh eaters help the grass eaters to survive. The most deadly foe of all animals is bacteria. Are the flesh eaters not collaborating with the bacteria to kill off and exterminate the grass eaters? Just the opposite appears to be true, for bacteria can do little against animals in vigorous health. Like the bacteria, the carnivores kill the enfeebled and hence keep the herd in high vigor. Thus we see a benevolence in the destruction by the carnivores of the menace of the weak.

But why do the lions, the wolves, the leopards, the foxes not completely exterminate the grass and the leaf eaters? Since the weaker members of the herds are destroyed, the grass and the leaf eaters, by breeding from fitness, are kept at the highest possible level of energy, making it continuously more difficult for the wolves, the lions, the leopards, and the wild dogs to take the keen-sensed and fleet-footed food. As a lion or a wild dog ages, there is no dole for him. He dies undefended. The hyena attends to his needs.

In order to survive, the grass eaters live in herds. The lone animal would perish. Even the newborn must keep up with the herd. Those that multiply are not only the fit but the most fit, for the males compete, often to death, for the post of leader of the herd. In this final fight for procreation, an antagonist less than perfectly brave, with a horn the least bit weaker or shorter or a bit more brittle, may leave no progeny. Thus the herd is afforded the protection of its ablest member, and leadership in the herd is a function of intelligence, power, and personality for the benefit of the herd.

Why is the leader of the herd always a male? Why is there not a matriarch of the herd? The female could influence but one offspring, whereas one male may impregnate the entire herd, thereby endowing the offspring with his superior powers that have been tested in the crucible of battle.

Herd breeding from one male brings line breeding. If there are no physical faults, no physical faults can be magnified by a blood relation. Line breeding means a perfect strain. It means that the members of the herd are equal to each other and that in seeing, smelling, and endurance they can act as a unit. The fate of the herd can never be left in the hands of a dull sentinel, for the herd is a multiple animal, coordinated by a unison reaction.

The Correlation of the Special Senses and Muscle

The grass eaters, leaf eaters, and flesh eaters depend wholly on their special senses to control by trigger action their muscle mechanisms for attack or escape. The vast preponderance of animals belong to these classes. These are the most highly muscled of all the animals.

If in a given animal there is seen a perfect development of the ear, the eyes, and the nose, as, for instance, in the zebra, the wildebeest, or in the antelopes or deer family generally, this development of the special senses is represented by a correspondingly large brain, heart, thyroid gland, and adrenal-sympathetic system. We found throughout our dissections that the conspicuous and perfect development of the eye, the ear, and the nose carried with it a highly developed brain, thyroid gland, and adrenal-sympathetic system, a well-developed heart and arterial tree, and capacious lungs.

In our dissections of these high-powered, long-distance-running animals, we found the long muscles beginning near the middle of the spinal column growing wider as the muscles passed down over the rump. This superb muscle mass is adapted to make the most powerful and the most complete contractions, thereby propelling the animal forward with a high speed.

Just as a perfectly made airplane, battleship, or motor car will exhibit a harmony of relations of each part that contributes to the whole mechanism, so in these sense-driven, bounding antelopes there was exhibited a harmony of sense and energy organs in relation to the muscles.

Our studies of herd animals also revealed a uniformity in the adrenal-thyroid pattern throughout growth to the adult state and, as a corollary, we found the behavior of the young of the herd analogous to that of the adult member of the herd. In line-bred animals phylogeny and ontogeny are identical.

The domestic animals have inherited this identical adrenal-thyroid energy pattern from their wild ancestors, but man has modified this pattern through breeding to serve his purpose, although to the biologic disadvantage of the domestic animals.

Thomson's Gazelle

The fact that recapitulation of behavior in the young is identical with that of the adult in line-bred animals, in contrast to the helplessness of the young of man, is well illustrated by a picture of a three-weeks-old African baby uninfluenced by struggle and survival and a three-weeks-old Thomson's gazelle in which natural selection had stepped up the brain-heart-thyroid-adrenal-sympathetic system to such a point of perfection that this little Tommie (Thomson's gazelle), unaided by its mother, was able to escape from the carnivorous enemies of the herd. This young and toddling antelope was presented to Mrs. Crile. Though only three weeks old, it had been able to keep up with the pace of the herd.

Observe the sensitive face of this little Tommie. The

FIG. 6.—The sensitive face of a young Thomson's gazelle.

large eyes, the wide-open ears, the dilated nostrils are evidence that such an animal is an escaping, not an attacking animal, and that the limit of its speed of energy is heatstroke.

As we approached, this little Tommie leaped from all knowledge of its herd, until, its limit of speed having been reached in exhaustion, we found it, terrified and trembling, in the long grass.

Mrs. Crile took it to her hut, warmed it, fed it milk, cared for it, worried about its diet, whether it was too cold or too hot, whether it would sleep better under her bed or out in the open, whether the milk should be diluted sometimes or at all times, what kind of grass it would eat, whether a pink or a blue ribbon would be more becoming, and whether it missed its mother. In fact, Mrs. Crile worried over every-

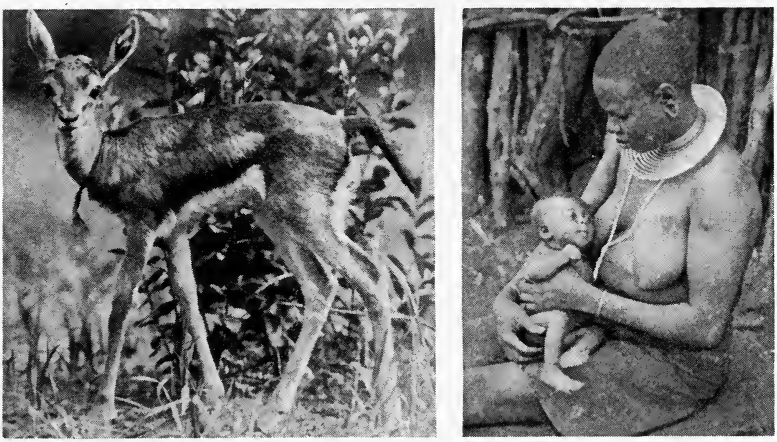


FIG. 7.—A comparison of a three-weeks-old Thomson's gazelle and a Mbulu infant. (*Mbulu infant photograph by Frank Anderson.*)

thing but its education, and this proved to be the most interesting thing about this young Tommie.

Because of its wild nature it had only two reactions. When the unusual occurred it crouched and froze, or ran, but always with head up and ears, eyes, and nose alert. When we took Tommie out in the open area about the camp it stood utterly still, moving its tense ears and eyes and nose in a slow semicircle all the way around to the middle of its back, then slowly around on the other side, completing the circle. It seemed most attracted to the far part of the horizon, the open grazing area. As it grew stronger it ate grass cautiously, raising its head every few seconds and sweeping the horizon, forward to both sides, then backward. After doing this several times it would walk forward a short distance and then repeat the process. In other words, it wrote upon its keen brain a series of circles, and it could not have lost its retracing steps.

The three-weeks-old Thomson's gazelle and the three-weeks-old native baby are examples of the rapid development of the simple brain of the Tommie and the long period of development required in the complicated brain of the child.

The Senses

The extraordinary development of seeing, hearing, and smelling among animals baffles civilized man. No animal in such a competitive world as tropical Africa could exist unless its senses were acutely attuned.

Native man, who freely mingles in the vast menagerie of powerful, fleet, cunning, and poisonous animals, could not survive without the possession of keen senses. Large, lumbering animals like the elephant, the rhinoceros, and the hippopotamus, protected by strength and by thickness of hide, have no further use for eyesight than seeing their food, their fellows, and the surface of the ground; yet the senses of all herd animals are more highly developed than in native man.

The predatory animal must kill to live, and the prey of the predatory animal in order to live must escape. Thus each species sees, hears, and smells with the acuteness that the survival of these senses has afforded its species. In comparison man has lost virtually all his sense of smell and hears and sees only indifferently. The visitor coming to Africa to collect animals finds himself outclassed by natives and animals as to the acuteness of his senses, fleetness of limb, such natural weapons as teeth and claws, passive defenses against heat and the fierce rays of the sun, and the ability to endure thirst and hunger.

As we returned to camp after belated dissections in the Rift Valley, our lanterns lighting our way, we were always amazed at the myriads of eyes flashing from the grass, the high bush about us and the trees. To possess survival value, the eye must collect sufficient light to form images in the brain. The more dim the light in which the animal lives the more prominent the eye. The most prominent feature of a fish is the large eye. So is it, also, with the night animals, especially the owls, the night herons and small lemurs that derive their living at night (Fig. 8).

FIG. 8.—Comparison of eye weights.
Python—1.12 grams. Eagle—30.96 grams.
Elephant—116.15 grams. Lemur—3.70 grams.

Consider the large sensitive eyes of the line-bred animals, especially the antelopes, and the small eyes of a crocodile, a venomous snake, a turtle, or a porcupine, animals protected by size, poison, carapace, or barb. In the latter the eyes are so dull, so insignificant, that they are hardly noticed, and the small size of the optic lobe in the brain of such animals indicates the low biologic value of sight to them. Thus one sees the development of sense organs—

seeing, smelling, and hearing—and brain and muscle to that degree of perfection required to effect survival.

In dissections the eyes are interesting. The marine eye, accustomed as it is to dim light, resembles the large eyes of the night prowlers. In fish the eyes often weigh more than the brain and even more than the liver. In a mackerel the weight of the eyes was four times that of the heart and five times that of the brain. In a muttonfish that we dissected the weight of the eyes was nine times that of the brain.

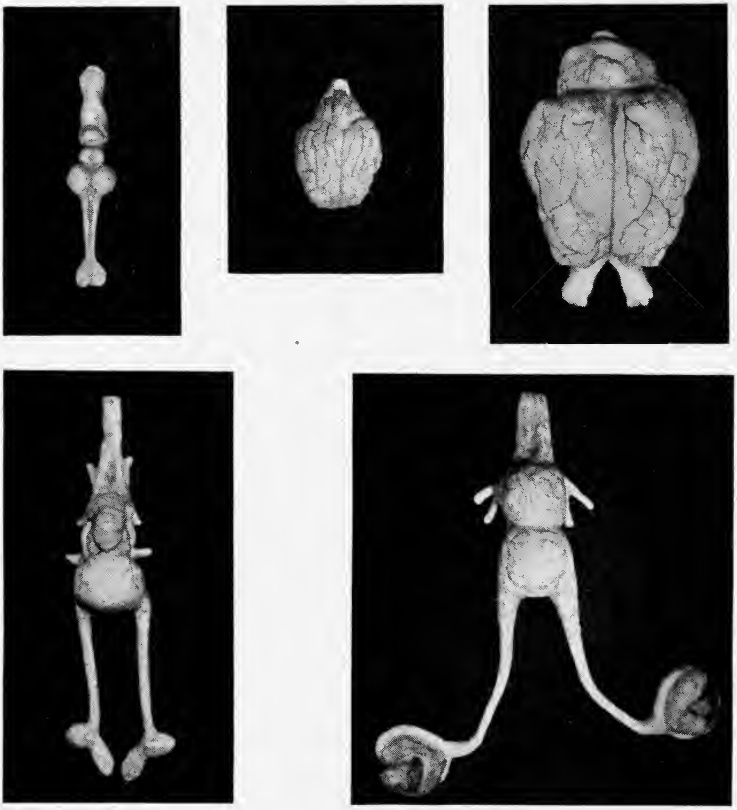
In dissections we have found that the size of the optic nerve and the size of the eye in most warm-blooded animals indicate the size of the optic lobe in the brain, and the size of the optic lobe and the ratio of the weight of the optic lobe to the weight of the entire brain indicate the dependence of the animal upon the sense of sight for survival.

In the elephant we found a small optic nerve and a correspondingly small optic lobe in the brain, which corresponds with the fact that the elephant can see scarcely fifty yards.

The composition and contour of the brain of an animal dependent on a single sense, such as an alligator or crocodile, is entirely different from the composition and contour of the brain of an animal dependent on an almost equal development of sight, hearing, and smell, such as the antelope, the deer, and all the grass and leaf eaters. The brains of these herd animals, instead of showing a primitive lobulation, as in the alligator and the crocodile, the sting ray, and the shark, are composed of large optic and acoustic lobes and a great number of association tracts. Such brains are rounded and symmetrical in contrast with the small elongated brains of the alligator, the sting ray, the crocodile, and the shark (Fig. 9).

In the primates and in man there is a progressive loss of the selective value of these trigger mechanisms—the special senses. In man the sense of smell has deteriorated. Hearing is not acute, and the sense of sight, although not so keen as in the eagle or the antelope, has a large capacity for continuous work. The optic mechanism, including the cerebral

Crocodile 15.60 grams. — Thomson's gazelle 90.8 grams. — African buffalo 540 grams.



Tiger shark 107.5 grams. — Sting ray 126.4 grams.

Fig. 9.—Comparison of brain weights.

representation in the brain of man, is therefore relatively greater than that of any other animal.

The following table shows the body-weight-to-eye ratios and the brain-to-eye ratios in seven animals of comparable weight representing seven species:

Species	Animal	Body weight, kilo-grams	Eye weight, grams	Body weight / Eye	Brain weight, grams	Brain weight / Eye
Bony fish.	Codfish	2.625	26.91	1:97	2.2180	1:0.0824
Reptile...	Turtle	2.163	1.35	1:1602	1.36	1:1.007
Bird.....	Tawny eagle	2.625	32.84	1:79.9	14.09	1:0.43
Edentate.	Armadillo	3.701	0.38	1:9739	14.20	1:37.36
Rodent...	Hare	2.93	7.37	1:397	10.23	1:1.374
Carnivore	Wildcat	2.70	6.41	1:421	28.48	1:4.443
Primate..	Gray monkey	2.9	9.94	1:291	61.46	1:6.18

It is significant that in the highly protected turtle and armadillo the eyes are smallest, indicating the low survival value of the eye to them in contrast to the high survival value of the eye to the fish and the bird.

14. THE TECHNIQUE OF HUNTING

THE members of the dog family as well as those of the cat family hunt. The members of the cat family stalk and spring. The greyhound is equipped to take his prey through high-speed sprinting under the sole guidance of the eye. This technique is totally different from that of the jackal, the coyote, the wolf, and the wild and domestic dog. The greyhound is constructed and energized on the pattern of the thoroughbred race horse.

The pursuit of the pack of wild dogs, of wolves, of coyotes, or of the fox is that of a chase; this technique is based on the exhaustion of their prey.

The advantage of the pack is that of rest, relay, and strategy, on the one hand, and the natural tendency of the pursued to circle back to their herd. This circling back of the grass eater gives the dog family the chance to close in upon the fatigued victim.

The hunting dog, the wolf, the fox all hunt small animals such as mice, rabbits, squirrels individually, but if they hunt in packs or pairs the prey must supply a meal sufficient to serve the pack. It would involve economic loss for a pack to run down a rabbit. More energy would be used by the pack than is contained in the rabbit.

Since evolution did not make a successful dog large enough to outrun a zebra or an antelope, it fragmented the theoretic dog into a number of smaller ones, namely, the pack. Of all the foes of game in Africa, the hunting dogs are preeminent. A lion returning from his kill will often be seen near the grazing spot of antelopes, but the appearance of wild dogs in a district is a signal to all antelopes to leave.

The cat family smells, looks, listens, stalks, and springs. Success or failure is instantaneous. In the cat family evolution stakes everything on the spring. Since this outburst of energy is the opposite of the technique of pursuit to exhaustion employed by the dog family, theoretically, one would expect to find in the cat family the organs of outburst energy, that is, the adrenal glands, celiac ganglia, and plexuses, relatively larger than the thyroid gland, the organ of constant energy; and so we found it.

Of great interest was the fact that among all the members of the dog family, namely, the jackal, the coyote, the wolf, the husky, with the sole exception of the greyhound, we found the adrenal glands only slightly larger than the thyroid gland. Among the fourteen dogs studied, whether in the tropics or in the temperate zone, we found no domesticated dog except the racing greyhound that possessed adrenal glands strikingly larger than the thyroid gland.

The greyhound, like the cat family, is set for outburst energy. Like the thoroughbred horse, the greyhound has been evolved as a sprinter. The racing greyhound and the racing thoroughbred horse share honors in a record of speed that is unique among all animals.

Our thesis is beautifully illustrated by the fact that in the greyhound the pattern of the energy system is that of the cat family and the race horse. In other words, even among members in the same species variation in the expression of energy is accounted for by variation in the relative sizes of the thyroid and adrenal glands, celiac ganglia, and plexuses.

Keeping in mind that the emotion of fear is the integration of the organism to flight or fight and that the millions of brain and nerve cells of the deer or antelope are instantly flared in oxidation at the apprehension of the wolf or the wild dog, that oxidation is augmented by adrenalin and sympathin, that all the processes of the body that are not needed in making the escape are completely inhibited, it is easy to understand why a thumping heart, trembling limbs, staring eyes, a raging metabolism comprise the state of integration of these fleeing animals under the fear of the pack.

As the members of the cat family and the dog family grow old and weak or as they become emaciated or disabled through infection or injury and find themselves unable to make the attack or pursuit, even when the majestic lion finds himself weakened by advancing years and by the fact that his share of food eludes him, there is nothing left but a lonely, wayside death, which is often hastened by the hyena.

When we contemplate the parade of death in its every form—the attack with instant death, the chase to exhaustion, starvation, hemorrhage, slow infection, disability, old age—the painless death in the midst of life as administered by the cat family seems merciful.

The simple minds of the wild animals seem to forget these dramatic episodes and are at peace in the intervals. In the case of man the opposite is true. The mind of man, being the organ of struggle, continuously keeps the energy system of man under the stress of fear, worry, and anxiety. The significance of this difference between the simple-minded wild animal and the profound-minded man is seen in the diseases peculiar to civilized man.

15. ELEPHANT AND MOUSE

The Hunt

MAJI MOTO CAMP, December 26, 1935. [Extract from Mrs. Crile's diary.][1] "We had planned to go to Ngaruka today for python, but last night the native boys came in with the news that they had seen fresh elephant spoor. A heavy rain the night before washed out all spoor; so this meant that in the late evening a herd of elephants had crossed the trail leading to our camp and were going north into the forest along the Rift wall.

"Long before dawn they started—the Chief (my husband) and Captain Hewlett, with three trackers. Dr. Quiring, Mr. Fuller, and I had finished breakfast and were at work in the laboratory when the native boys returned, much excited. The word was 'a Tembo' and that the 'Cutting Doctor' got it. After a few scurried moments, we were off for a four-mile drive along the shore of the lake. On the very outskirt of the forest we found the trackers waiting.

"Slowly, in single file, every other man with a big gun, we followed the sandy game trails through the thick thorn, in and around the large clumps of bush, around huge trees, the great gnarled branches of which reached at least 75 feet in each direction, over giant logs, with birds screaming overhead, baboons chattering, buffalo tracks everywhere, until finally a snort and a scuffle warned us that it was rhino country, too. . . .

"Just behind us rose the escarpment covered with thick forest; just at our feet was a deep karonga, the sandy bed of which was now dry. We scrambled down its precipitous bank and over a few loose rocks, then mounted a turn, and there, right in the middle of this sandy river bed, like a giant basaltic bowlder, rose the black mass of the elephant.

[1] CRILE, GRACE, "Skyways to a Jungle Laboratory," W. W. Norton & Company, Inc., New York, 1936.

"The Chief told me later that to watch Captain Hewlett was like watching a detective work out his clue. There was not a speck of evidence that the Captain did not examine:

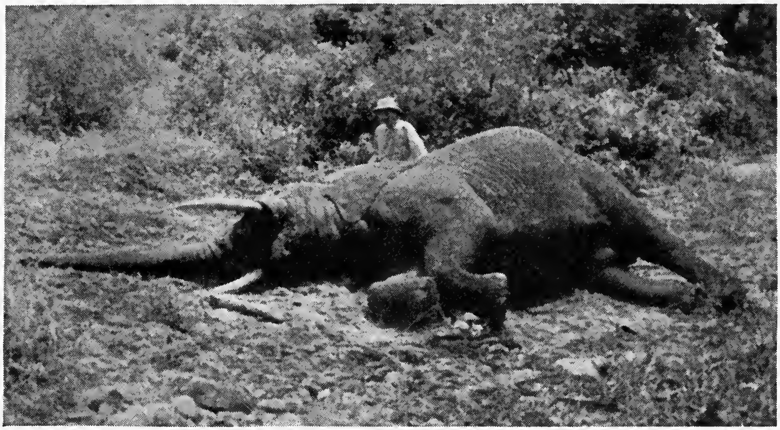


FIG. 10.—The elephant.

the age of the spoor, as shown by the configuration of the footprint; when the grass was last trodden as evidenced by its dryness; when this tree was scraped against, when that branch was broken; whether or not any of these happenings show that old Tembo suspected they were following him. If he were suspicious of them, Captain Hewlett said, he would not rip bark from the trees or break off branches, but instead would browse noiselessly as he moved along.

"Captain Hewlett felt that the elephant was suspicious of them as he not only always kept down-wind but was continually going deeper into the forest where his tracks would finally mingle with those of the buffalo.

"Once, while penetrating deep bush, they disturbed a huge buffalo which, just in time, changed his mind about coming in their direction. A little further on, they heard the arresting and unmistakable rumbling of the elephant's intestines. Captain Hewlett sent a native tracker to locate the exact position. Captain Hewlett and the Chief sat down; one of the boys climbed a tree to watch.

"Shortly, they saw the barefoot tracker hurriedly returning. Old Tembo was located. With rifles loaded and safety catches off, the men tiptoed cautiously through the head-high thick bush, Captain Hewlett constantly testing the wind by dusting ashes from his little bag. Across a dry river-bed, through heavy forest, over big logs, they made their way until at last, standing at right angles to them, his great gray head facing the stream, was Tembo. He had just come down a precipitously steep dirt bank from the Rift wall, breaking a tree as his foot slipped, and was on his way to cross the dry river-bed not more than fifteen feet beyond. When the Chief and Captain Hewlett first spied him, it was like looking at the top of a black wall, as neither the hind quarters nor the head of the elephant was exposed.

"On tiptoes they crept to within thirty yards of the big pachyderm—a long distance for a finishing shot, but the elephant was in too thick cover to run the risk of losing him. Even from this distance the entire elephant could not be seen, so thick was the bush, but the top of the side of the elephant and the top of the shoulder were clearly exposed.

"For days there has been discussion as to how to kill the elephant. The two fatal shots of an elephant are the brain shot and the heart shot, but as we are collecting the brain and the heart it was necessary to find some other shot. As the .465 and .470 guns have an impact of 5,000 pounds at the muzzle, the Chief felt that four or five shots in quick succession in the region of the big nerves in the shoulder should kill by shock alone—and they did.

"From beginning to end, it lasted only a couple of minutes and, from beginning to end, the elephant did not move twice his own length. In majesty and dignity the great beast made his exit. It was as if he had matched his wits against those of Captain Hewlett and had accepted with resignation his defeat."

Dissection of the Elephant

The skin of the elephant was beautifully reticulated. It was soft slate-gray in color and blended curiously into the landscape—the green foliage, the dead foliage, and the rock. Looking closely at the surface of the skin, one could see a beautiful interlacing of depressions or little grooves. These perhaps are for giving spaces for elasticity in bending.

A few scattered hairs on the surface of the skin attested the ancient phylogeny of this great pachyderm. When the skin was cut there was a darkish area about an inch and a half in thickness, which faded into a white rubberlike substance. The skin seemed bloodless. The weight of the skin, except that of the four legs from the knees down and the tail, was 2,005 pounds.

The ears were enormous. They measured 3 feet 11 inches by 5 feet 10 inches. The tusks weighed 85 pounds. Their entire length was 67 inches, the length from the point where they emerged being 43 inches. The eyes were inconspicuous and, related to the mass of the elephant, small. Obviously, better vision would contribute nothing to the present security of the elephant. But the elephant would have little use for especially good vision. What would an elephant do with the eye of an eagle? The elephant does not search for distant food or danger. His food is immediately before him. His enemies are only other elephants and man. On the other hand, the elephant has a most highly developed sense of smell and a good sense of hearing.

The great legs resembled Grecian columns. The front foot was round, measuring 60 inches in circumference. The hind foot was elongated, 57 inches in circumference. One could see that as the elephant placed his weight on his foot the foot would expand, and if it was in the mud the foot would elongate as he drew it out, thus allowing him to extricate it more easily.

The trunk was indescribably adaptable and flexible, the numerous muscles being placed along the axis, increasing in mass toward the skull, thus giving the beautiful conical, symmetrical shape of the great head.

As in the rhino, the masses of muscle were concentrated in five areas of the body—that which moved the head and jaws and those which moved each of the four legs. A thin, muscular sheath extended over the sides and belly and there was a narrow strip of muscle along the length of the spine.

The abdominal viscera were so large that it was necessary to place ropes around the segments in order that the native boys might pull on them in unison until we dissected them free. At the point of freeing the stomach from the esophagus, no special mechanism was found by which the animal could have introduced his proboscis to suck out water to spray himself when hot, as is sometimes stated. The weight of the stomach and intestines, with their contents, was 2,034 pounds.

The diaphragm was a great surprise. Around the sides and at the base of attachment, running up a distance of about a foot, there was a mass of muscle that, at the point of its attachment, was just over 3 inches thick.

The chest capacity, compared with that of the rhinoceros, was much larger; the lungs weighed 306 pounds.

The heart lay low in the chest, in the median line. It measured 51 inches in circumference and weighed 57½ pounds. The wall of the aorta was extremely heavy and, in comparison, the wall of the vena cava seemed exceptionally thin. I thrust my arm into the aorta.

For the most part, the bony skeleton was cancellous and light, and this was especially true in the case of the skull. The bones that were directly weight-bearing were dense and very difficult to cut with an ax. The muscle attached to the periosteum was so firm that it was necessary to chop it off with a hatchet. The weight of the trunk, or proboscis, without the skin, was 264 pounds. The head alone, without the trunk and skin, weighed 625 pounds. The skin of the head and ears and trunk weighed 510 pounds, bringing the entire weight of the head to 1,399 pounds.

The total weight of the muscles, fascia, and fat, weighed in sections, was 4,365 pounds. This does not include the weight of the four legs from the knee down.

The liver weighed 235 pounds; the kidneys, 40 pounds; a small section of the trachea, including the larynx, 16 pounds; and the salivary glands, nearly 18 pounds.

The pendulous portion of the penis weighed 44 pounds; the internal portion, 25 pounds; and the testes, nearly 20 pounds.

We followed the splanchnic nerve up into the chest as far as the fourth rib, but a better dissection might have carried a small film further. The splanchnic nerve received additions at each vertebra all the way down through the diaphragm, at which point the splanchnic widened out into a sheet about 1½ inches in width, where it entered the celiac complex.

The thyroid gland was fused and lay in the thoracic opening, as in the case of the hippopotamus.

In this entire dissection we collected only 26 pounds of fat. African animals exhibit little or no neutral fat. The animal that would perhaps be inclined to show the most fat is the zebra. The lions showed little fat. As a consequence of the absence of fat, incidentally, the natives crave it. In our dissections we have found fat constantly present, however, in certain locations and in certain organs of all the wild animals. We have found fat distributed at the base of the heart and at the beginning of the aorta. This distribution of fat, like the special fats constituting the brain, is not consumed in starvation. The lipoids of the brain are a vital structure, therefore are constant.

The heart muscle, like the brain and unlike all other muscles of the body, does not lose weight in starvation. The heart is a vital organ.

In our dissections we have found that the adrenal-sympathetic complex as a whole, including the adrenal glands, is enveloped in a special orange-colored fat. In all animals there is also a highly specialized fatty envelope that encases the large nerve trunks and the spinal cord. So, too, around the optic nerve and behind the fundus of the eye, opposite the retina, a special covering of fat is a constant.

Fat is a nonconductor. It is also a reservoir of surplus potential energy. In the cold north, fat is accumulated under the skin as a protection against the cold and, in hibernating animals, as a reserve store of energy. In summer fat largely disappears, then reappears again in the autumn. In this sense fat is a supplementary thermoregulator.

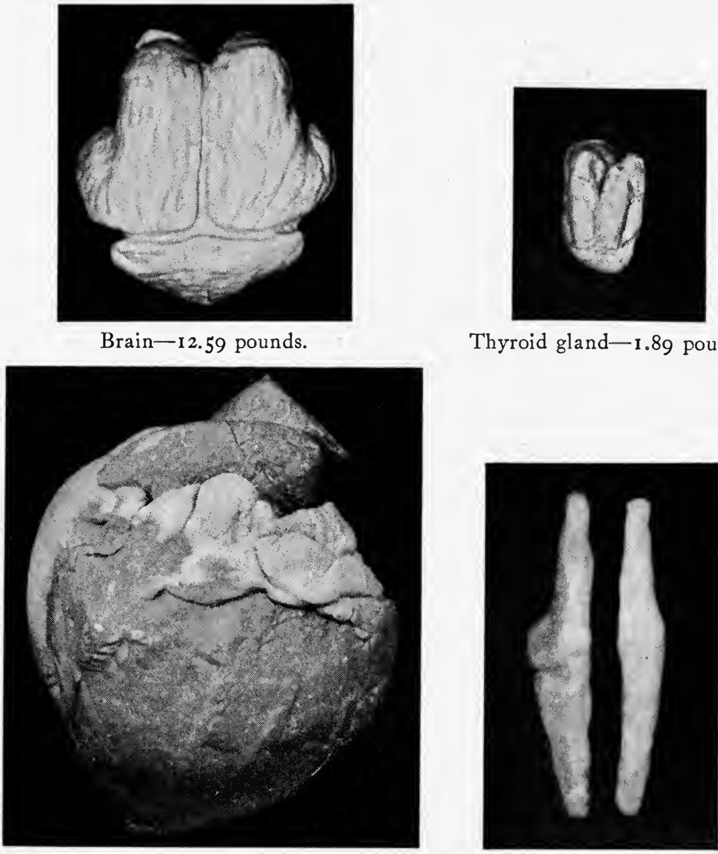
But, theoretically, the special fat that covers the brain, the spinal cord, and nerve trunks of the splanchnic nerves and adrenal glands, the fat behind the retina, and, in particular, the fat in which the celiac ganglia and plexuses are embedded might serve as electric insulation.

Against this, it might be pointed out that around the base of the urinary bladder, at the base of the gall bladder, at the hilus of the kidney, and at the base of the intestines, not covered by the peritoneum, there is a white fat, not the specialized type of fat found in the nervous system. In these situations there is certainly little or no genesis of radioelectric energy, but these positions are chemically vulnerable. The fat found in these positions in all animals could serve as a physiologic protection against the chemical penetration and infiltration of bile, urine, and intestinal contents.

What does the evidence show as to the relation between the size of the brain-heart-thyroid-adrenal-sympathetic system and the behavior characteristics of the elephant?

The brain of the elephant weighed 12.59 pounds and, with the exception of the brain of the blue whale, is the largest animal brain in the world. The brain of the elephant expresses the intelligence, power, and personality of the elephant.

The difference in lobulation of the brain of the elephant is due to a great preponderance of the olfactory lobe, a lesser development of the acoustic lobes, a slight development



Brain—12.59 pounds. Thyroid gland—1.89 pounds

Heart—57.50 pounds. Adrenal glands—2.07 pounds.

FIG. 11.—The energy-controlling organs of the elephant.

of the optic lobes, and only a fair development of the communicating fibers or thinking brain.

In the field, a comparison of the elephant's unique face and preponderance of trunk—his prehensile smelling mechanism—with the brain, showing a prominence of olfactory lobe, revealed a perfect relationship.

The adrenal gland weighed 2.07 pounds; the thyroid gland weighed 1.89 pounds. Except in of the arctic, larger adrenal glands than thyroid gland is the pattern of the leaf and the grass eaters the world over.

The elephant needs crisis energy for extricating himself from the swamp and for climbing the mountain side—in other words, for meeting the mechanical vicissitudes of his daily life.

The energy principle involved in the mechanism of the elephant we shall see more clearly by comparing the mechanism of the mouse with that of the elephant. In the mouse the adrenal gland is nine times as large as the thyroid gland. This is a pattern of insecurity. Although the mouse is a well-adapted animal, it lives a very precarious life. The mouse represents the highest degree of adrenalism known.

Because of the large surface in relation to the body weight of the mouse, the rate of cooling in the mouse is many times greater than that in the elephant. Relatively, the brain of the mouse is much larger than the brain of the elephant, the ratio being 1:33 in the mouse and 1:1164 in the elephant. In the elephant it is the principle of heat-stroke that limits the size of the brain-heart-thyroid-adrenal-sympathetic system.

The elephant is slow; the mouse is quick. The difference in the energy tension of these two animals is due to the high rate of metabolism per unit of mass in the mouse and the low rate of metabolism per unit of mass in the elephant. The difference is due primarily to the great facility for cooling in the mouse and the low facility for cooling in the elephant.

Comparing the high-tensioned mouse, with its heartbeat of 300 per minute, and the elephant, with its nearly glacial movements and its heartbeat of 28 per minute, we find that the life span of the mouse is about two years, and that of the elephant from eighty to ninety years.

16. FISH

At Key West, Florida, the first *cabaña* on the beach served as our laboratory. Benches inside this improvised laboratory held our small scales and supplies. Our large scales swung over the eaves. On the porch stood two barrels filled with formalin solution, and on the smooth sands stood our 8-foot dissecting table.

As we looked out upon the ocean and beheld vivid lightning pierce the sea and contemplated the constant stream of electrons striking the sea and the land and when we observed the clear sky, the tropical sunlight, with its ultraviolet rays, we visualized the untold numbers of nitrogen fixations continually taking place through lightning, showers of free electrons, and ultraviolet light.

Just as the roots of plant life and Azotobacter utilize the nitrates in the soil, so plant life in the sea utilizes nitrates. Sea water contains in solution all the metals contained in the soil. The sea is soil in solution, and to this soluble soil, as in the case of the land, there is constantly being added fixed nitrogen in the form of nitrates.

The nitrates in the sea could well form organic molecules as basic food for ultramicroscopic forms. These ultramicroscopic units of plant and animal life would then be subject to struggle and survival, building up living units of increasing size and of increasing power until such a unit would be large enough to be classed as a "lowest" form.

The varieties of plants and animals would seem to be as inevitable as are the physical differences in the variables of temperature and moisture, and evolution of the energy-controlling organs would seem to be as inevitable as the evolution of teeth and bones and hair and special senses. When a river overflows its banks, it is no surprise that the power of gravity fills every depression: equally, it is no surprise that the force of sunlight and lightning fills every energy niche in the world of the living. Therefore, it should be no surprise that there are as many variations in the size of the brain, the heart, the thyroid gland, and the adrenal-sympathetic system in the animals in the sea and on the land as there are wave lengths and chemical units in the great blanket of life that falls continuously upon the sea and the land.

The amount of oxygen available to the fish in the sea is limited to the 1 or 2 per cent of oxygen in the water compared with the 20 per cent of oxygen in the air available to the animals on the land.

The specific gravity of the fish is about the same as the specific gravity of the sea water. Therefore, the fish has a fundamental advantage over land animals in that the warm-blooded land animals must carry their own weight, whereas the weight of the fish is borne by the buoyancy of the water. In consequence, fish develop neuromuscular mechanisms primarily for attack or escape and not for the maintenance of the warm-blooded state.

Since the power of the fish is limited by the amount of oxygen available in the water, we should expect to find a small development of the heart and blood vessels and, especially, of the capillaries in fish. The size of the brain should vary in accordance with the number of neuromuscular patterns, that is, in accordance with the activity of the animal.

The jewfish is not found on the great highways of the sea. It is found down the blind alleys. Like the lobster, the turtle, the alligator, the crocodile, the jewfish is not a hunter; he is a still fisherman. His build is for a stationary rather than an active life. Therefore the ratio of the brain weight of the inactive jewfish to its body weight would be expected to be far below that of an active, aggressive, hunting shark.

Let us compare the energy-controlling mechanism of a jewfish with that of a sand shark of approximately the same weight, as the ratios express the energy characteristics of each.

We see in the following table a striking preponderance of brain in the shark as compared with the weight of the brain in the jewfish—as striking as the difference in the behavior characteristics of these two animals.

Animal	Body weight, pounds	Brain weight, grams	Thyroid weight, grams	Heart weight, grams
Jewfish........	72.5	2.31	0.32	49.23
Sand shark.....	78.0	48.8	1.81	41.6

The green turtle of the sea is protected by a complete and efficient armor into which it can withdraw its neck and head and feet. Much of the food on which the turtle lives floats to it.

The great advantage that the turtle has over the shark and the jewfish is that the turtle has lungs and breathes air that has a high concentration of oxygen. When the lungs—hence the blood—is well saturated with oxygen, the turtle has greater power than a fish that has to depend on the attenuated oxygen in the water. The muscles of the turtle, therefore, exhibit a greater capillary circulation than the muscles of a fish.

The large heart and the large volume of blood in the turtle are an adaptation not for muscle power or for the maintenance of the warm-blooded state but for providing stores of oxygen to sustain the turtle while he is submerged in search of food. This point is supported by the following evidence: A turtle weighing 150 pounds had a brain weighing 5.81 grams, whereas a sand shark weighing 79 pounds had a brain weighing 50.03 grams.

Though unlimited oxygen is available to it, the reptile has been evolved toward a minimum use of oxygen. Competing against other reptiles and against the warm-blooded mammals by means of inaccessibility and a minimum food supply, the reptile maintains only a pilot light of energy.

The fact that reptiles are evolved for negativity and fish for positivity is shown in the following table, in which reptiles and fish of approximately the same weight are contrasted.

Class	Animal	Body weight	Brain weight
Reptile	Alligator	450 lb.	14.08 g.
Fish	Tiger shark	442 lb.	107.50 g.
Reptile	Python	6,140 g.	1.12 g.
Fish	Bonito	6,291 g.	3.57 g.
Reptile	Iguana lizard	4,190 g.	1.44 g.
Fish	Yellow jack	4,274 g.	7.56 g.
Reptile	Turtle	2,163 g.	1.36 g.
Fish	Common jack	2,305 g.	2.97 g.
Reptile	Turtle (*Testudo graeca*)	320 g.	0.30 g.
Fish	Electric ray	345 g.	0.78 g.

Although fish are the most numerous vertebrate animals in the world and occupy three-fourths of the earth, in their struggle for existence they are limited to from 1 to 2 per cent oxygen tension in contrast to 20 per cent oxygen tension available to warm-blooded land animals. Therefore, because the fish has at its disposal far less oxygen than has the warm-blooded animal, we should expect to find the size of the brain, the heart, and the thyroid gland in a fish smaller than in a warm-blooded animal of the same weight.

This fact is illustrated in the table on page 115, which presents comparisons of two groups, in each of which are a fish and a mammal of nearly the same body weight.

In warm-blooded animals, heatstroke is the universal ceiling that limits the size of the brain, the heart, the blood volume, and the thyroid gland.

Class	Animal	Body weight, grams	Brain weight, grams	Thyroid weight, grams	Adrenal weight, grams	Heart weight, grams
Fish.......	Black grouper	2,712	1.99	0.032	....	2.08
Mammal..	Thomson's gazelle	2,430	54.61	0.460	1.04	31.70
Fish.......	Green moray eel	3,510	0.51	0.054	....	4.62
Mammal..	Gray fox	3,749	37.28	0.154	0.39	21.97

In the gill-breathing fish the ceiling is just the opposite. The size of the brain, the heart, the thyroid gland of the fish are dependent on the concentration of oxygen in the water. There is no problem with fish as to heatstroke, because water abstracts heat twenty-seven times faster than air of the same temperature.

There is a greater concentration of oxygen in cold water than in warm water; therefore, the energy-controlling organs of the fish and the power and personality of the fish are greater in the cold water of the arctic than in the warm water of the Gulf Stream; on the shallow beaches where the bubbling water holds more oxygen than in the still waters of the marsh; in the rapid mountain stream than in the quiet river; and in water over which the constant trade winds blow than in water outside the influence of these beneficent winds.

In such fish as the sting ray, with its batlike wings, whose habitat is the shallow, foaming water of the beaches, in the trout that is found in the tumbling mountain stream, and in the tarpon that swims near the surface of water fanned by the trade winds, one would expect to find a larger brain, a larger heart, a larger thyroid gland, and one may suppose more chromaffin tissue, the forerunner of the adrenal glands.

Increased concentration and constancy of oxygen in the water give increased oxidation. Increased oxidation confers increased electric potential. Increased electric potential executes increased nervous and muscular power, hence a quicker strike, a more powerful rush, a better game fish; therefore a higher ratio of energy-controlling organs should be found in the fish of the cold north and in the mountain trout and salmon than in the sunfish, the sucker, and the carp.

The marine eye deals with dim light, which is concentrated on the retina by the large lens. The characteristic is the wide pupil and the large size of the eye, which is set prominently so as to catch the greatest amount of light.

The most outstanding sense in fish is that of smell. The olfactory lobe in fish may approach the rest of the brain in size, and the olfactory nerves are the largest nerves in fish.

This emphasis by evolution upon the olfactory sense is easily understood when one considers that in terrestrial animals, except in the case of man, the olfactory lobe is highly developed in all the large mammals, in the ungulates, and especially in the carnivores. The chemical emanations that stimulate the sense of smell in the water are all-pervading, as in the air, and the sense of smell is of even greater value to fish than it is to animals on the land, since scent permeates the water more evenly than it does the air. Like the wolves, foxes, and dogs, pursuing fish follow the scent.

The chemical substance that is the basis of smell is the excreta of fish. In land animals this substance is the secretion of the skin and the feet. Since fish have no sweat or oil, only the excreta and the specialized scent glands about the intestinal tract and organic matter from the outside give scent.

The internal ear of the fish is within the skull, near the brain, giving the appearance of a sounding chamber. With the exception perhaps of monkeys, fish require a more delicate balancing mechanism than mammals. The balancing mechanism or small "stone" lies loose in the chamber of the internal ear in a fish. After removing this stone from the cavity of the ear and replacing it by an exact counterpart made of iron, Steinach found that, as he lifted the iron stone from one position to another with a magnet, the fish underwent gyrations accordingly.

The flash energy of escape in fish is provided not by a pair of adrenal glands serving the entire organism but by a number of masses of adrenalin-secreting substances called "chromaffin tissue."

The Sting Ray

The sting ray is a sedentary animal. Most of the year it occupies a protected position, partly buried in the sands of the shallow sea. Like the alligator and the crocodile, it is a biologic trap. The nostrils and the wide transverse mouth are placed on the flat undersurface of the head, but the eyes are on the upper surface. These active centers locate the brain, over which there is a sloping, carapace-like cover, as smooth as a tight-fitting glove, that extends over the entire disk. Because every part of the sea is hunted over by the great and small carnivorous fish, the passive, protected fish must have developed the most complete negativity to escape.

The sting ray, although partly buried in the sand, must keep the margins of his flappers protected against the chance of getting between the teeth of a voracious fish. He must not allow the water to make an uneven surface beneath him lest a small enemy creep under his flappers. He must have the means of progression. We found in the sting ray a unique nerve-muscular mechanism. Dissection showed that each flapper of the ray is provided with 94 muscle plates several centimeters in width, extending in depth down to the middle of the flapper, where there is a partition of cartilage. These muscle plates extend from the thickest part of the mid-line to the extreme edge of the flapper. A fibrous film separates each plate from its neighbor. These muscle plates are attached to the firm skin and to the cartilage that divides the flapper longitudinally as well as to the connective tissue that divides the plates. To these 94 plates are supplied 94 nerves that emerge from the spinal cord. Thus, in the ray, there are 188 nerve muscle

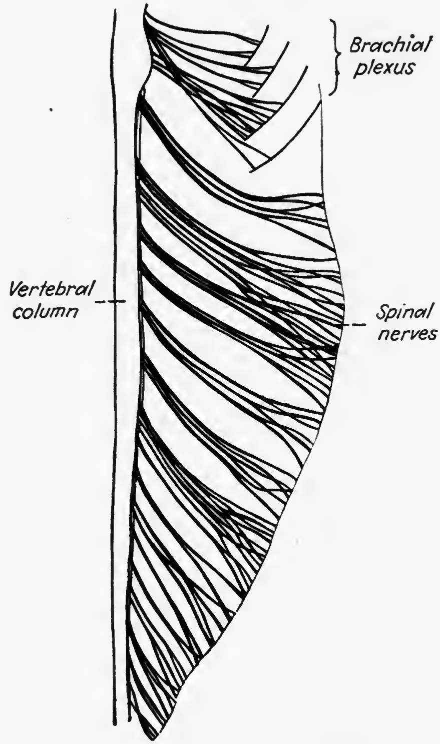


FIG. 12.—Nerve supply to flapper of sting ray.

mechanisms, each with an end organ, a driving brain, a conducting spinal cord, and nerve fibers that energize the muscle plates. It is as if an eagle had a special nerve-muscle control over each feather of the wing.

We found that the brains of the sting rays that we collected were larger in relation to their body weight than the brains of any other fish except those that weighed under 500 grams. The large brain of the sting ray is related not only to gross power but also to finesse in the use of many muscles in the execution of coordinated action as well as to the oxygen content of the foam on the shallow beaches. The finesse of the flapper of the sting ray may be compared to that of the trunk of the elephant, which, consisting of a large number of muscles, can move in any direction. The development of ninety-four pairs of fingers on each hand would be an equivalent in man.

Numerous muscles require numerous action patterns (brain patterns): numerous action patterns necessitate, accordingly, a larger brain, for the size of the brain, like the size of a comptometer, is related not alone to gross energy but also to the number of separate acts performed.

The thyroid gland of the sting ray, as one would expect from the size of the brain and the constant energy needed to supply the constant action of the ninety-four pairs of muscles, is also large in comparison with the thyroid gland of other fish.

The Electric Ray and the Sting Ray

A comparison of the sting ray with the electric ray is significant. The sting ray, as we have stated, has ninety-four pairs of nerves leading to the ninety-four muscular segments of the flappers. The electric ray also has ninety-four pairs of nerves leading to the different segments of the flappers. The difference between the sting ray and the electric ray is that, in addition to muscular contraction, the neuromuscular mechanism of the electric ray generates electric energy. This electric energy is transmitted to the muscles in the flappers. The electric ray, instead of escaping by swimming or by hiding in the sand, uses its electric energy as a defense mechanism by giving electric shocks to the animal that attacks it, for the speed of the electricity generated in the electric ray is greater than the speed of action of the muscles that close the jaws of the attacking enemy. Therefore, the discharge of electricity instantly disarms the attack. This circumstance is in harmony with the conception that all animals are essentially electric in nature, for if they were not so the sting ray could not have been converted from a muscular to an electric mechanism.

The brain of the sting ray, as stated, is large because each of the ninety-four pairs of nerves emerging from the brain has a mechanism of its own in the brain. For the same reason, the brain of the electric ray is large, for each of the muscles that has been converted into an electric cell has its own mechanism in the brain. The ratio of body weight to brain weight in the sting ray was 1:209; that of the electric ray was 1:441. The need of constant muscular-electric-energy to maintain the sting ray and of electric energy to maintain the electric ray is shown by the comparable ratios of thyroid gland to body weight, 1:9989 for the sting ray, 1:11897 for the electric ray.

Thus, on the shallow beaches where the water is richly mixed with air, evolution raised the energy and increased the size of the energy-controlling organs. The batlike ray, living at the shallow edge of the sea, where the trade winds blow and the waves ceaselessly mix the rich oxygen content of the air with the water, has been adapted to a greater supply of oxygen than is possessed by other fish. The constancy of the tide and the trade winds brings about a constancy of waves and foam. The trade winds being constant, foam is constant, increased atmospheric oxygen in the water is constant, and the larger brain and higher metabolism of the sting ray, with its increased muscular activity, are constant. Thus the tides and the trade winds are responsible for the exceptionally large brain, large heart, large thyroid gland, and rich blood supply of the sting ray as compared to other fish.

In the sting ray and Thomson's gazelle we have two animals far removed from each other—a gill-breathing animal and a lung-breathing animal, a cold-blooded animal and a warm-blooded animal. The sting ray in his foamy habitat has such an exceptionally high concentration of oxygen that it is able to operate a mechanism almost as complicated as that of the Thomson's gazelle. This is evidenced by the fact that the brains and also the thyroid glands of these two animals are of nearly equal weight, as shown in the following comparison:

Animal	Body weight, grams	Brain weight, grams	Body weight / Brain	Thyroid weight, grams	Body weight / Thyroid	Heart weight, grams	Body weight / Heart
Thomson's gazelle.	24,940	90.8	1:275	1.85	1:13481	290.00	1:86
Sting ray.........	25,396	126.4	1:209	2.80	1:9070	82.67	1:306

Although the brain and the thyroid gland of the sting ray and Thomson's gazelle are of nearly equal weight, the work they do is of unequal value, through the operation of van't Hoff's law, that with every degree centigrade of rise in temperature the speed of chemical activity is increased 10 per cent.

We were fortunate in collecting a sloth from the American tropics of the same weight as a salmon from the swift-flowing Restigouche River in Canada. The sloth is one of the most negative of all animals. For inactivity it occupies about the same place in the warm-blooded scale as the alligator does in the cold-blooded scale. It is not possible to compare the intelligence of the warm-blooded sloth and the cold-blooded salmon. Nor is it possible to estimate the portion of the 23-gram brain of the sloth that is required to spark the oxidation needed to maintain its warm-blooded state and its limited intelligence and muscular activity. It is reasonable, however, to think that the greater part of the weight of the brain of the sloth is used to maintain the body temperature.

In this comparison between the sloth and the salmon we have an excellent example of the fact that the primary role of the brain is to maintain the body temperature, muscular power, and the electric strain necessary to sustain the living protoplasm of the body. This point could be clarified by determining the basal metabolism of the two animals.

Animal	Body weight, pounds	Brain weight, grams	Thyroid weight, grams	Adrenal weight, grams
Two-toed sloth	10.64	23.07	3.307	0.6857
Salmon	10.85	1.029	0.010	

In a porpoise and a tiger shark, two occupants of the Atlantic Ocean having approximately the same weight, we found an example of the influence of the concentration of oxygen on the size of the brain, the heart. the volume of the blood, and the thyroid gland.

These two animals represent the warm-blooded and the cold-blooded state in the sea. The porpoise, a lung-breathing, warm-blooded animal, although living in the sea in the midst of slower swimming creatures, lives dangerously. In constant danger of drowning, the porpoise brings its young into the world, suckles them, and protects them in the presence of sharks—the pirates of the sea.

Immediately after the death of the porpoise we made an incision in the smooth skin and inserted a clinical thermometer. It registered the normal human temperature of 98.6°. The layer of pure white blubber varying from 3/16 inch in places to 2½ inches in thickness recalled the thick skin found in the rhinoceros, the hippopotamus, and the elephant.

In the case of the African animals, the thick skin serves to insulate them against external heat; in the case of the porpoise—a warm-blooded animal living in the cold sea—the thick skin serves to preserve the internal heat in a medium colder than air.

Inasmuch as water abstracts heat twenty-seven times faster than air, the warm-blooded mammal that returned to the sea would be equipped with a larger brain, a larger

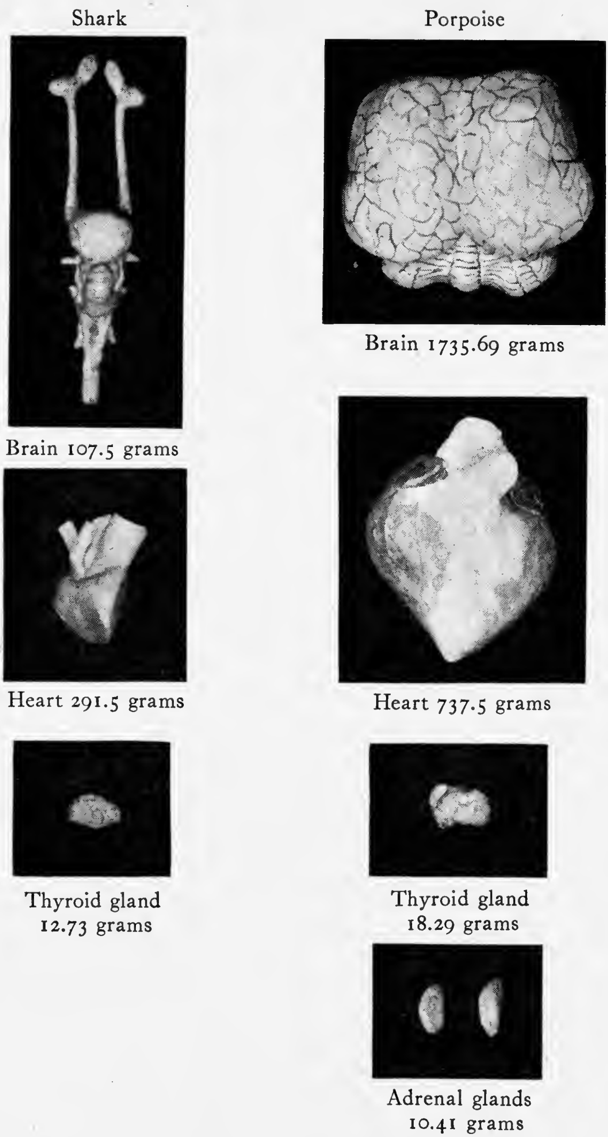


FIG. 13.—A comparison of the energy-controlling organs of a shark and a porpoise.

heart, a larger thyroid gland, and a greater volume of blood than a mammal of corresponding size on the land. It is the abstraction of heat by water that enables the porpoise to use such a high degree of constant energy without heatstroke.

In the dissection of the porpoise it was at once evident that the muscles were those of a mammal. In vascularity and in color they were strikingly different from those of a fish. The color of the muscles was even richer and darker than that of the muscles of a lion or a zebra.

The thyroid glands lay in the usual mammalian position and were connected by a slender isthmus. The weight of the thyroid glands was 18.29 grams. Not until we saw the adrenal glands, which weighed only 10.41 grams, did we fully appreciate the continuous activity necessary to maintain the high level of mammalian oxidation in a cold sea.

Outbursts of activity would not benefit the porpoise. The porpoise requires an exceedingly high level of constant activity, supplemented by emergency oxidation. Therefore, the porpoise needs a large brain, a large heart and blood volume, a large thyroid gland, and, as in man smaller adrenal glands.

Dissecting out the brain and the pituitary gland in the porpoise was almost as difficult as chiseling the brain out of its bony case in the elephant. The brain of the porpoise weighed 1,735 grams. It was strikingly larger than the human brain and had a ratio of brain-to-body-weight of 1:85, approaching the ratio of the brain-to-body-weight of man.

The energy requirements of the porpoise are above those of any land animal or bird or fish, since the land animals and the birds and the fish do not have to travel to get their breath. In order to secure its prey, the porpoise must compete with the shark, the sailfish, the barracuda. For aeons the porpoise has been under the necessity of swimming to the surface to fill its mammalian lungs. It is as if the porpoise ran uphill all its life.

The tiger shark is the most formidable member of the fish family. It is an active and fierce fighter. It has a wide range of activity and no protection such as carapace, sting, or poison. The tiger shark is as much a free lance as the lion, the wolf, or the hunting dog.

Animal	Body weight, pounds	Brain weight, grams	Thyroid weight, grams	Heart weight, grams
Porpoise.......	314	1,735.69	18.29	737.5
Tiger shark....	442	107.5	12.73	291.5

In this comparison between the porpoise and the tiger shark we have in the porpoise an example of adaptation to the production of internal temperature and constant muscular activity. This adaptation has taken the form of an increase in the size of the brain, the heart, the volume of the blood and the thyroid gland, but not of an increase in the size of the adrenal glands. It will be seen that such an energy formula equips the porpoise with a mechanism for compensating the rapid loss of heat in the water. The shark, being cold-blooded, assumes the temperature of the water.

Since the oceans and lakes and rivers communicate with each other, the sea would seem to be the theater of the most complete evolution of the mechanism upon which the intelligence, power, and personality depend.

In the preceding chapters we have shown that upon the size of the brain, heart, blood volume, thyroid and adrenal glands and sympathetic system depend the intelligence, power, and personality of the mammals and the birds already cited. It was especially significant that we found that this ratio applies to the negatively evolved reptile. We now find that this formula applies to fish likewise. Consequently, we should expect to find that the formula would apply also to the domestic animals and to the primates, including man.

17. THE HORSE FAMILY

WE HAVE now completed our studies of the wild animals, some of which are the ancestors of such domestic animals as the horse, cattle, sheep, swine, and fowl, which, through breeding and domestication, have been modified by man. In these domesticated animals, as in civilized man, we expect to find the influence of hybridization and mutation. The most outstanding examples of the influence of hybridization and mutation are seen in the horse and in civilized man.

The antelope, the deer family, and the wild ancestors of cattle possess horns for defense against their enemies, the carnivores. The sole defense of the horse is its speed. So effective have been the speed and endurance of the horse that he has spread over most of the grazing world. In geological time the record of the horse goes back about forty-two million years.

The horse is the sole animal that man has bred for energy alone. It therefore occurred to us in our research into the energy-controlling systems of animals that the long-time modification in the intelligence, power, and personality of the horse, effected by man through breeding, offered a unique means of testing our thesis. If it holds for the horse, we may expect that it will hold for man, and especially for civilized man.

The types of horse bred and adapted for carrying burdens are the ass, or the burro, and the mule. The type of horse bred for drawing loads is the Percheron. The type of horse bred for riding and light harness is the saddle and trotting horse. The horse famed in romance and fiction, the companion of man in the desert and in war, is the Arabian horse. The horse bred for centuries for short-distance speed only, in contrast with long-distance endurance, is the thoroughbred or race horse. The Shetland pony, a native of the cold, wet Shetland Islands, is used as a circus horse. The zebra, a fast and furious runner, mingling with the antelopes, exists in great numbers among lions and other Carnivora that always seek its flesh.

Because the horse family presents a fair test of the validity of the energy conception in our thesis, we turned at long last to a study of the pattern of the energy-controlling organs of these various types of horses. To that end we studied 231 horses. Among these were burros, mules, work horses, western horses, hunters, saddle horses, polo ponies, Shetland ponies, zebras, Arabian stallions, Kentucky thoroughbreds, newborn foals, and fetuses.

For our purpose, we tested these data to see whether there was an energy formula for horses bred for carrying a pack; another for horses bred for slow power, such as the work horse; another for horses with more mobile energy, such as the saddle horse and hunter; another for horses with great endurance and gentle disposition, such as the Arabian; and another for horses with great speed or explosive energy, such as the thoroughbred.

We also contrasted these various types of horses with the wild zebra of the hot tropics and the Shetland pony of the cold north to see what might be the influence of climate upon their energy mechanisms.

For thousands of years the horse has been developed by man through breeding selection. Breeding selection by man partly suspends the law of natural selection in the wild, such as is effected in the lion, the tiger, the leopard—in fact, in all the carnivores, the rodents, and the hoofed animals.

In the natural selection imposed by the carnivores upon the herbivores, there has always been involved the extermination of those that are weakest in muscle and the least fit in the special senses; therefore, natural selection leaves those with the keenest senses, the fleetest feet, the most intelligent minds to reproduce their kind. In this selection the carnivores, unlike man, did not impose a selection as a calculated advantage for the long future. The immediate necessity of the carnivores was food.

In breeding the horse, man imposed on the horse conditions calculated in effect to contribute more to man's own future needs than to his immediate necessity. Therefore, in his selective breeding of the horse, man bred the horse not alone for energy but for the kinds of energy most calculated to help man to survive.

In the wild state the horse evolved in much the same way as the deer and the antelope. During the forty-two millions of years of the known existence of the horse, the greatest change in its fate took place with the rise of man.

The brain, the thyroid gland, and the hand of man are unique among all animals. The rise of man appears to be an example of the principle of orthogenesis applied to the thinking brain and the thyroid gland. This principle, as explained by Eimer, is that when a species begins to vary definitely in any direction it cannot reverse itself, even if it is tending toward its own destruction. As orthogenesis made man increasingly more intelligent, man gained control over the energy of plants and animals as well as of the wind, the waterfall, and coal. Man found that the four feet of the horse could be substituted for his own two feet in traveling and in carrying burdens and that the horse was of particular advantage in war.

The sculptures of early man show that at a very early date man found that the legs of a horse could carry him faster and longer in attack or retreat than his own legs. By riding, he could attack his fellow man by a combined man-and-horse attack, or, in case of a hand-to-hand combat, the horse would deliver him fresh for a surprise attack. In fact, such a unit was man and his horse in early days that in art we find realized the concept of the centaur—a beast half horse and half man.

As man's brain evolved, he bred those horses that had the greatest endurance, speed, and courage and that could best meet with the vicissitudes of food and climate. Even at that early day man must have glimpsed the principle of inheritance. He must have noticed that the horses of highest speed reproduced their kind and that slow and inefficient horses reproduced their kind. Thus the advance of the brain of man carried with it the advance of the speed and endurance of the horse.

It would naturally follow that the greater advance of the horse would occur among the people who depended most completely on it, in particular those who represented high intelligence. This would be among the desert people who had to fight for the water hole and travel long distances for pasture. The desert belt runs across North Africa and Arabia, the domain of the Barbs, the Arabs, and the Turks. It is here that the horse was advanced by natural selection and breeding. The fertile plains and valleys of the far north could not have produced as much human need for the highly developed horse as was provided by the desert.

Thus, with the rise of man came the rise of the horse, until finally the desert-bred stallions were transported to the British Isles. Here they were bred with native mares whose brains, hearts, blood volume, and thyroid glands through the influence of the cold, blustering northern climate, had been advanced in size.

Dr. W. J. Stewart McKay, in his study of the thoroughbred, cites evidence that the thoroughbred horse owed an important debt to the native English mares.

The Shetland pony is an example of a horse whose energy system has been modified by cold. The ratio of the weight of the brain and the thyroid gland to the body weight of a Shetland pony that we collected was 1:294; the ratio of the weight of the brain and thyroid gland to the body weight of Equipoise, the famous thoroughbred, was

Type	Sex	Body weight, kilo-grams	Body weight, pounds	Brain weight, grams	Body weight / Brain	Thyroid weight, grams	Body weight / Thyroid	Adrenal weight, grams	Body weight / Adrenal	Heart weight, grams	Body weight / Heart
Shetland pony	Stallion	150.35	331.52	496.1	1:303	14.70	1:10228	16.29	1:9230	1375	1:109
Zebra	Stallion	254.37	560.88	545.5	1:466	21.09	1:12062	23.08	1:11020	1850	1:137
Nureddin (Arabian)	Stallion	461.76	1,018.18	618.0	1:747	46.80	1:9872	26.80	1:17239	3908	1:118
Equipoise (thoroughbred)	Stallion	521.52	1,149.95	808.5	1:645	33.40	1:15614	46.62	1:11187	4455	1:117

1:619, and the ratio of the weight of the brain and thyroid gland to the body weight of Nureddin, the famous Arabian stallion, was 1:694.

In our expedition to the subarctic region we studied the ratio of the energy system to the body weight of the caribou, the wolf, the husky dog, the hare, the fox, the lemming, the mouse, as well as of the Eskimo himself. We wished to learn whether in the cold north wild animals and man require a greater rate of oxidation to maintain the warm-blooded state, as shown by a higher ratio of the weight of the brain and of the thyroid gland to the body weight, than is shown in man and comparable animals in the temperate and the tropical zones. This we found to be the case.

It would seem, therefore, that the factors contributed to the thoroughbred horse by the mares of the cold north were a larger brain, a larger heart, a greater volume of blood and a larger thyroid gland than were possessed by the desert stallion, such as the Arab, the Barb, and the Turk, to which these native mares in Britain were bred.

Dr. McKay has shown that the rather abrupt appearance of this new type of horse was seen in Matchem, Herod, and Eclipse, in a period ranging from 1748 to 1764, and he states[1] that it is certain " . . . that all the important horses of today can be traced back to Matchem, Herod, or Eclipse; but in dealing with the origin of the thoroughbred we must take a wider view of the matter, because we know that there were other horses before the Byerley Turk, the Darley Arabian and the Godolphin Barb, who richly deserved some credit for their contributions to the origin of the thoroughbred.

"While we must give the Eastern sires and some of the Eastern mares their due, we must at the same time bring out the tremendous importance of the contributions derived from the native English mares. In fact, it was the happy combination of the Eastern sires and the English native mares that brought into existence a horse that no other country, but Britain and Ireland, was able to produce by the crossing of Eastern sires with mares indigenous to that particular country."

During the rapid change in the speed and size of this new product, the thoroughbred, no change was seen in the native Arabian or native Barb or native Turk stock in Africa and Asia. Nor was any advance seen in the speed or size among the native stock in the British Isles or in Scandinavia or in France. The only advance made was due to blending the northern stock with the desert stock. Dr. McKay logically accounts for this fact by the principle of mutation as laid down by De Vries. Dr. McKay considers the desert stallion an "elementary species" and the English mare, a "mongrel." Crossing these two stocks would produce great variations in the offspring and might give rise to a new line. This actually occurred. The result was the thoroughbred.

The zebra, for instance, is bred in the tropics under conditions opposite to those for the Shetland pony. The quick

[1] McKay, W. J. Stewart, "Evolution of the Endurance Speed and Staying Power of the Race Horse," Hutchinson & Co., Ltd., London, 1932.

getaway power of the zebra was "bred" by the most rigid stable master in the world—the lion; and the "staying heart" of the zebra was "bred" by the pack of wild dogs. In the wild state the daily life-and-death races of the zebra keep him in a continual Derby. The Shetland pony, on the other hand, is bred by the rigorous discipline of cold and storm. In either case the energy-controlling organs have been "bred," that is, stepped up over long periods of time.

Let us now see how the energy systems of these two members of the horse family compare with each other.

Since cold alone steps up the energy organs higher than does the race of destiny, we should expect that the Shetland pony would have a higher ratio of the combined weights of the brain and thyroid and adrenal glands to its body weight than the zebra. The ratio of the weight of the brain and thyroid and adrenal glands to the body weight in the case of our Shetland pony, which weighed 150.35 kilograms (331.52 pounds) was 1:285; in the case of the zebra, which weighed 254.37 kilograms (560.88 pounds) the ratio of the weight of the brain and, thyroid and adrenal glands to the body weight was 1:432.

Let us now compare the weight of the brain and the thyroid and adrenal glands to the body weight of a wild zebra collected on the plains of Tanganyika, the American thoroughbred stallion Equipoise, and the Arabian stallion

Animal	Body weight, kilograms	Body weight, pounds	Brain-thyroid-adrenal weight, grams	Body weight / Brain-thyroid-adrenal weight
Shetland pony...	150.35	331.52	527.09	1:285.24
Zebra...........	254.37	560.88	589.67	1:431.37
Nureddin.......	461.76	1,018.18	691.60	1:667.66
Equipoise.......	521.52	1,149.95	888.52	1:586.95

Nureddin with the Shetland pony of the bleak and frigid north.

Although the Shetland pony weighs the least of these four animals and the energy-controlling organs weigh the most in Equipoise, it will be seen that the Shetland pony possesses the highest ratio of energy-controlling organs to the body weight. By using the power formula we can see this more accurately.

The power formula, also known as the "relative-growth equation,"[1] offers a means to compare the degree of glandular and organ development in animals of widely varying weights. This makes it possible to overcome the usual difficulties involved in evaluating the relative organ weight. Thus, the relative brain weight of the mouse may be higher than that of man, being in the ratio of 1:28 against the human ratio of 1:40. Measured on the power-formula scale, however, the mouse stands at the 0.1222 level, and man stands at the 3.415 level. In other words, if we imagine the mouse brain fixed at 0.1222 feet above the base line of the developmental scale, the human brain will tower above that of the mouse at a level of 3.415 feet, or 24.31 times that of the mouse. Whenever, in these chapters, data are given in terms of the power formula, it should be borne in mind that the smaller figures indicate lower degrees of development of the particular structures in question.

The power formula gives the following values for these members of the horse family:

Brain Value		Thyroid Value		Adrenal Value	
Nureddin	0.5327	Equipoise	0.6003	Nureddin	0.3282
Zebra	0.6431	Zebra	0.6285	Zebra	0.4740
Equipoise	0.6539	Shetland pony	0.6907	Equipoise	0.5099
Shetland pony	0.7850	Nureddin	0.8602	Shetland pony	0.5289

[1] Quiring, D. P., "A Comparison of Certain Gland, Organ, and Body Weights in Some African Ungulates and the African Elephant," Western Reserve University, and Cleveland Clinic Foundation, *Growth*, Vol. 2, No. 4, pp. 335–346, 1938. Quiring, D. P., "The Scale of Being," to be published in *Growth*, Vol. 5, No. 3, 1941.

The combined values of the brain and the thyroid and adrenal glands, based on the power formula, are as follows:

BRAIN-THYROID-ADRENAL VALUE

Nureddin	1.721
Zebra	1.745
Equipoise	1.764
Shetland pony	2.004

In Dr. McKay's account of the rise of the thoroughbred horse, we note two component facts:

1. In the crossing of the Arab, Turk, and Barb with the native mares of the north, there appeared occasionally a superior horse. This is typical of mutation.

2. As these superior mutants appeared in increasing numbers, the percentage of superior horses increased.

The summation of the mutation of the horse by crossing the desert-bred stallion with the cold-bred mares was seen in the horse Eclipse, which represents the pinnacle of this transformation. In other words, according to the power formula, the energy-controlling system of the cold-adapted Shetland pony shows a degree of development 1.15 times greater than that of the thoroughbred American stallion Equipoise.

It would seem that further crossing between the offspring of Eclipse and the Arabian, the Barb, and the Turk would not advance the present thoroughbred, nor would crossing with the native mares advance the thoroughbred. The thoroughbred would now seem to have a career of its own that began with the appearance of Matchem, Herod, and Eclipse.

If there has been no further advance by the crossing (from time to time) of the desert-bred stallions and the northern mares, how, then, can we account for the fact that in these years the thoroughbred has advanced as to speed, conformation, and height?

This brings us to the second point of great interest in the account of Dr. McKay, namely, that the advance was through selective line breeding from the offspring of the great foundation stallions Matchem, Herod, and Eclipse.

We can account for this continual advance of the thoroughbred in only one way, namely, through the operation of the law of orthogenesis. When a horse or a man exhibits a progressive increase in the size of an organ or group of organs, this progression may continue until the offspring exhibits such extremes as to affect the line unfavorably. In man, the brain, the heart, the thyroid gland, and the sympathetic system have been increased in activity by the operation of the law of orthogenesis to the ceiling of his energy possibilities. In some cases the activity of man's energy-controlling organs is so extreme that he is impaired and destroyed by exophthalmic goiter, by hypertension, by diabetes, and by nervous, mental, and heart diseases. Therefore, we may expect that some day the thoroughbred horse, in which the brain, the heart, and the adrenal-sympathetic system have undergone an increase in size and power, will, as in man, reach the pinnacle, and this achievement will be expressed by an increasing incidence of sterility, nervous instability, and energy diseases not yet well defined. Examples of such instability are seen in Brown Eyes and Roxana.

The thoroughbred Brown Eyes was out of Katy of the West, by Caughkill, and the sire of Katy of the West was Spendthrift, an outstanding race horse. Brown Eyes was a horse of high promise; her owners believed that if she could be started in a race she would be a winner. But because of her excitability she could not be properly started. Her behavior was clarified when we found the abnormal size of the adrenal glands, the largest that we have seen in any horse. These adrenal glands weighed 60.78 grams; the ratio to the body weight was 1:9030 as contrasted with the adrenal-to-body-weight ratio in Equipoise of 1:11187. Brown Eyes is an example of a mutation so great as to disqualify her as a race horse.

One other point of fundamental interest in relation to Brown Eyes is the weight of the brain. The brain of Brown Eyes, which weighed 650 grams, should be compared with

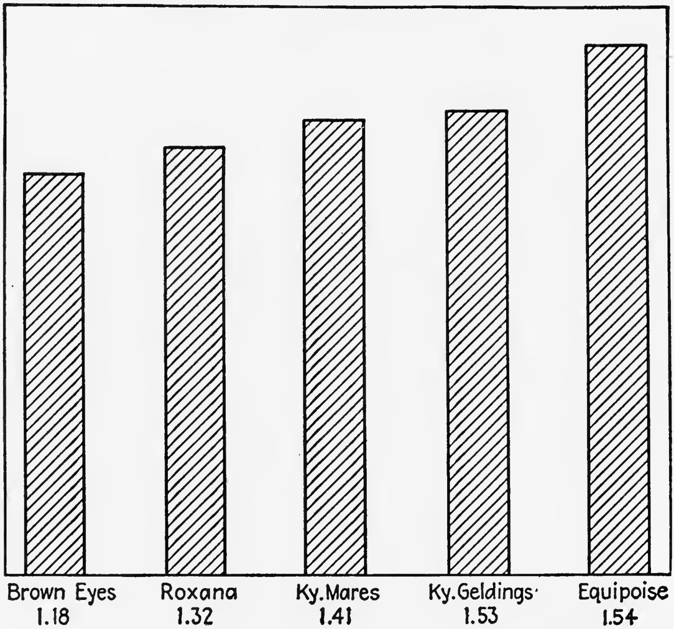


FIG. 14.—Grams of brain per kilogram of body weight in various horses.

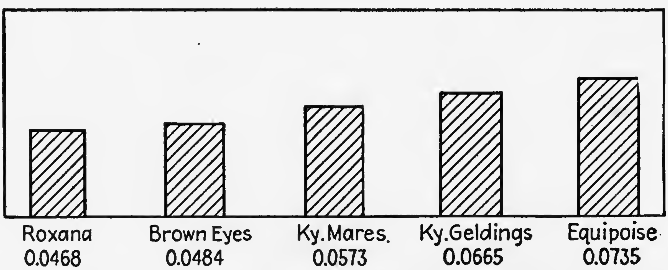


FIG. 15.—Grams of thyroid gland per kilogram of body weight in various horses.

the brain of Equipoise, which weighed 808.5 grams. The brain-body weight ratio in Brown Eyes was 1:840. The brain-body weight ratio in Equipoise was 1:645.

Another example of mutation yielding a bizarre behavior characteristic is seen in Roxana, a thoroughbred saddle horse. This restive, temperamental horse could not be

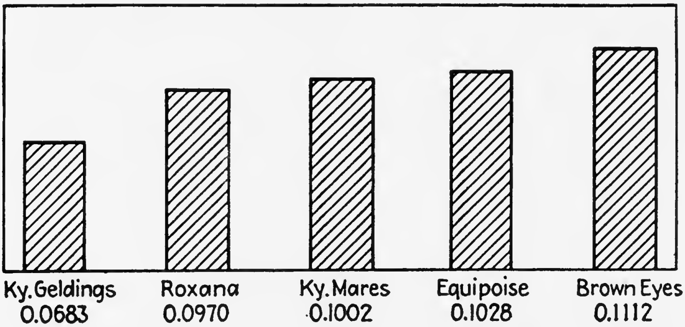


FIG. 16.—Grams of adrenal glands per kilogram of body weight in various horses.

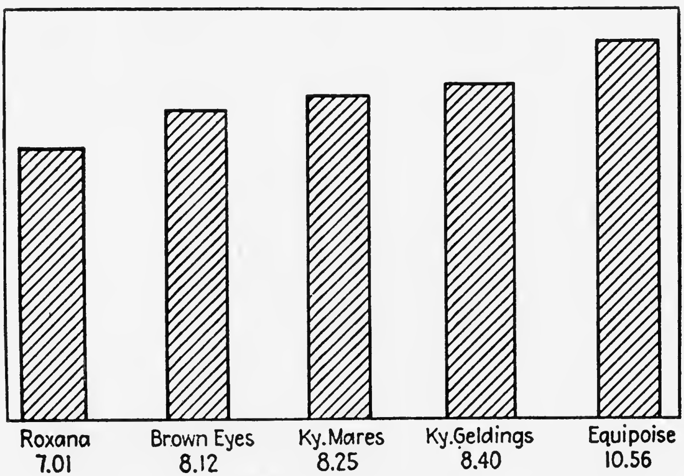


FIG. 17.—Grams of heart per kilogram of body weight in various horses.

trained. As in the case of Brown Eyes, investigation showed in Roxana a striking size of the adrenal gland, the adrenal-body weight ratio being 1:8507, as compared with 1:11187 for Equipoise. In both Brown Eyes and Roxana we have an unbalanced energy control, the adrenal glands being developed in excess of the brain-adrenal pattern of a dependable horse. In Equipoise we see a well-balanced energy system. These mutations seen in the horse family are similar to mutations seen in the human family.

The Arab Compared with Three Generations of the Thoroughbred

Through the kindness of Mr. Roger A. Selby, of Portsmouth, Ohio, we had the privilege of studying his famous Arabian breeding stallion Nureddin, bred at Crabbet stud, England (sire, Rijm by Ibu Mahruss, out of the famous mare Rose of Sharon, dam, Narghileh, by Champion Mesaoud) as well as his famous white Arabian stallion Mirage (sire, A. Kehilan Ajuz, of the Anazeh; dam, A. Seglaw ieh Jedran, of Dalia).

Through the interest of Major Beard, of the Whitney stables, and Dr. Dimock, of the University of Kentucky, we were given the opportunity in Lexington to study Pennant, the famous twenty-seven-year-old thoroughbred stallion, and an eight-months-old colt. The sire of Pennant was Peter Pan out of imported Andirella; the dam, Royal Rose by Royal Hampton.

Through the cooperation of Major Beard of the Whitney stables, Dr. Fred Rankin, of Lexington, Kentucky, Dr. Dimock, and Dr. Errington, the brain-thyroid-sympathetic system and heart of the famous race horse Equipoise, sired by Pennant, out of Swinging, were sent to the Cleveland Clinic Laboratories for study on the night that he died. This gave us the unique opportunity of comparing three generations of thoroughbreds—Pennant, Equipoise, and the young colt sired by Equipoise out of imported Air Fleet—grandfather, father, and son, with Nureddin, the tallest known pure-bred Arabian stallion.

A comparison of the size of the brain, the heart, and the thyroid and adrenal glands of these three thoroughbreds with those of Nureddin, the Arabian, follows.

Horse	Body weight, kilo-grams	Body weight, pounds	Brain weight, grams	Thyroid weight, grams	Adrenal weight, grams	Heart weight, grams
Equipoise colt.......	262.1	577.93	611	20.04	13.20	2038
Pennant............	442.1	974.83	735	36.35	25.02	5250
Nureddin...........	461.76	1,018.18	618	46.80	26.80	3908
Equipoise...........	521.52	1,149.95	808.5	33.40	46.62	4455

If the relative weights are taken into consideration, it will be noted that the brains of the thoroughbreds Pennant, Equipoise, and the Equipoise colt are all larger than the brain of Nureddin, the Arabian.

It will be noted in the Arabian horse Nureddin that the thyroid gland is larger than the adrenal glands, showing the adaptation of the Arabian for long-distance traveling. In the colt of Equipoise, also, the thyroid gland was larger than the adrenal glands, showing that the energy organs had not yet assumed the adult pattern characteristic of the thoroughbred. In Equipoise the thyroid-adrenal relation is the pattern of the thoroughbred horse. In a study of 142 thoroughbreds, this is the pattern that obtained.

Pennant, a retired thoroughbred, twenty-seven years old, showed pathologic changes in the heart and thyroid gland; so these organs could not be used for comparison.

Of significance is the fact that of a total of eighty-seven fetuses and newborn foals of thoroughbreds examined by us, eighty-three followed the Arabian pattern in which the thyroid gland is larger than the adrenal glands. In one grade foal and in twenty saddle-bred and in two standard-bred foals, a similar thyroid-gland dominance was found. It would appear that the energy organs in the prenatal state have the pattern of the Arabian ancestors of the thoroughbred.

The thoroughbred, or race horse, is under the control of man—a control that allows the brain, the heart, the thyroid gland, and the adrenal-sympathetic system to increase to a remarkable size. Were these race horses subjected to a chase by a pack of hounds or wolves, the thoroughbred, with its ability for high speed, might, in its effort to escape, so increase its internal temperature that it would be overcome by heatstroke.

No animal such as the zebra or the oryx possesses so highly developed an energy-controlling system as the thoroughbred horse. In this connection it is to be borne in mind that the horse is the only animal save man that sweats all over. Sweating facilitates the elimination of internal heat and in consequence permits the development of a larger brain, larger heart, larger thyroid gland, larger adrenal glands, and larger celiac ganglia and plexuses, with diminished danger of heatstroke.

The endowments of the Arabian horse that make him a gentle companion of man, requiring a small amount of food, capable of enduring long-distance travel but not equipped for as high a speed of outburst energy as the thoroughbred, are expressed in a brain and adrenal glands smaller than the thoroughbred's. The balanced energy system of the Arabian horse is comparable to the balanced energy system of Oriental man. Thus it is this unique energy formula, possessed only by the Arabian horse, that endows it with its unequaled endurance, coupled with high intelligence and gentleness.

Pattern of the Draft or Work Horse

The draft horse does not require outbursts of energy, as would the cavalry horse or the running horse. The draft horse requires a mechanism adapted to the long, continuous carrying of a pack and the long, continuous pulling of a load. The kind of energy man wished to transfer from himself to a member of the horse family was that of carrying a load, including the load of man himself. The draft horse does not need outbursts of energy. Therefore, the draft horse requires a smaller brain, a smaller heart, a smaller thyroid gland, and, in particular, smaller adrenal glands, celiac ganglia and celiac plexuses than the thoroughbred or running horse. A typical example of the draft horse is the Percheron.

Horse	Sex	Body weight, kilo-grams	Body weight, pounds	Brain weight, grams	Thyroid weight, grams	Adrenal weight, grams	Heart weight, grams
Thoroughbred (Equipoise)......	Stallion	521.52	1,149.95	808.5	33.40	46.62	4,455
Percheron....................	Stallion	635.04	1,400.26	662.0	40.84	39.22	5,600

The ratio of the combined weight of the brain, thyroid, and adrenal glands to the body weight is:

Percheron.. 1:856
Equipoise.. 1:586+

According to the power formula, the values are as follows:

Horse	Sex	Brain	Thyroid	Adrenal	Heart
Percheron..................	Stallion	0.4803	0.5755	0.3652	0.6545
Thoroughbred (Equipoise).....	Stallion	0.6539	0.6003	0.5099	0.6269

The combined values of the brain, thyroid, and adrenal glands, based on the power formula, are:

Percheron.. 1.421
Equipoise.. 1.764

In other words, according to the power formula, the energy-controlling system of Equipoise is 1.24 times greater than that of the Percheron.

The sizes of the brain and the adrenal glands were consistent with the speed and power of Equipoise as compared with the Percheron.

The heart and the thyroid gland of the Percheron would appear to be larger than normal, as in the case of lions in captivity. The brain is the master organ. Throughout adult life it does not change in weight.

The Ass, the Mule, and the Shetland Pony

Wishing to entrust valuable freight to its back, man selected an animal that, by nature and breeding, possessed a characteristic the very opposite of those of the thoroughbred, namely, dependability. Man needed an animal that was not easily frightened, that had less temperament—hence a lower relative amount of adrenal-sympathetic tissue—than the excitable thoroughbred. Therefore, man bred the ass and the mule for carrying the load.

The koulan or wild ass of the Mongols and the onager of the ancients are held by many authorities to be the same animal as the koulan still found on the steppes of Asia. So highly are these animals endowed with energy and so skillful are they in warding off danger with their hoofs that wolves do not attack vigorous koulans.

The progenitors of the present-day ass live in Africa and, according to Brehm, are represented by two species, the ass of the plains and the Somal ass, which is thought to be a link between the Asiatic ass and the zebra.

Like the koulan and the onager, the ass of the plains and the Somal ass run in herds of about twenty, each herd guarded by the leader, a stallion. The shy and wary ass of the plains has been domesticated from earliest time, wild specimens having been continually used to maintain the vigor of the breed.

Of all the asses of the plains, the asses of Arabia, bred in Jemen, are the most superior. One type is large and well adapted to the use of the saddle; the other is small and adapted to carrying burdens.

The drier the soil and the more frugal the food, the healthier the ass. The desert ass, like the desert horse and the desert camel, does not require such a large amount of food as do those animals in regions in which food is abundant.

Although the ass has for a long time been adapted to a warm climate, the size of the energy system of the ass has not been adapted to the production of large amounts of heat for maintaining the warm-blooded state, as in the case of the Shetland pony. Therefore, this low-geared pack horse of the tropics and subtropics, like the burro, requires much less food than the northern Shetland pony of equal size.

Relevant to this statement, it must be borne in mind that the master of the lazy ass is correspondingly lazy and correspondingly requires less food, whereas the master of the active Shetland pony is subject to the same adaptation against cold as the Shetland pony and, therefore, requires a correspondingly larger amount of food. The cold Shetland pony and his vigorous master can, of course, perform a greater amount of service than can the warm, lethargic ass and his lethargic master.

The subarctic-adapted Shetland pony and the subtropic-adapted ass are not the only members of the horse family at our disposal for analysis of the energy-controlling system. The remaining member of the horse family has not been modified by man. This animal is the African zebra.

The Zebra

The zebra is adapted to the tropics and the subtropics. The zebra possesses keen senses and great speed and is so high-tempered that man has found it difficult to tame.

An analysis of the energy-controlling systems of the ass, the Shetland pony, and the zebra, with respect to the sizes of their brains, hearts, and thyroid and adrenal glands, is given below.

Animal	Sex	Body weight, kilo-grams	Body weight, pounds	Brain weight, grams	Thyroid weight, grams	Adrenal weight, grams	Heart weight, grams
Ass (burro, Panama)	Male	140.61	310.04	265.0	5.00	8.00	800 (estimated)
Shetland pony	Stallion	150.35	331.52	496.1	14.70	16.29	1,375
Zebra	Stallion	254.37	560.88	545.0	21.09	23.08	1,850

The ratios of the combined weights of the brain and the thyroid and adrenal glands to the body weight are:

Shetland pony	1:285
Zebra	1:431
Ass	1:505

According to the power formula, the values are as follows:

Animal	Sex	Brain	Thyroid	Adrenal	Heart
Ass (burro, Panama)	Male	0.4357	0.2498	0.2764	0.3269
Zebra	Stallion	0.6431	0.6285	0.4740	0.4885
Shetland pony	Stallion	0.7850	0.6907	0.5289	0.5469

The combined values of the brain and thyroid and adrenal glands, according to the power formula, are:

Ass	0.9619
Zebra	1.7456
Shetland pony	2.0046

These values show the energy-controlling system of the Shetland pony to be 1.14 times greater than that of the zebra and 2.08 times greater than the ass.

In the Shetland pony the large brain, the large thyroid gland, and the vigorous temperamental personality show an adaptation to cold. In the zebra, which is tropically adapted, there is also a large brain, large thyroid and adrenal glands, and a highly temperamental personality. The energy system of the ass seems to be far below that of the cold-climate-adapted Shetland pony and the lion and wild-dog-adapted zebra.

In the Shetland pony, the high-energy equipment is normal for the subarctic region and conforms to the high-energy equipment of the warm-blooded whale, the warm-blooded porpoise, seal, and walrus found in the cold Arctic Sea, as well as for the caribou, the wolf, and the Eskimo found in the north. All these warm-blooded animals exhibit a high-energy equipment in order to maintain their warm-blooded state and to enable them to exercise their ability in securing food.

Then what of the high-tempered zebra that lives in the hot tropics? We may as well ask what of the highly energized lion, the leaping leopard, the wild dog, the impala, the wildebeest—in fact, the entire antelope family in the tropics.

The answer for the lion, the tiger, the leopard, the wild dog is that they are obliged to chase high-tempered food. To catch such highly energized food, the carnivores must themselves rush and spring and pursue in order to live. So, too, must the antelopes, the great eland, the water-buck, the wildebeest, and the zebra be bred not for climate but for escape.

For aeons the zebra, like all wild horses, has been bred by the lion, the leopard, and the pursuing pack. The energy system of the zebra has been adapted not to climate but to escape.

But what of the ass? True asses differ little from the zebra, save in their coats. Whether from Africa or Asia, the ass has been long subjected to the lion's rush, the leopard's spring, and the carnivore's pack. Judging from its energy system alone, as shown by its ratios, it is evident that somewhere along the line the ass must have been bred either in the high plateaus along with the mountain sheep or goats, where food was scarce, or in the more individualistic background of the deserts, where the supply of food was meager and water holes far apart, thus making it possible for the ass to become adapted to restricted food and drink.

The ratio of the weight of the brain of the ass to his body weight is 1:530, as compared with 1:645 for Equipoise. According to the power formula, the values for the ass, as compared with those for Equipoise, are as follows:

Animal	Brain	Thyroid	Adrenal
Ass (from Panama)	0.4357	0.2498	0.2764
Equipoise	0.6539	0.6003	0.5099

These power-formula values place Equipoise on a higher plane of intelligence, power, and personality than that of the ass. But the ratios of the rest of the energy system to body weight place the ass in the low-energy group, away from the rushing and pursuing canivores.

Animal	Body weight / Brain	Body weight / Thyroid	Body weight / Adrenal	Body weight / Heart
Ass	1:530	1:28122	1:17576	1:175
Equipoise	1:645	1:15614	1:11187	1:117

Where is such a habitat? In the desert and in the high steppes there are many high-strung herbivores and high-strung carnivores, such as mountain sheep, mountain goats, mountain lions, wolves, and desert lions. Where, then, was the ass?

There remain two alternatives: first, the high steppes, or a desert so barren that the ass alone could find as low a sustenance level as the cold-blooded animals. But no other warm-blooded animal is known to live at such a low sustenance level. Apparently the ass stems back to neither the cold steppes nor the barren desert.

But this leaves the ass without a family tree. The second alternative is that man found the ass when the ass was highly energized, when man himself had a difficult problem of survival, and that by the joining of forces through a sort of biologic symbiosis, the greater intelligence of man and the greater burden-bearing power of the ass profited both man and ass.

In the absence of facts, let us suppose that struggling man and the struggling ass found each other on the high steppes or at the edge of, or even in, the desert. Let us suppose that the ass, from the energy point of view, was then a highly energized animal. Let us suppose man had already found the sheep. The greater intelligence of man would lead the ass and the sheep to the green pastures and the still waters. The superior intelligence of man, which had invented the spear and developed the tribe to give effective, watchful care against the wolf or the leopard, would lead the ass and the sheep to a land of greater plenty in order that, by the association of man with the sheep and the goat and the ass, each could survive in larger numbers than if each went its separate way. Thus the ass, the sheep, the goat would find better pastures, and, in turn, man would find food and clothing from the goat and the sheep and transportation from the ass.

The sheep and the goat were once wild, just as the ass was once wild and just as man was once wild. Man could have bred the sheep and goats only from the sheep and the goats that would be least likely to run from the fold. Man did not breed from the lost sheep. The lost sheep were prevented from being man-bred by the wolf that took the lost sheep for the good of the wolf. So, too, with the goat; so too with the ass.

The intelligence of man encircled the sheep and the goat and the ass by a benevolent restraint, benefiting all three partners; but the protection by man of the sheep, the swine, the cattle has taken from them the necessity for high speed or endurance. Wild asses, wild goats, wild boars—all these animals, when domesticated, have low-energy mechanisms.

On the other hand, the constant adaptation by breeding and work, of the pack horse, the work horse, the cavalry horse has so changed their energy systems that they are entirely different from the energy systems of the cow, the sheep, the goat, and the swine.

The ass was bred for docility and strength so that he could carry his burden with the minimum of food. Had the ass been bred by the intelligence of man for cavalry or for sport, as is the thoroughbred horse, or for turning a wheel, for drawing a load, or for ploughing the field, the same human intelligence would have stepped up the energy system of the ass as it did in the work horse or in the thoroughbred. If the ass had been turned loose and exposed to the lion or the wolf, either the ass would have perished as a species or it would have matched the lion and the wolf through the breeding of energy-for-survival characteristics, as in the case of the zebra. This the wild ass did.

The question arises, could a domestic animal be bred by the intelligence of man in the arctic or in the temperate zone to as low an energy level as that of the ass? We believe not, for since the ass is warm-blooded, its existence as a species demands the maintenance of the warm-blooded state. The warm-blooded state is maintained solely by an animal's own oxidation, except as man shelters and warms animals. Had the ass been bred in the cold north and been left unsheltered to take the penetrating cold, it would have developed the high-energy equipment of the Shetland pony, the husky dog, the wolf, the caribou, and the Eskimo.

Therefore, we may conclude that in the tropics the ass could not have taken the pattern of low energy of the tropics except by the encirclement of man's protecting intelligence. Man's protecting intelligence allowed the element of tropical warmth to demobilize the thyroid gland and the adrenal glands of the ass. The one feature that was stepped up by the intelligence of man was that which could most effectively advance the progress of man. Therefore, the ass that was most trustworthy and could best carry the heavy load survived by being bred. An ass that would kick his master or buck him off its back or run away would not receive the approval of its master and, therefore, would be less likely to multiply and replenish its kind.

At this point it is worth while to consider the opposite, or counter, evolution, seen through breeding by man. I refer to the selective breeding of the thoroughbred. The ancestors of the thoroughbred came upon the scene later than the ass, and the stage was quite different. The ass belonged to the time of the shepherd kings. The high-tempered horse came from the colder north and fitted into the picture of man at war. The high-tempered horse carried impact and surprise. It was the high-tempered horse, not the lethargic ass, that speeded the chariot.

The versatile energy system changes with the seasons. As a seasonal adaptation, the thyroid gland of man and of animals becomes larger in winter than in summer. So, too, the thyroid gland made its adaptation as animals migrated from a warm to a cold climate and from a cold to a warm climate, thus bringing about a selective evolution.

In the winter the brain is more active. Other factors being the same, a more active brain is required to produce a greater amount of energy. Oxidation is required to maintain the warm-blooded temperature of 98.6° all day, all night, all the year round. Thus we account for the large brain, the large heart, the large thyroid gland, the more highly vascularized muscles, and the highly energized temperament of the cold-adapted Shetland pony, the most easily trained circus pony known. These qualities and characteristics of the Shetland pony, in contrast with those of the lethargic ass, devoluted from a wild, natural, selective state of higher energy to the energy level of the tropics. The ass explains the mule. The ass explains the sheep. The horse, the sheep, the goat, the cow, the pig, the hen, all profited by man's intelligence. Unless man can benefit his domestic animals the domestic animal will degenerate and disappear as a species.

18. INFLUENCE OF CAPTIVITY AND DOMESTICATION

To domesticate animals requires superior intelligence. Not only must the life of the animal be protected, but living conditions must be provided that will promote health and tranquility. For the animal must thrive and multiply; must produce good eggs, good leather, good wool, good meat, or good milk; must have adequate strength to plow the fields or carry the pack or hunt for man, or even cajole man; otherwise domestication will fail.

In our study of the variation in the relation between the intelligence, power, and personality of animals through the development of the brain-heart-thyroid-adrenal-sympathetic system, animals in zoological gardens and domestic animals offered a rich field for investigation. We are indebted not only to those already cited in the preceding section but also to Mrs. Henning Chambers, of Louisville, Kentucky, Mr. A. B. Hancock and Mrs. Ogden M. Edwards, Jr., of Lexington, Kentucky, and Mr. J. M. Dickinson, of Franklin, Tennessee, for material on thoroughbred horses. We are also indebted to Mr. W. W. Swett, of the Bureau of Animal Industry, for data on cattle, to Mr. W. R. Hearst, and the zoological gardens of Cleveland, Detroit, and Philadelphia for various animals in which we observed the effects of domestication and captivity.

We have found of special interest the data on the effect of keeping in captivity in zoological gardens such high-powered animals as the lion and tiger, the leopard, bears, birds of prey, gorillas, chimpanzees, monkeys, and seals. It would appear that a common effect of restraint in zoological parks is the production of goiter. One of the great lions bred in the zoological garden of Philadelphia, the brother of the lion of movie fame that roars at the beginning of the Metro Goldwyn Mayer film, was examined in our laboratory. He had, to our surprise, an exceptionally large goiter. In our laboratory we dissected eleven lions and tigers that were obtained from zoological gardens or circuses. Every one had a goiter, in spite of the fact that in some cases iodine had been given with the food. Likewise, bears, chimpanzees and monkeys taken from zoological gardens had goiters. In no case did corresponding animals taken in the wild have goiters. Although animals in the wild suffer from privation, uncertain forays, a precarious food supply, and live dangerously, they do not have goiters.

Even when we purchased animals directly from importers, the effect of captivity was evident. Such animals as chimpanzees, baboons, monkeys, examined when the consignment arrived, had goiters. We later found that instead of capturing the animals in the wild state and delivering them immediately, the importer secured the animals in Africa or Asia from natives who had held them in captivity since they were young. Thus it would seem that the fact of captivity is more important in producing goiter than the place of captivity.

For these reasons we were compelled to secure animals ourselves in the wild state. None of the animals so taken had goiter.

Let us take the lion as an example for comparison between the wild state and that of captivity. In the Research Laboratory of the Cleveland Clinic Foundation we have killed nine lions by means of chloroform anesthesia, and studied them immediately. One of these lions was bred near the sea at San Simeon, California, on the ranch of Mr. W. R. Hearst, under the most nearly perfect conditions possible. This lion had a large goiter. None of the six lions taken in the wild state on our African expeditions in 1927 and 1935 showed a goiter. Not only is the thyroid gland profoundly affected by captivity but other organs and tissues as well are affected.

In the wild, the lion must starve or exist by capturing the high-powered antelope or zebra. The food of the lion in the zoological garden is given him at regular intervals; it is regular as to selection, bone, vitamins, and, in some cases, iodine, for the "zoo" lion eats from a table prepared for him, just as civilized man eats from a table prepared for him. The "zoo" lion, like civilized man, has poor teeth, poor texture of hair and skin, and impaired strength of bone. Not only did the six wild lions taken in our African expeditions exhibit no goiter but their bodies as a whole—all their tissues and organs—were in a higher state of physical perfection than those of the lions in captivity. These characteristics go with the glory and the romance of the wild state.

In addition to the thyroid gland, two other organs show the contrast between wild and captive life. The heart of the lion from the Philadelphia Zoological Garden was hypertrophied, probably as the result of the long years of frustration and daily fretting in a cage, just as the heart of civilized man is affected profoundly by the frettings and frustrations of his incarceration in the web of life which he has created. The hearts of the African lions taken in the wild showed no hypertrophy.

Not only did the thyroid gland, the heart, the skin, and the bony skeleton of the zoological lions show deterioration from captivity but another and a most important organ showed a marked contrast in the lions in captivity as compared with those in the wild state, namely, the adrenal glands. It would seem to be of especial significance that the organ so markedly contrasting in the wild state with the state of captivity is the organ that expresses more than any other organ the power and the personality of the lion. One might suppose that the greatest change would be seen in the brain or the heart of the animal known in romance as being "lion-hearted," but the nerve tissue—brain, spinal cord, celiac ganglia, celiac plexuses, sympathetic nerves never become enlarged by use, and the brain and the sympathetic system do not shrink through disuse.

On the other hand, the thyroid and adrenal glands vary in size according to use and disuse. Since the temper, power, and personality of the lion in captivity, as well as of the lion in the wild state, are expressed primarily by the adrenal-sympathetic system and since this is the only system that provides the intensity of the flash of energy, we should expect to find that the adrenal glands of the wild lion would be larger relatively and absolutely than the adrenal glands of the lion in captivity.

We found just that! The adrenal glands of the lions taken in the wild state were 25 per cent larger than the adrenal glands of the nine "house guests of civilized man."

Perhaps our greatest surprise was at the large size of the goiter in the great Bengal tiger that had often been exhibited as a performer in Beatty's Circus. Because his eye had been injured we were able to secure this adult animal in prime condition. As we have already stated, the celiac ganglia have more branches and are larger and the plexuses are larger and more complex in the lion and in the tiger than in any other animal of comparable size. This significant fact is correlated with another equally significant fact, namely, that no other animal of comparable size can execute an equal outburst of energy.

In this connection it is significant that that great primate, the gorilla, which defends itself and its family by sheer power against the lion and the leopard, possesses so violent a temper and so great an equipment for outburst energy that only few survive captivity, and it is rarely that a gorilla bred in captivity lives to adult age. Through the kindness of Dr. William K. Gregory and Dr. Henry C. Raven of the American Museum of Natural History, Dr. Quiring and I were permitted to take measurements of the glands, *in situ*, of the gorilla collected by Dr. Henry Raven.[1] After careful measurements of the various dimensions were made, the weight of the adrenal glands was estimated at 35 grams and the thyroid gland at 6 grams. The body weight was estimated at between 375 and 400 pounds.

In contrast to the adverse effect of captivity on the highly energized animals, the low-powered animals such as alligators, crocodiles, snakes, turtles, and fish seem indifferent to captivity. In breeding and domestication, however, we find variable effects upon the energy-controlling organs.

Effect of Breeding and Domestication on the Energy-controlling Organs of Animals

The mechanism of the bull, the bullock, the ram, the stallion, the buck, and other male members of the herds and flocks of leaf- and grass-eating animals exhibits an evolution of the characteristics of the male that in many respects is the opposite to that of the female. Inasmuch as the contribution of the female is greater, because of the metabolic work of producing the young in her uterus and of fabricating milk to carry the young over the helpless period, her functions represent a very important adaptation for the perpetuation of the species. The male is the protector of the female as well as of all the other members of the herd or flock. Therefore, natural selection, seizing upon chance mutations, has endowed the male with a larger brain, more powerful muscles, and better developed and more powerful horns. In consequence, he protects the female and the young against the carnivores. He fights off the less fit males. He impregnates the females, securing thereby the highest fitness in the offspring. Thus the male is endowed with greater intelligence as well as greater size, physical power, and bravery, a larger heart and a larger blood volume than the female.

[1] Gregory, William King, and H. C. Raven, "In Quest of Gorillas," Darwin Press, New Bedford, Mass., 1937.

In young males castration prevents the development of the typically male characteristics, namely, the larger brain, more powerful muscles, larger blood volume, and the mental characteristics of pugnacity.

Therefore, we may presume that, just as the thyroid hormone reaches the brain cells through the blood stream and continues to influence the brain cells as long as the thyroid gland functions normally, so the testicular hormone reaches the brain cells through the blood stream and continues to influence the brain cells as long as the testes function normally.

If the billions of brain cells take up the sex hormones, then every brain cell in the gray matter of a great bull is a bull brain cell, and, correspondingly, in the white matter there are bull action patterns. Thus may we account for the characteristic behavior of bulls, boars, rams, and stallions. When the male is castrated, no matter at what age, a change occurs at once; the masculine characteristics, physical, mental, and emotional, are lost.

In the female there is an analogy between the mobilization of the thyroid hormone in summer and winter and the mobilization of the thyroid hormone in the cycles of mating, fertilization, pregnancy, and lactation. In the female the neuroglandular mechanism governing reproduction is stepped up by the thyroid hormone, which, in turn, increases the metabolism of the body.

As in the act of fight or flight, the organism is so integrated that it is directed to the one purpose only, and energy is withdrawn from such diverse mechanisms as eating and digestion, until the fight or flight is concluded. If, however, during the integration for reproduction the more powerful integration of fear involving flight is started, the integration of fear supersedes the integration for reproduction.

Thus, through selective breeding, on the one hand, and desexing, on the other hand, man has "invented" domestic animals, for the term "domestication" includes breeding as well as care and training. The influence of breeding and domestication varies with the needs and taste and fancy of man. The influence of man on the energy-controlling organs of the Jersey cow, the Holstein cow, the hen, the pig, the horse has caused these animals to reach a point somewhat near the limit of their physical safety.

The aims of breeding vary according to the desired end. In the case of the thoroughbred horse and the racing greyhound, high speed for a short distance being the aim, man takes advantage of the mutations and breeds for a large brain, a large heart, and a large adrenal-sympathetic system but not for a large thyroid gland.

On the other hand, when man breeds for endurance and companionship, as in the case of the Arabian horse, he breeds for a larger thyroid gland and a smaller brain, heart, and adrenal-sympathetic system.

When man desires a greater number of eggs from a hen, a larger amount of fat from the hog, better steaks and chops from the beef and sheep, a larger fleece of wool, or a greater amount and richness of milk from the cow, he breeds for tranquility rather than temperament. To produce tranquility, he breeds toward a smaller brain and a smaller adrenal-sympathetic system. To produce more eggs, more fat, beef, wool, and milk, he breeds toward a large thyroid gland in order to maintain a high level of protoplasmic activity—hence more eggs and more milk.

Let us take, for an example, the Jersey cow. By selective breeding, the mind of man has so altered the Jersey cow that she now finds herself largely a chemical factory, taking in a great amount of hay and grain but not transforming this prodigious amount of fodder into roaming the fields, escaping from a mountain lion or a pack of wolves, or journeying in adventure to other scenes and other pastures; not knowing the thrill of being hungry and thirsty and finding food and drink; not being permitted to be cold and to shiver and then find shelter; not being allowed the romance of being picked up by a roaming bull; not being allowed to suckle her own young. The Jersey cow is fed and warmed and sheltered and protected by man, and her sole activity, from birth to death, is to be fed, to bear young, and to give milk. The result is that the Jersey cow is showing deterioration.

According to Dr. Dimock and Professor Ely, of the University of Kentucky, the breeding of the Jersey cow is becoming more difficult. Aid must be given increasingly to achieve delivery of the calves. And the calves need increasingly greater care in their growth to maturity. So much calcium goes into the production of milk that there is not enough for the cow to give to her offspring; therefore, the bones of the calves are becoming brittle. The eyesight of the Jersey cow, as well as her resistance to disease, also seems to be deteriorating.

The following tables give a comparison of the energy system of the domestic cow with that of an African buffalo that was nursing its young.

Animal	Body weight, pounds	Brain weight, grams	Thyroid weight, grams	Adrenal weight, grams	Heart weight, grams
Average of 218 Jersey cows....	956	407.70	27.90	27.40	1,605
Nursing buffalo..............	1,261	642.38	37.30	43.27	3,050
Average of 200 Holstein cows..	1,325	415.	38.1	37.7	2,245

According to the power formula, the values are as follows:

Animal	Body weight, pounds	Brain	Thyroid	Adrenal	Heart
Average of 218 Jersey cows....	956	0.3552	0.5214	0.3012	0.2506
Nursing buffalo..............	1,261	0.4928	0.5740	0.3368	0.3896
Average of 200 Holstein cows..	1,325	0.3106	0.5620	0.3099	0.2755

The foregoing tables indicate the deteriorating influence of domestication.

Just as the Jersey cow has survival value not for itself but for the use of man, so the hen also has been forced into such a high level of production that she too has survival value only for the use of man. Just as the cow is bred for milk, the steer for meat, the pig for fat and lean, so the hen is bred by man for eggs and meat.

But just as carrying a heavy pack is hard work, so, too, is the production of milk and eggs hard work. It is significant to see how the thyroid gland of the hen is stepped up as compared with that of the fighting cockerel. Her fame is in egg-laying contests, and the organ that contributes most to the egg-laying marathon is the thyroid gland.

Animal	Body weight, grams	Brain weight, grams	Thyroid weight, grams	Adrenal weight, grams	Heart weight, grams
Cockerel	2,200.0	3.55	0.14	0.26	8.78
Leghorn hen	2,331.5	3.50	0.28	0.18	8.92
Tawny eagle, male	2,250.0	14.13	0.26	0.41	17.20

We should expect the adrenal glands of the fighting cockerel to be larger than those of the hen. But of surprising significance is the fact that the brain of the tawny eagle collected in Africa is four times larger than the brain of a leghorn hen of comparable body weight.

The large brain, the large heart, and the large adrenal glands are the formula of a bird of prey. The individualistic eagle is the "lion" of the air. Although the cockerel seems to be a fighting bird, a comparison of the size of his brain, heart, and adrenal glands with the size of the brain, heart, and adrenal glands of the tawny eagle establishes the inferiority of the cockerel in this respect.

Since eggs, butter, cheese, milk, wool, and meat are produced by constant energy analogous to that required for growth, the animals supplying these products require the special function of the thyroid gland rather than the function of the adrenal-sympathetic system. The biochemical energy required to produce a steak, an omelet, or a thick growth of wool, is the product primarily of collaboration of the brain and the thyroid gland to provide a high level of constant energy.

Outburst energy, produced by adrenalin, such as is manifested in fright or anger, would interfere with the quiet growth of the lazy sheep, the idling cow, and the stuttering hen. Thus man has bred his domesticated animals toward serenity, to the end that every bit of food energy be converted into wool and meat and eggs and milk and not wasted by fighting or running or fright.

The adrenal-sympathetic system exerts a sensitive control over the digestion of animals. Note the psychic serenity that is desirable for the cow in a milk-producing contest. So sensitive is the brain-adrenal-sympathetic system that during milk trials the presence of a quiet visitor or the change of clothing of attendants may change the milk production.

In the domestic dog we have a further example of breeding and training. This is particularly true in the case of the greyhound. Whereas all dogs that hunt by scent have the wolf pattern of brain-heart-thyroid-adrenal glands, the greyhound, which runs not by scent but by sight, has developed, over years of breeding and training by man, a race-horse pattern of energy organs that empowers him to overtake his prey in a short rush. The energy organs of the greyhound follow the pattern of a short sprint at high speed.

Note the adrenal predominance in the racing greyhound from Memphis, Tennessee, in contrast with the thyroid predominance in the pursuing Timber Wolf from northern Minnesota. Cold is a factor in the size of the thyroid gland.

Animal	Body weight, pounds	Brain weight, grams	Thyroid weight, grams	Adrenal weight, grams	Heart weight, grams
Greyhound	54	105.9	2.34	3.36	308.0
Wolf	66	152.4	3.49	3.37	314.5

Just as we found a higher development of the energy system in a thoroughbred horse than in the Arabian or the work horse and in the cold-adapted Shetland pony than in the tropic-adapted ass, so we found a higher development of the brain-heart-thyroid-adrenal-sympathetic system in a racing grey-hound than in a petted house dog.

With the exception of the thoroughbred horse and the greyhound, all the domestic animals, as well as all members of the grass- and leaf-eating families, are geared to run the course of destiny, whether it be the chase, the escape, or the long pull of producing milk or meat or eggs for man. The pursuers, the pursued, and the wild animals bred by man to be domestic drones in order to make the long-continued output of energy, have thyroid and adrenal glands that are more nearly balanced.

It is interesting to compare the means by which cattle and sheep are bred for domestication by man with the means by which antelopes and zebras are "bred" for speed by the lion and other carnivores.

By taking for his food the slowest-going members of the herd, the carnivore is effecting for the herd what man does in the breeding of domestic animals. The carnivore kills the less fit; man breeds from the most fit.

If the influence of man were withdrawn overnight from the world, what would be the effect on the domestic animals whose body formula of energy and form has been adapted for food they could not have found in the wild state? The special senses, as well as the brain and the heart of domestic animals, have so deteriorated that the chance of escape from the pack of dogs and wolves would be seriously diminished. How easily would the pack of wolves or dogs run down and destroy these domestic animals that are unadapted to the wild state. The size of the energy-controlling organs would speedily change, and natural selection would ultimately restore the energy-controlling organs of the domestic animals to the state of those of their wild ancestors.

In the breeding and domestication of animals, use is made of mutations to develop what is desired in the domestic animal. When line breeding of these mutations is carried to the extreme, the physiologic balance of the animal may be so stepped up in one organ or system that a serious unbalance may occur in other organs or systems.

It will be seen later that this principal of mutation plays a role in the genesis of certain diseases in civilized man.

19. THE PRIMATES

IN THE primates and, particularly, in anthropoid apes, one might expect to find the pattern of the human being with respect to the relative size of the brain and the thyroid and adrenal glands. We found in the 536 primates that we dissected a larger ratio of brain to body weight than in any other wild or domestic animal of comparable size, but the ratio of the thyroid to adrenal glands in the primates other than man did not follow the relation of the thyroid to adrenal glands in man.

The primates in the wild state in their tree life require an energy mobilization exactly the opposite to that of walking, thinking man. The surface area of the primates, with their long arms and legs, endows them with exceptional facilities for eliminating the internal heat resulting from their extreme activity.

One has only to consider the stealthy, tree-climbing leopard, the enemy of the primates, to realize that if the primates had the thyroid-adrenal equation possessed by man they would be more intelligent but too slow to escape the leopard. In such a dramatic existence, primates having the energy pattern of walking, thinking man, with his large thyroid gland and small adrenal glands, would have left no progeny.

The physical prowess of the gorilla is overwhelmingly superior to that of man and other primates, possibly even to that of the lion. The size of the brain of the gorilla, the degree of his intelligence, the fact that he can walk upright and is a ferocious caricature of man, and the further fact that the adrenal glands of the gorilla have been estimated to be five times as large as the thyroid gland—the formula of the adrenal-thyroid relation of the human fetus—suggest the apelike ancestor of man.

In the great Budonga forest in Uganda, in the midst of a tropical vegetation in which the trees tower 150 feet or more in height and the undergrowth is so thick that the only means of penetration is to follow the elephant trails, Dr. Quiring and Mr. Fuller collected an adult male and an adult female chimpanzee. Pulling themselves up into these giant trees, leaping fantastically from bough to bough, lolling in the sunshine, and tending their young, chattering, screaming, bickering, these great anthropoids looked as large as men in the dimly sunlit forest.

The brain of the 115-pound male chimpanzee weighed 440 grams, the brain-to-body-weight ratio being 1:129. The female, which weighed 97 pounds, had a brain that weighed 325 grams, the brain-to-body-weight ratio being 1:135. According to the power formula, the size of the brain for the male chimpanzee was 1.179 and for the female, 0.8978.

A comparison of the chimpanzee with an African antelope of approximately the same weight shows, as seen in the following table, that the chimpanzee has a larger brain and larger adrenal glands, whereas the thyroid glands in the two animals are relatively the same in size. The adrenal glands in the chimpanzee are twice the weight of the thyroid glands, whereas the thyroid and adrenal glands in the antelope are nearly balanced in weight. The significant fact in this comparison is the unique size of the brain in the chimpanzee, indicating greater intelligence. Superior intelligence in the chimpanzee is associated with large adrenal glands, whereas in man, superior intelligence is associated with a large thyroid gland.

Animal	Sex	Body weight, pounds	Brain weight, grams	Thyroid weight, grams	Adrenal weight, grams	Heart weight, grams
Chimpanzee	Male	115	440	4.85	8.93	250
Bushbuck	Male	117	190	5.08	5.09	350

What were the circumstances under which man departed so completely from the other primates in the relative size of the thyroid and adrenal glands? The gorilla, the chimpanzee, the baboon, and the monkeys have adrenal glands two or three times larger than the thyroid gland, for all of these tree-dwelling anthropoids have need for outburst energy to escape the leopard and other enemies in their active tree existence. Although the long arms and long legs of man, his final upright posture, and his manipulative hand evolved during his tree life, the brain and the thyroid gland of man could not have been evolved during that period. Walking, thinking man in the tree would be an energy misfit. Nor did the tree life equip man to escape his enemies by running. Man's adaptation was the evolution of the organ of strategy, namely, a thinking brain. The early ancestors of man underwent their gradual evolution from a life in the trees to a life on the ground, with a slow assumption of an upright posture, as exemplified by the gorilla today.

Thus we may suppose that dawn man came down from the trees in the tropics, followed his animal food to the grasslands, and became a hunter and a nomad. In consequence, gradually the adrenal glands, through natural selection, devoluted, and the thyroid gland evoluted, finally reaching the formula of modern man, whose thyroid gland is two and a half times the size of the adrenal glands.

20. THE SUBARCTIC EXPEDITION

IN EQUATORIAL Africa we had studied the energy-controlling organs of 220 animals, comprising 77 species. In order to contrast the influence of tropical heat with the influence of arctic cold on the size of the brain, the heart, the blood volume, and the thyroid gland, we next collected animals in the subarctic.

On our way north we noted a gradual decrease of wheat, of trees, and of human endeavor. As the wheat and the trees grew scarcer, the days grew longer, the air cooler, until finally we reached the land of tundra and muskeg, where, throughout the year, the earth remains frozen for a short distance below the surface.

Perched on high rocks, holding the fort at the point, now called Churchill Harbor, where the broad Churchill River empties into Hudson Bay, with a beach where the tides leisurely rise and fall about 10 feet, was Churchill. Enormous, lichen-covered granite rocks rose at the water's edge, black crowberries, red, bitter-tasting buffalo berries, blueberries, and cranberries growing in their crevices.

The pebbly beach was devoid of shells, of seaweeds, and of sea life; but arctic terns perched on the rocks near the shore, and the bellies of the white whales glistened as the great animals tumbled and turned in the water.

Two trappers, a white man and a half-breed, stood with their dogs waiting to push off, their canoes, well filled with supplies. Where were they going? Two hundred miles north to stay through the long winter—in the solitude, in the ice and snow, with nothing save caribou, foxes, the aurora borealis, and endless night about them. Except for man, the husky dogs, the animals to be trapped or to be eaten, and the aurora borealis, all is negativity on the land, for these are the only forms of energy in the silent night of snow and ice and cold and wind.

Yet there is a greater amount of life in the northern seas than in the seas of the equatorial region. In the arctic, where the sunshine is seemingly the least abundant, the animals in the sea are not only the most numerous but also the largest; therefore, there must be some source of energy in the arctic that fades out southward.

Since sunlight alone cannot generate protoplasm and since lightning, terrestrial electricity, and Azotobacter alone can fix nitrogen, the essential base of protoplasm, and since there is less snow and rain in the arctic zone than in the warmer climates, there is, therefore, less lightning and less terrestrial electricity, and there would therefore be less nitrogen fixation, hence less protoplasm, in the arctic region, were there no source other than solar energy.

The one overwhelming electric phenomenon in the north is the aurora borealis. The aurora borealis is as stupendously greater than any electric phenomenon in the temperate or tropic zones as the enormous blue whale is greater than any other animal in the temperate or tropic zones.

This one form of energy, the aurora borealis, is peculiar to the arctic region. Its intensity fades toward the equator, the area of strongest sunlight, in much the same manner that sunlight, rain, trees, and plants fade in the opposite way toward the poles, the areas of least sunlight. The band of the most intense aurora passes northern Russia, Siberia, across northern Canada, and along Baffin Land, Greenland, and Newfoundland at about 60° latitude, and this electric phenomenon is the most colossal spectacle in the world. Accompanying it is a violent electric disturbance of telephone, radio, and telegraph systems.

As they pass through the atmosphere, light rays ionize the gases in the atmosphere, and the electrons that are set free, as they pass into space, ionize the air. It is this ionization of the air by the free electrons that is expressed in northern lights.

When these free electrons come into the magnetic field at the poles, they are deflected southward. Therefore, the northern lights are not so marked around the magnetic pole as they are at about 60° north latitude, where there seems to be a band of highest intensity. From this band southward, the impact upon the earth is increasingly oblique; hence its force is diminished, and at the eouator there is none.

As the crow flies, the magnetic pole, which is in Boothia peninsula, is about 800 miles north of Churchill; yet throughout Hudson Bay the ships' compasses are so disturbed that ships are obliged to carry a gyroscopic compass, which is uninfluenced by the proximity of the magnetic pole.

If the arctic region were bombarded in the same manner by the radiant and electric energy that makes up the aurora borealis, as the temperate and tropic regions are bombarded by the radiant and electric energy that makes up terrestrial electricity and lightning, nitrogen fixation would occur in the cold air in the frigid zones, the fixed nitrogen would gravitate to the sea, and plankton would be formed, just as the smallest units on the land—the Azotobacter of the soil—are accounted for through nitrogen fixation.

Since the genesis of living forms is due to radiant and electric energy and since the intensity of radiation and electron bombardment is a measure of the intensity of the aurora borealis, then at the band of greatest aurora intensity it would appear that there should be found the greatest massing of sea life; and so there is.

The sea holds within it all the elements needed for the formation of vegetable and animal life. In accordance with this point of view, the sea is continually fertilized with nitrates. In both the soil and the sea an infinity of living ultramicroscopic and visible forms exist. From these emerging energy units tiny plankton and giant whales are formed.

In a hearing of a committee representing the council for the conservation of whales and other marine mammals before a special committee on wild-life resources of the United States Senate, Mr. Lewis Radcliffe gave the estimate that in the year 1931 alone 42,000 whales would be killed, yielding at least 150 million gallons of whale oil.

If each of the 42,000 whales killed in 1931 averaged 34,500 pounds in weight, that would establish a total weight of whales taken annually, of about 1,450,000,000 pounds. But what percentage of the total whale population are these 42,000 whales, taken annually?

In pounds, the weight of the whales taken annually would equal that of 14,500,000 sheep, averaging 100 pounds each in weight, or 1,450,000 fat steers, averaging 1,000 pounds each in weight. If one acre of good pasturage supports two sheep, it would require 7,250,000 acres of land to support the number of sheep that equal in weight the number of whales taken in 1931. This gives some idea of the vastness of the green pastures in the dark depths of the polar seas.

In the arctic, with the handicap of far less sunlight, with little or no lightning, and with only a desert level of rainfall, it is estimated that there is produced in the sea 2½ times the food value that is produced in 1 acre of land in the fertile Mississippi Valley.

From the arctic regions toward the equator there is a fading out of plankton, just the reverse of the fading out of sunlight from the equator to the poles, of the fading out of plant life from the equator to the poles, and of the fading out of trees from the equator to the poles. Therefore, some basic energy must contribute to the building up of life in the Arctic and Antarctic oceans that is not found in a comparable amount in the temperate and tropic zones.

Looking out upon the water in the brilliant noon sunshine at Churchill, on the Hudson Bay, we noticed one white flash after another. These were belugas, or white whales, such whales as were here on the day, in 1782, when the French and the English fought for Fort Prince of Wales and all it commanded. The white whale was here before the French and the English were civilized. The whale preceded the arrival of the Eskimos and the Indians from Asia when they came across the straits. The whale was here before man came into being as a species. Breeding from the most fit, the whale has kept its biologic ledger balanced.

21. INFLUENCE OF COLD

In warm-blooded animals, when the body temperature rises or falls a few degrees above or below the normal, death occurs. When the body temperature of man rises to 108.5°F., he is in the inaugural state of heatstroke. When the body temperature of man falls a limited number of degrees below the normal, death from cold occurs.

From the equator to the arctic region, every degree of habitat temperature exists. Countless animals and men live between equator and the arctic region. The wide swings of the cold of winter and of the torrid heat of summer profoundly affect man and the wild and domestic animals. In the cold north, animals live as if within a Thermos bottle, fur, fat, blubber, and oil serving as nonconductors of heat from within and of the icy cold from without.

In winter, in the temperate zones, many animals put on a thicker fur and may gain some fat. In the tropics all animals are lean. No seal or mink or otter skins are found in the tropics. On the contrary, in the hot climate there is protection against external heat by hair, not fur. All carnivores pant in the hot noon of the tropics; sweating over all the body is seen only in man and the horse.

In the heat of the day, in the tropics, a universal truce is observed by lions, leopards, foxes, the antelopes, and man. The external conflict occurs only in the cool of night and in the early morning. Such great animals as the elephant, with its critically low facility for cooling, are adapted to the water and the swamps.

Let us now turn from considering these external negative adaptations to extremes of heat and cold to internal adaptations, such as the size of the energy-controlling organs, the blood volume, fat, and blubber.

Theoretically, we should expect to find that the principal adaptation against cold alone in the arctic would be a brain of uniquely large size, a thyroid gland of correspondingly large size, a large heart, and a large volume of blood, fat, and blubber. It would seem that the Thermos bottle principle in evolution, whereby the living furnace is encased in blubber, is not sufficient in the cold north and that the inner furnace has to be stoked to a higher constant intensity; in other words, in the cold north, in order to maintain the normal warm-blooded state, the internal furnace must burn more intensely.

Allowing for the slight differences in weight, the adaptation to cold alone upon the size of the brain may be seen in a contrast of the weight of the brain in a hartebeest collected in equatorial Africa with that of a caribou collected during the summer in the arctic and in a contrast of an African hare with an Arctic hare.

Animal	Sex	Body weight, kilograms	Body weight, pounds	Brain weight, grams	Heart weight, grams
Hartebeest	Male	133.8	295.02	275	875
Caribou (from Tavane)	Male	149.23	329.05	329.3	1,247
Arctic hare	Female	2.03	4.476	14.80	31.57
African hare	Female	2.925	6.449	10.23	30.00

In Hudson Bay at Churchill we collected eight white whales. We took their temperatures immediately after capture and found them to be the same as our own temperatures. The internal temperature of the whale and the porpoise is the product of all the protection that fat, oil, and blubber can give to keep out the cold and keep in the heat.

On the other hand, the high rate of metabolism executed by the uniquely large brain, the uniquely large thyroid gland, and the uniquely large heart and blood volume of the whale and the porpoise produces a rate of oxidation not at all approached by any land animal in the tropic or the temperate zone.

Thus not only did we find that the brain, the heart, and the thyroid gland in the warm-blooded animals in the cold north and in the cold sea were larger than in the warm-blooded animals of comparable weight in the tropics and the temperate zones, but we found also an increase in the size of the heart and in the volume of blood in the warm-blooded land animals in the cold north and in the cold sea.

The largest white whale that we collected weighed 1217.5 pounds. The blood of the white whales showed a high oxygen content, the hemoglobin being approximately 20 per cent higher than that of man, and there were vast numbers of blood vessels holding reserve supplies of blood, hence of oxygen.

On what basis do the white-whale family and the human family exhibit surprising analogies? The human family and the white-whale family breathe the same rich oxygen of the air. Each has a large development of the brain. Each has a great thyroid gland. The thyroid gland in its location in the neck, in its connecting bridge between two flattened lateral lobes, is of precisely the same pattern in the human being as in the white whale.

We are indebted to Harry C. R. Darling, F.R.C.S., of Sydney, Australia, for the energy-controlling organs of an Australian aborigine. In the brain of this aborigine, in the brain of the white whale, and in the brain of the porpoise there are marked resemblances and marked differences. The brain-to-body weight ratio in the aborigine weighing 76.2 kilograms (168 + pounds) was 1:56; in a porpoise weighing 142 kilograms (313 + pounds) it was 1:82; and in a white whale weighing 552.25 kilograms (1,217+ pounds) it was 1:235. According to the power formula, the values for the brains were as follows:

White whale	2.301
Porpoise	2.737
Australian aborigine	3.080

showing the degree of brain development in the aborigine to be 1.13 times greater than that of the porpoise and 1.33 times greater than that of the white whale.

In contrasting the brains of the white whale and the porpoise with the brain of the aborigine, a preponderance of the thinking portion of the brain is seen in the aborigine. This preponderance of the thinking portion of the brain enables man to have the advantage of work performed by energy outside himself.

By comparison with the whale, man is a newcomer on this earth. The rise of man seems to be due to the development of his forefeet into hands and the development of the thyroid gland and the thinking portion of his brain. Throughout geological time the whale has maintained himself as a perfect mechanism. Unlike man, the whale shows no diseases of the energy system, although the thyroid gland of the whale, the adrenal gland, and the sympathetic complex are as fully developed as in the case of man.

The white whale needs a highly developed energy system, for the white whale not only must capture its food but must outswim or fight off its enemies. Producing its offspring in the sea, the white whale, like the porpoise and man, must protect its helpless, inexperienced young during infancy, childhood, and adolescence through a family unit.

The white whale, the porpoise, and man, each being supreme in his own field, need less crisis energy for survival. The thyroid gland of the white whale, like that of the porpoise, is of the same pattern as that in the human being and, like that of the human being, is more than twice the size of the adrenal glands.

During our study of the energy system of various animals, it was our good fortune to collect two animals—one in Hudson Bay, the other in Kentucky, which approximated each other in weight. The animal from the subarctic weighed 552.25 kilograms; the animal from Kentucky weighed 521.52 kilograms. The animal taken in Kentucky was one of the most highly energized animals known. The forebears of this animal point back forty-two million years. The animal from the arctic has a heritage of forty million years. Therefore, both the animal from Kentucky and the animal from Hudson Bay preceded the animal that rode the Kentucky thoroughbred Equipoise in his winning race or dissected the white whale of the cold north by millions of years, for the animal man is credited with a heritage of less than a million years on this earth.

The weight of the brain of Equipoise, one of the swiftest warm-blooded animals known, was 808.5 grams. Equipoise was geared for a high-speed, short dash to exhaustion. The weight of the brain of the white whale that was obliged to keep its protoplasmic fires burning constantly at a high level in the cold arctic sea and that had to swim to the surface at short intervals to breathe was 2,355 grams. The extraordinary number of individual acts in the process of breathing and the infinite number of impulses from the brain to the muscles to maintain the internal protoplasmic fires at such intense heat against the cold demanded an exceptionally large thyroid gland in the whale for stepping up the rate of oxidation of the brain. For the white whale this requirement was vital.

For Equipoise the opposite was needed. To win the race, the vital requirement for Equipoise was an adrenal gland larger than the thyroid gland. The following table shows the marked contrast in the energy requirements of these two animals.

Animal	Body weight, kilograms	Body weight, pounds	Thyroid weight, grams	Adrenal weight, grams
White whale.	552.25	1,217.7	108.00	34.76
Equipoise....	521.52	1,149.95	33.40	46.62

These two animals also show a striking difference in the heart. In the whale, the heart circulates the blood from birth to death at a fairly even speed. In Equipoise, the thoroughbred race horse, the heart had the task of circulating the blood as a crisis need to prevent an oxygen deficit during the pinnacle of expenditure of energy in the race. The heart also had the task of establishing a high negative electric potential to balance the exceedingly high positive potential of the brain. Thus the brain and the heart together form the pinnacle of driving power of the muscles in winning the race.

The weight of the heart of the white whale was 3,175 grams, and the weight of the heart of Equipoise was 4,455 grams. Thus, in the energy formulas of these two exalted animals upon whom evolution has lavished her gifts for forty and forty-two million years, we see still another corroboration of our thesis as to the mechanism of intelligence, power, and personality.

After two days' sail on the *Nascopie* from Churchill, we came to anchor at Chesterfield Inlet, at the edge of the Arctic Circle. As we stood on deck, waiting to land, four settlements spread out before us: the gray Mission Hospital, the Hudson's Bay post, Dr. and Mrs. Thomas Melling's little white house with the green roof, and the radio station. Long-haired, but jolly-looking Eskimos were unloading. Their short legs and long bodies showed great strength, and old and young seemed capable of carrying heavy burdens.

Through the kindness of Dr. and Mrs. Melling, there had been collected for us seals, caribou, and even a young walrus.

The thyroid and adrenal glands of the seals we found to be of the pursuing dog and wolf pattern—nearly balanced in weight, and unlike those of the white whale, which have the pattern of man.

The big "oodjuk," or square flipper seal, known to us as the "bearded" seal, which Dr. Melling had cached for us, weighed 620 pounds. It was too large to hoist from its tomb, so we dissected it where it lay. The bearded seal is the largest of all northern seals and is more or less solitary in its habits. Its skin is thicker than that of any other northern seal and is much valued by the Eskimos. The bearded seal, like the walrus, feeds on mollusks and crustaceans. The ring seal is a fish eater.

Animal	Weight, pounds	Brain weight, grams	Thyroid weight, grams	Adrenal weight, grams	Heart weight, grams
Ring seal	100	255	2.76	2.70	320
Bearded seal	620	460	22.83	22.04	1245

When we reached Morso Island, a walrus hunt was in progress. The Eskimos, with long, curved knives, worked with incredible speed.

In contrast to animals in the equatorial regions, the walrus, a warm-blooded mammal living in the cold sea, had a thyroid gland much larger than the adrenal glands.

In our studies of the energy-controlling organs of animals in tropical Africa and of animals in the arctic, we found definite evidence of the influence of cold and of heat alone upon the size of the energy-controlling organs of warm-blooded animals. Temperature alone in the arctic requires a larger brain, a larger heart and blood volume, and a larger thyroid gland to execute the oxidation necessary to maintain the warm-blooded state. The influence of habitat temperature is clearly seen in the case of the walrus that we secured in the arctic.

In the case of the rhinoceros secured in equatorial Africa, the opposite is seen, for, because of the ceiling of heatstroke, the influence of tropical temperature is toward a smaller brain and a smaller thyroid gland.

The second basic influence seen in the comparison of the energy-controlling systems of the walrus and the rhinoceros is that of energy behavior, which is always reflected in the size of the adrenal glands. In the hot-tempered, rushing rhinoceros, the adrenal glands are 3.79 times larger than those of the even-tempered, slow-going walrus, as indicated by the following comparison:

Animal	Body weight, kilo-grams	Body weight, pounds	Brain weight, grams	Thyroid weight, grams	Adrenal weight, grams	Heart weight, grams
Walrus	667.+	1,471.11	1,126.50	70.04	27.07	4,536
Rhinoceros	763.+	1,682.41	655.00	53.05	88.00	4,800

Power Formula Values

Animal	Brain	Thyroid	Adrenal
Walrus	0.8918	0.9581	0.2103
Rhinoceros	0.4304	0.6412	0.7988

In other words, although this young adult rhinoceros was larger than the walrus, the brain of the cold-adapted walrus was 2.07 times larger than the brain of the tropic-adapted rhinoceros, and the thyroid gland of the walrus was 1.49 times larger than the thyroid gland of the rhinoceros.

These two outstanding animals of the arctic and the tropics illustrate the influence of cold and heat upon the size of the brain and thyroid gland. This principle applies equally to the habitat temperature of the races of man.

In a comparison of 28 tropical rodents with 123 subarctic ones, 15 tropical Carnivora with 23 subarctic ones, 14 tropical ungulates with 4 subarctic ones and in an examination of 8 white whales, Dr. Quiring, by means of the relative-growth equation, found the degree of brain development to be markedly larger in the subarctic rodents and Carnivora than in the tropical ones. The brain was larger in the subarctic ungulates than in the tropical ones. He found the brain of the white whale to be 300 per cent larger than those of any other of the 284 species exclusive of the human—examined among the 3,734 animals studied in this research.

The aquatic Carnivora exhibited a degree of brain development 89 per cent higher than that of the tropical land Carnivora, and the subarctic, doglike Carnivora possessed a brain coefficient 26 per cent higher than that of the tropical, catlike Carnivora.

In his study of the thyroid glands evaluated on the relative-growth scale and expressed in terms of the thyroidization coefficient, Dr. Quiring found that both the subarctic rodents and the subarctic Carnivora showed a larger coefficient than those collected in the tropics. The white whales that we collected showed thyroid coefficients over 300 per cent larger than the next highest group of Carnivora, and the ungulates showed a difference, but the difference was not so great.

The coefficient that expresses the relative degree of heart development, Dr. Quiring found, shows a significant difference favoring the subarctic rodents, the Carnivora, and the ungulates. The heart coefficient of the whales was found to be on the same level as that of the tropical ungulates.

The differences between the northern and the tropical animals studied, when expressed numerically, Dr. Quiring found to be as follows:

Animal group	Brain	Thyroid	Adrenal	Heart
Tropical rodents	0.0996	0.0885	0.4374	0.1122
Northern rodents	0.1262	0.2056	0.7240	0.1270
Tropical carnivores	0.3900	0.4293	0.3883	0.2450
Northern carnivores	0.6119	0.6030	0.2850	0.4350
Tropical ungulates	0.6500	0.4122	0.2940	0.3620
Northern ungulates	0.7040	0.4327	0.2874	0.5196
Cetacea	2.295	1.5878	0.3722	0.3722

The influence of cold for forty million years on the whale explains the larger brain, heart, thyroid gland, and blood volume in the animals of the arctic as contrasted with the animals of the tropics. It also explains the larger brain, the larger volume of blood, the larger chest, and the higher metabolism of the Eskimo and Chippewyan Indians of the far north as compared with the man of the tropics and the north temperate zone.

Through the collaboration of Dr. Melling, of Chesterfield Inlet, Keewatin Territory, metabolism studies were made at sea level, 63.45° north latitude, on 63 Eskimos, giving an average reading of +22.7 per cent. At Churchill, Manitoba, 58.44° north latitude, metabolism studies were made on 13 Chippewyan Indians, giving an average reading of +18.2 per cent. Through the collaboration of Dr. P. Jorda Kahle and Dr. H. Reichard Kahle, Dr. Quiring made metabolism studies in New Orleans and around the Mississippi Delta, 30° north latitude, on thirty Negroes, giving an average reading of −14.6 per cent.

In keeping with the high metabolic rate of the Eskimo are his lively personality, flushed, warm skin, and free perspiration. Palpation of the brachial and the radial arteries of a number of Eskimos indicated a low blood pressure and a large blood volume.

This is in harmony with our concept that the brain executes energy and that the thyroid gland, which governs the rate of oxidation in the brain, varies in size as an adaptation to cold and to the needs of constant energy.

In our wide range of studies of man and animals we have seen in the comparisons of their adaptation to the heat of the tropics and the cold of the north that heatstroke in the hot tropics and freezing in the cold north have been determining factors in the size of the brain, the thyroid gland, and the blood volume. This, however, does not take into account that part of the brain which we designate the "mind," or "thinking brain," and the manipulative hand.

The rise of these two organs has been an important factor in the development of man as the master animal.

The Energy Pattern of the Master Animal

A master animal must be able to survive in the tropics, the temperate zone, the Arctic zone, in the desert, in the marsh, on the plains, or in the mountains.

Because of their breathing the rich oxygen of the air and their higher speed of oxidation, the warm-blooded animals of the sea, namely, the Cetacea, are in the sea something of what man is on the land. No fish is a match for the whale, and no land animal is a match for man.

If a master animal must be able to compete successfully with all other animals, then the vast hordes of smaller fish that are eaten by larger fish could not be master animals. The shark family would be disqualified as a master animal by the fact that the killer whale and the porpoise are their masters. What of the formidable killer whale?

Just as the lion and the tiger failed on the land to appear in large numbers and therefore to qualify as master animals, so the killer whale has failed to appear in great numbers. The salmon, the cod, the herring, although they are numerous, cannot qualify as master animals, for man, as well as many animals in the sea, takes them in vast quantities. This eliminates every animal in the sea, up to the great whales. The most perfect example of adaptation is that of the mammals that reentered the sea. According to Karl Brandt[1] blue whale calves measure twenty-three feet or more at birth. They continue to grow one to two inches a day, until at the end of the nursing period the young blue whale may have attained a length of some fifty-four feet. Brandt states that not only while being suckled does the blue whale calf gain 220 pounds a day, but from the time of

[1] Brandt, Karl, "Whale Oil: An Economic Analysis," Food Research Institute, Stanford University Press, 1940.

Brain
6,800 grams

Thyroid gland
3,450 grams

Adrenal glands
1,385 grams

Fig. 18.—Blue whale, 58,059 kilograms—128,020 pounds.

weaning at about seven months until it is two years old it continues to add 200 pounds a day to its weight until at an age of eleven years it ceases to grow.

Brandt states that blue whales reach a maximum length of 100 feet and a weight of 150 metric tons, or 330,693 pounds. They reach their maturity for reproduction at the age of two to three years and the period of gestation is 315 days.

So completely adapted is the whale to life in the sea that he has no need for emergency power to overcome gravity or to pursue food. The great whales take their nourishment in the form of plankton, for they swim, as it were, in a bowl of soup. The whale is balanced in the water. The whale needs no crisis energy, as does the elephant, to pull himself out of the mud and up a slippery bank; the whale is in command of his security. The only enemies of the whale family are a fellow whale and man. The killer whale benefits the whale family by killing the least fit; just as the lion benefits the antelope by killing the least fit. Man kills the most fit among his fellow men.

In the large brain, the large heart, the large blood volume, the large thyroid gland, and smaller adrenal glands we see the typical formula of the arctic.

The whale by his size, by his giving birth to but one young at a time, by the certainty of his food supply, by his geological record, and by his most nearly perfect adaptation is the most masterful animal, save man.

Having found a neuroendocrine formula characteristic of animals in the arctic, a formula expressed most strikingly in the whale family, the question arose: Is the unique size of the brain, the heart and blood volume, and the thyroid gland in the whale family an adaptation to cold, to muscular activity, or to both?

That the unique size of these organs is not an adaptation to muscular activity is seen in the comparison between the racing stallion Equipoise and the white whale.

To determine whether or not this formula found in the north is an adaptation to cold, we studied the evidence found in a member of the order Sirenia that lives in tropical waters only. I refer to the manatee.

The manatee feeds on sea grass. Sea grass is dependent upon sunlight for its growth. Therefore it requires an all-year-round warm climate and shallow water. Thus the manatee not only is limited as to its habitat, but its temperature habitat is the opposite of that of the whale; and the shoaly habitat of the manatee protects it from large and formidable enemies. Therefore, we expected that a manatee comparable in size to a white whale would have a smaller brain, a smaller heart, a smaller blood volume, and a smaller thyroid gland.

In our subarctic expedition we collected the energy-controlling organs of whales that varied in weight from 764 to 1,217 pounds. Therefore, in order to make a comparison, it was desirable to secure a manatee of comparable weight.

In Florida the manatee is protected by law, but through the interest and cooperation of Mr. S. C. Murray permission was granted by Mr. G. W. Petersen, the conservation agent, for us to secure one manatee.

Through Captain Blair of the Goodyear dirigible "Reliance," permission was also granted to Mr. Murray for our party, consisting of Mrs. Crile, Dr. Quiring, Mr. Al Pflueger, Mr. J. H. Kearns, and me, to observe manatees from the air, in order to select one the size that we required.

From the "Reliance," we were able not only to select the manatee that we wanted, but so slowly does the manatee move, that we were able to return to Miami and, in a motor boat with the guidance of Captain Blair from the air, identify and harpoon the manatee that we had selected.

This manatee measured 10 feet 3 inches and weighed 935 pounds. Compared with a 928-pound white whale, the weight of the brain, the heart, and the thyroid gland were as follows:

Animal	Body weight, pounds	Brain weight, grams	Heart weight, grams	Thyroid weight, grams
White whale...	928	2,339	2,268	97
Manatee.......	935	351	1,250	57

The striking difference between the size of the brain, the heart, and the thyroid gland of the white whale of the cold arctic sea and the manatee of the warm tropics, each being warm-blooded and each having mammalian lungs necessitating rising to the surface of the water to breathe, offers further evidence that climate alone is one of the most potent factors in the evolution of warm-blooded animals.

This comparison affords further evidence that the neuro-endocrine formula of the north, namely, a large brain, a large heart and blood volume, and a large thyroid gland, is an adaptation against cold.

As a corollary, it requires a higher degree of intelligence, power, and personality to live an active life in the cold north than an indolent life in the tropics.

22. MAN IN THE ENERGY SCALE

If the constant tempo of the brain is governed by one gland only—the thyroid gland—it would follow that an animal that must work at a high tempo continuously and keep its metabolic fires burning at a high level to protect its warm-blooded state against constant cold would be equipped with a larger or more active thyroid gland than the warm-blooded animal. Such animals in the sea are the whale, the porpoise, the walrus.

On land, the only animal with such requirements is that animal which covers the earth, that animal which works physically, mentally, and emotionally all day and worries all night—civilized man. According to the power formula, the brain and the thyroid gland—and no other organ—of man bears a higher ratio to his body weight than is seen in any other animal.

In addition to the provision for maintaining the constant tempo of energy in man and animals, there is a provision for emergency energy. Emergency energy is preeminently required by the lion and the other members of the cat family in their explosive attack, by the escaping rodents and hoofed animals, by the wild animals on the land and the birds in the air. All are evolved in a greater or lesser degree to execute flash energy in attack and in escape.

The mechanism that executes flash energy is the brain, the heart, the adrenal glands, the celiac ganglia and plexuses, and the sympathetic system. The energy characteristics of what we call the "wild" state are the result of the emergency power of the specific action of adrenalin and sympathin, each of which profoundly affects the brain and the sympathetic system. The activation of the adrenal-sympathetic system affects every cell in the body more intensively in the lower animals than in the lower races of man, more intensively in the lower races of man than in the higher races of man, more intensively in children than in adults.

We have stated that the power of an animal is executed solely by the brain. The constant oxidation is due to the thyroid influence, but the thyroid gland alone does not produce emergency energy. The adrenal-sympathetic system, in collaboration with the thyroid gland, governs the outburst of energy in attack or escape and in the expression of the emotions.

In the infinitely delicate white matter, or matrix, of the brain, physical conductance paths of microscopic dimensions are established by electric charges as they pass through the matrix. These molecular paths of conductance become facilitated with the repeated passage of electric currents that are generated in the cells of the gray matter of the brain which is stimulated by the sense organs.

Could this network of facilitated pathways in the matrix of the white matter be detected by an infinitely powerful microscope, a single brain might exhibit a number of "hookups" comparable to the telephone wires, exchanges, and receivers in a great city. Could one look with an eye of infinite magnification into the recording matrix of the brain of an animal, one could therein read the configuration of its multitude of action patterns, that is, one could read every act, every experience of that animal, from the moment of its birth. This is the mechanism of memory, reason, and imagination, or "mind," in man and animals.

But within this plastic and passive matrix on which the special senses have caused to be etched this network of conducting pathways of action, no power is generated by which its intricate system can be operated. It is in the cells of the gray matter of the brain that the energy required to operate this system is generated.

Since the only energy available to the animal is that which the animal captures in the form of food from the plant and since the energy held within the plant is captured from solar radiance and from the nitro group in the soil, the energy that operates the brain in fabricating memory, reason, imagination is not like, but is, in fact, the radiant and electric energy that is released by oxidation in the brain cells and controlled by the thyroid gland.

It would appear, therefore, that "mind" or intelligence is not a separate power. Intelligence is the use of the switchboard of memory, reason, and imagination. Intelligence is present in any animal, no matter how low in the animal scale, whose action currents cause the muscles of that animal to move away from or toward any object or to cease movement. This is the kindergarten stage of intelligence. Between this lowly form of intelligence and the intelligence of a Newton, there exists every intermediate stage.

Upon what is based the statement that the only force that can operate this most delicate mechanism—the brain—is electric energy? The principal evidence that it is electric energy and electric energy alone that operates this mechanism is based upon three facts. (1) Brain cells possess no function but the generation of electric charge by the process of oxidation. (2) When oxidation is diminished by anesthetics, narcotics, asphyxia, hemorrhage, or shock, the intelligence, power, and personality are correspondingly reduced. (3) Electric stimulation of the cells of the outer surface of the brain causes that part of the brain to perform its work precisely as it performed it naturally.

As a student I worked with that brilliant surgeon-scientist, Sir Victor Horsley, of London. He plotted the separate centers of the brain by noting the effect of stimulating the cortex of the brain of chimpanzees and by stimulating electrically the exposed cortex of the human brain during operations and observing the resulting muscular contractions. In the chimpanzee and man, when the cortical centers that govern the movements of muscles were stimulated, there was a grimace, movement of the eyes, puckering of the lips as in whistling, or pointing of the finger. Not only were such gross movements as shrugs of the shoulder and movements of the arms, fingers, toes, and hands produced, but also such motions were produced as are used in running. The question that arises is—did an electric current pass from the brain to the contracting muscles? During the stimulation, the galvanometer indicated the passing of electric currents, in the spinal cord.

In our own researches on animals we have found that such physical constants as temperature, electric conductivity, electric capacity, and electric potential vary in the living brain in the normal state, in the state of excessive activity, and in the state of depression. The administration of thyroxin is followed by an increase in the electric potential, electric conductivity, electric capacity, and temperature of the brain. Thyroidectomy is followed by a slow decrease in the electric potential, electric conductivity, electric capacity, and temperature of the brain. The injection of adrenalin causes an abrupt rise in the electric potential, electric conductivity, electric capacity, and temperature of the brain, followed by an equally abrupt fall in these physical constants.

In man, thyroid deficiency is attended by a correspondingly lowered activity of the brain. Excessive activity of the thyroid gland, whether through hyperplasia of the thyroid gland or through the administration of thyroxin, raises the level of activity of the brain, causing, first, a high normal tone and, if carried to the extreme, excitability and, finally, delirium.

Not only does the thyroid hormone increase the rate of oxidation in the billions of brain cells but equally increases the activity of the nerve cells constituting the ganglia and nerves of the entire sympathetic system. Not only does thyroxin produce all these fundamen

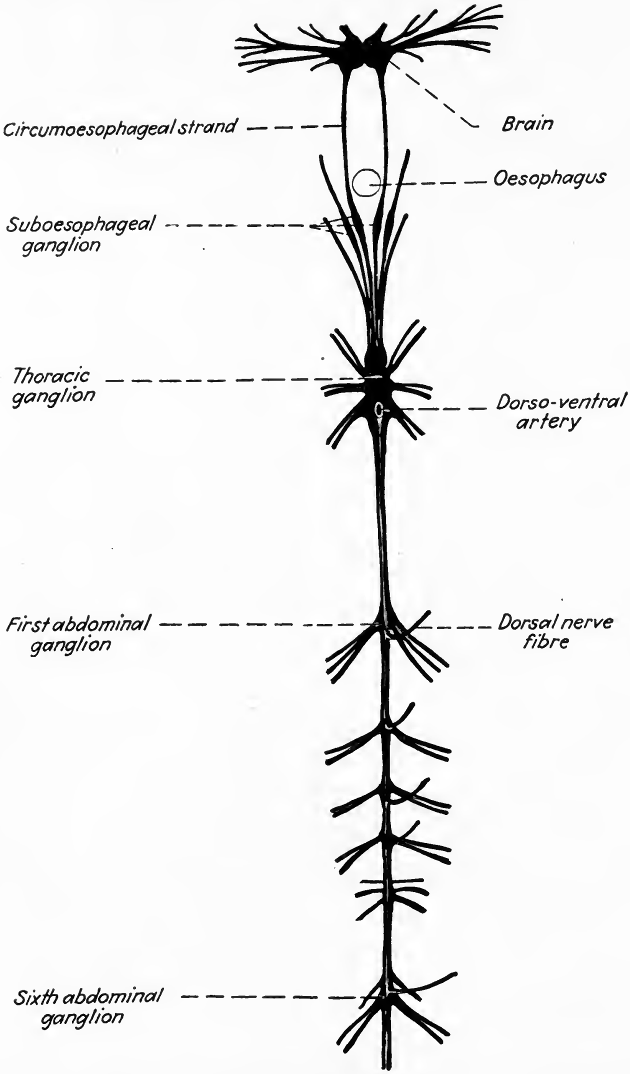


Fig. 19.—The nervous system of the crustacean (marine crayfish).

the brain and sympathetic nervous system, but it increases the effect of the sole agent of flash energy, namely, adrenalin.

On the other hand, total excision of the thyroid gland

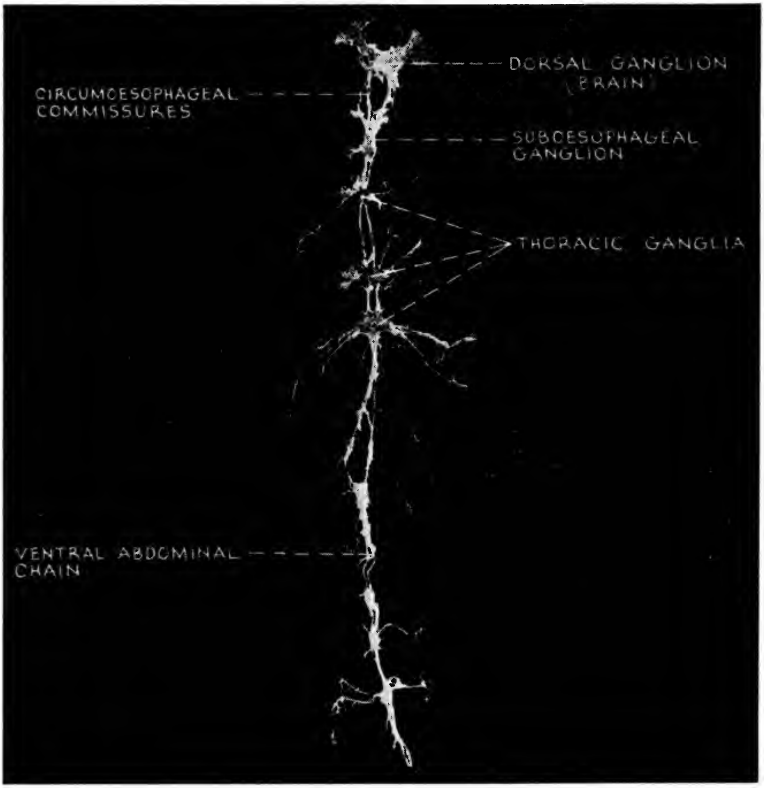


FIG. 20.—The nervous system of the insect (grasshopper).

causes a state of low metabolism, a cold, drowsy, lethargic, almost vegetative state. In this state, a hypodermic injection of even a syringeful of adrenalin has little or no effect upon the heartbeat, the blood pressure, and the mental and the emotional state. In the normal state, a few drops of adrenalin injected hypodermically may cause sweating, tremors, dilation of the pupils, weeping, and such an increase in the blood pressure and in the activity of the heart, that the subject of the treatment may be described as suffering an emotional crisis.

A final proof that thyroxin governs the rate of oxidation

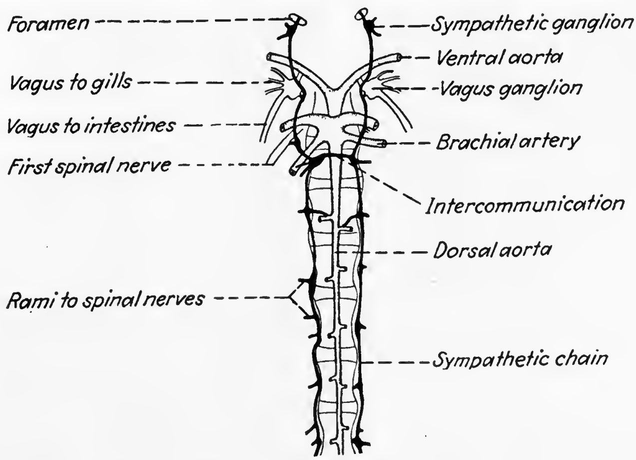


FIG. 21.—The sympathetic nervous system of the fish (barracuda).

of the brain cells and the cells of the sympathetic system is shown by the immediate effect of thyroidectomy in a case of exophthalmic goiter.

A second fact of fundamental significance is that severing the sympathetic nerve supply to the adrenal glands completely cures exophthalmic goiter, the increased vascularization of hyperplasia of the thyroid gland disappears, and the exalted state of the brain, hence of the metabolism, and the emotional state return to normal.

There is a significant contrast between the innervation of the thyroid gland and the innervation of the adrenal glands. The thyroid innervation is so slight that it is not easy to find. The innervation of the adrenal glands is abundant and complicated according to the power and personality of the animal. In the alligator the adrenal glands, the celiac ganglia, and the sympathetic system are insignificant; in the lion they are large, powerful, and formidable.

Figures 19 to 33 illustrate the rise of the sympathetic nervous system from the fish to those most complex of all sympathetic systems found in the lion and in the tiger.

The role of the adrenal-sympathetic system in the proc-

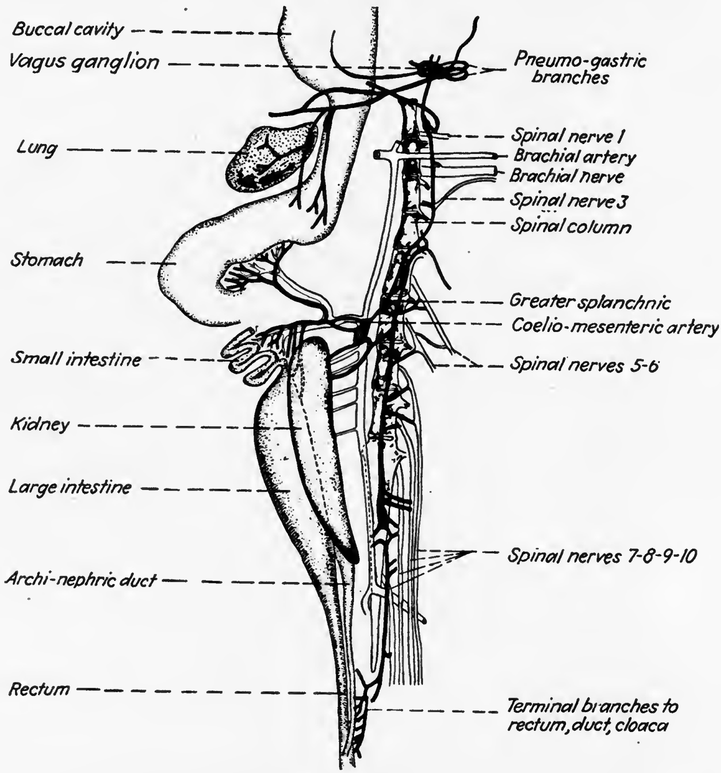


FIG. 22.—The sympathetic nervous system of the amphibia (bullfrog).

ess of memory, reason, and imagination in man is a minor one in comparison with the role of the thyroid gland; but adrenalin, through its establishment of high oxidation and high potential, causes to be etched a deeper action pattern, hence vivid memories and a more highly facilitated pathway.

Although training and education are largely a collaboration of the brain and thyroid gland, the secretion of the adrenal glands so reinforces the action patterns that the facilitated pathways are more quickly and more lastingly made under the drive of emotion. Emotion deepens and facilitates the action patterns during the adrenal-sympathetic state of fear, anger, love, worry, pity, etc.

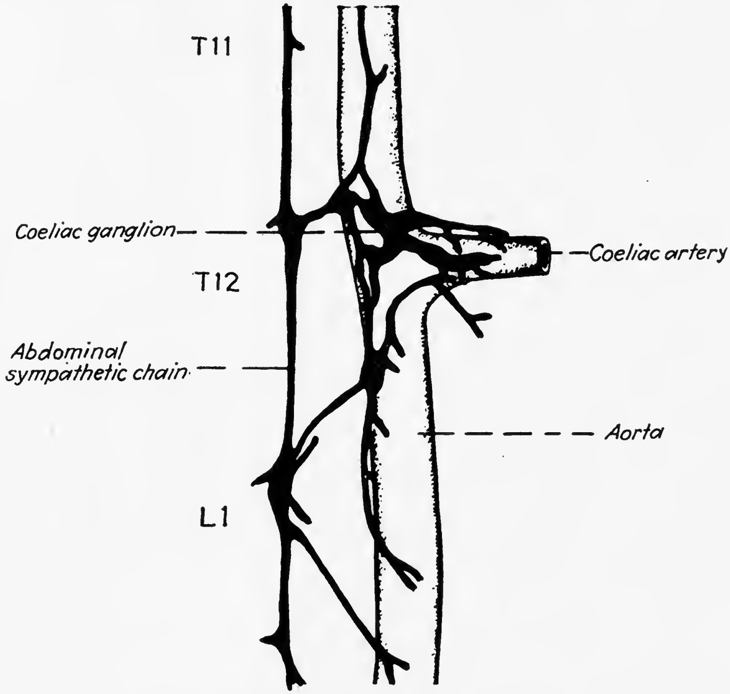


Fig. 23.—The sympathetic nervous system of the reptile (alligator).

In our discussion of the adrenal gland, we must adjust the important fact that the cortex of the adrenal gland is essential to the integrity of the brain. This fact is probably due to the unique composition of the adrenal cortex, a lipoid substance that possesses many properties resembling those of the matrix of the brain and the lipoid films enveloping the brain cells. Without the adrenal cortex life ends. Without the adrenal medulla life continues, but at a low level. Thyroxin is not a substitute for adrenalin or for the adrenal cortex.

When the brain is integrated for fear, for fight, or for flight, impulses are sent to the adrenal-sympathetic system, and from there adrenalin is sent to the brain, giving the stimulation that the brain and the sympathetic system

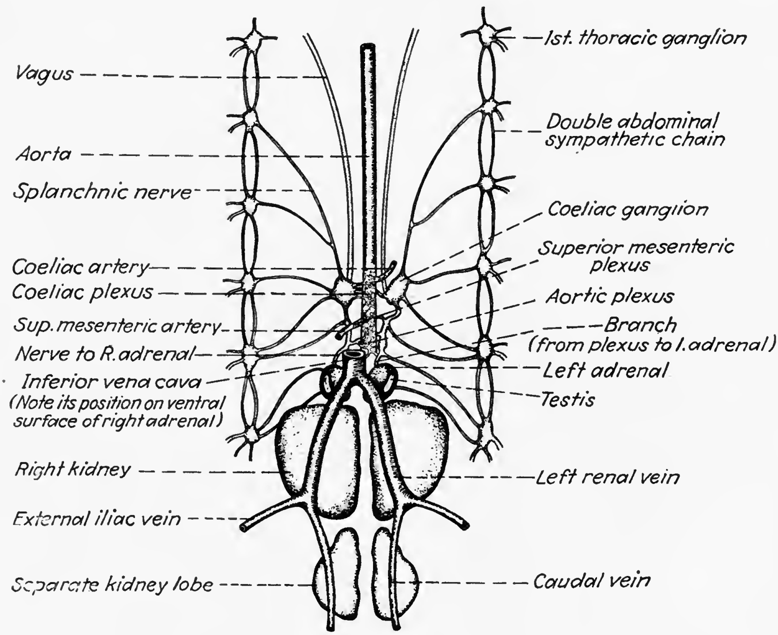


FIG. 24.—The sympathetic nervous system of the bird (horned owl).

require. Animals are bipolar mechanisms. Their energy-controlling systems are divided into two parts: that which controls the positive potential and that which controls the negative potential. The positive potential is generated and maintained by the brain and the sympathetic system. The negative potential is generated and maintained by the heart and the vascular system.

The force and frequency of the heart beat is correlated with the degree of intensity of stimulation of the brain. Oxidation itself completes the metabolic arc, as in the carbon lamp. Thus are basic and adaptive metabolism executed.

What is the difference between man and the ape as to intelligence, power, and personality? In monkeys, baboons, and apes the adrenal glands are much larger than the

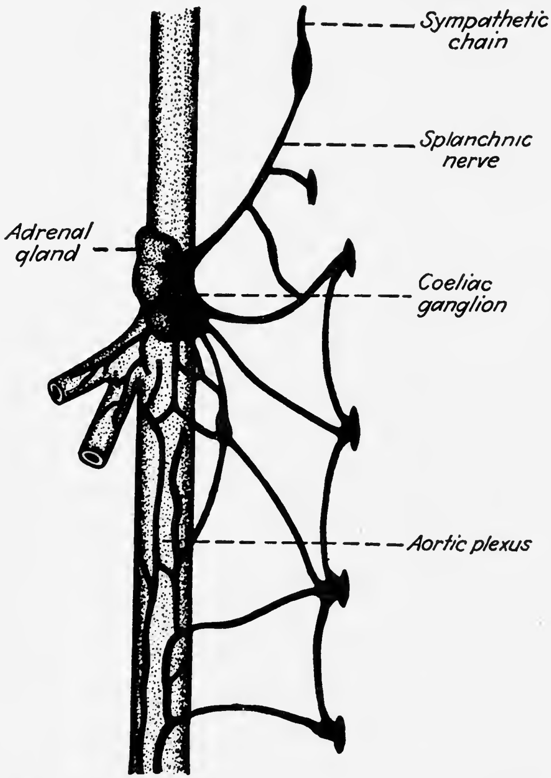


Fig. 25.—The sympathetic nervous system of the duck bill (the lowest order of mammals).

thyroid gland. In man the reverse holds; the thyroid gland is 2½ times the size of the adrenal gland. The gorilla, the chimpanzee, and the monkeys have probably reached the highest level of intelligence possible in the presence of preponderating adrenal glands. A thinking, reasoning brain is possible only with a high level of thyroid control.

Upon what basis is the statement made that memory, reason, and imagination—in other words, training and education—are interfered with when the thyroid control is superseded by adrenal control? In advanced exophthalmic goiter the normal action of adrenalin is so increased that a

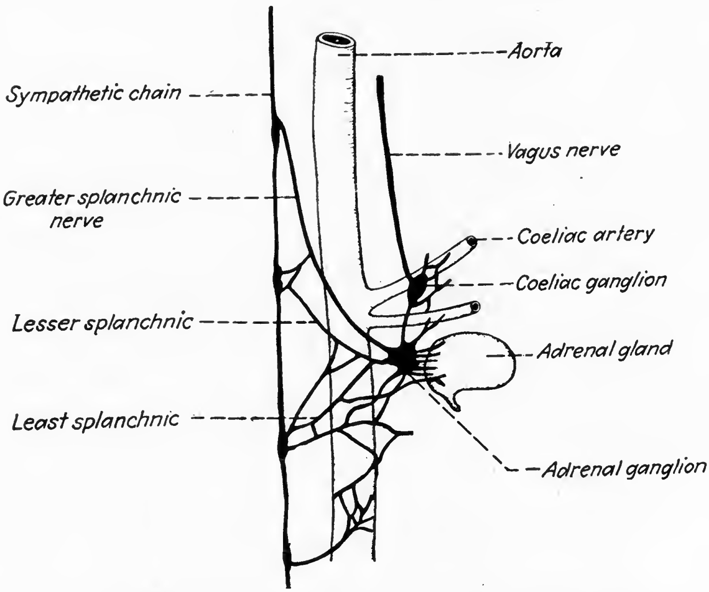


Fig. 26.—The sympathetic nervous system of the ungulate (gazelle).

state of continuous emotionalism is established. In this state there is marked interference with memory, reason, and imagination, or "mind." Thus, we can glimpse that the fundamental reason why a gorilla cannot respond to the education of man is that the gorilla is adrenal-controlled.

As shown by the power formula, the size of the brain of the ape is below that of man. The ape cannot acquire the intelligence of even the lowest aborigine.

The Missing Link

Where, then, is the missing link between the adrenalized ape and the thyroidized man? Did man arise from an independent thyroidized ancestor or from the adrenalized ape?

One important fact mav have a bearing on this query.

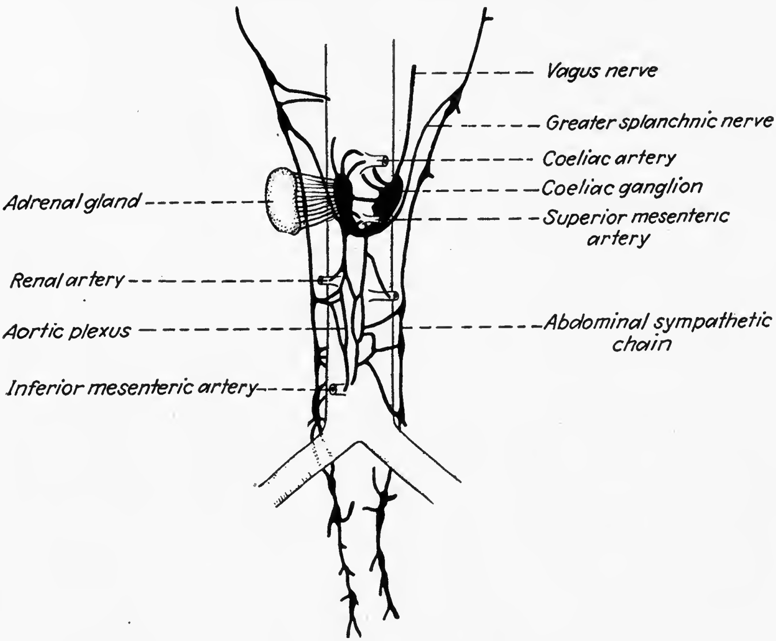


Fig. 27.—The sympathetic nervous system of the carnivore (polar bear).

This fact is in accord with Haeckel's law of ontogenetic and phylogenetic recapitulation. In accordance with this law, during fetal life animals recapitulate their ancestral past. In the human fetus the adrenal glands are far larger than the thyroid gland. This is the adrenal-thyroid pattern of the ape. Following birth, the adrenal glands in man, relative to body weight, become smaller, and the thyroid gland, relative to body weight, becomes larger until about the twelfth year, when they approximate each other in size. Following this period, the thyroid gland continues to become larger and the adrenal glands smaller until about the twenty-first year, when the adult human formula is estab-

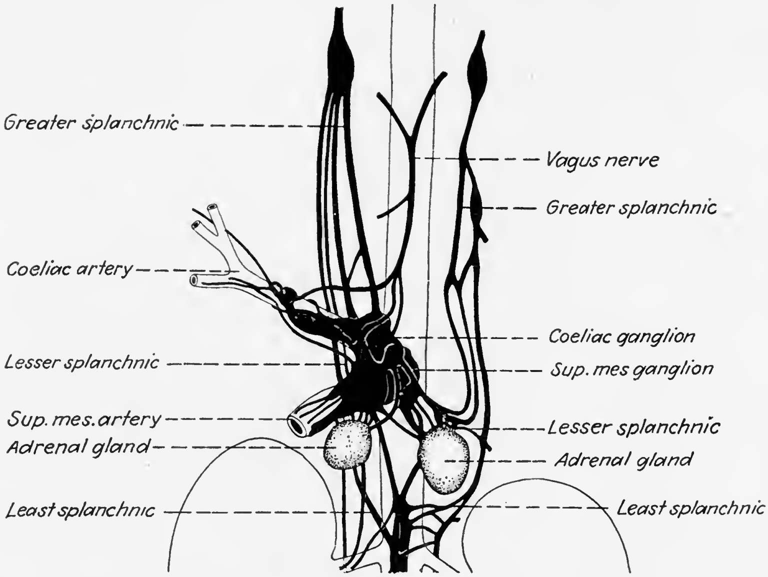


Fig. 28.—The sympathetic nervous system of the carnivore (walrus).

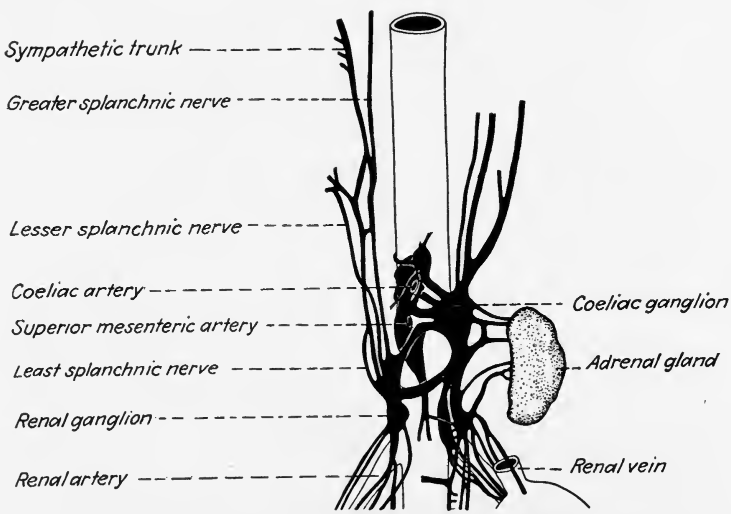


Fig. 29.—The sympathetic nervous system of the cetacea (porpoise).

lished and the thyroid gland is about 2½ times larger than the adrenal glands. This suggests the evolution of the adrenalized ape to the thyroidized man and also interprets

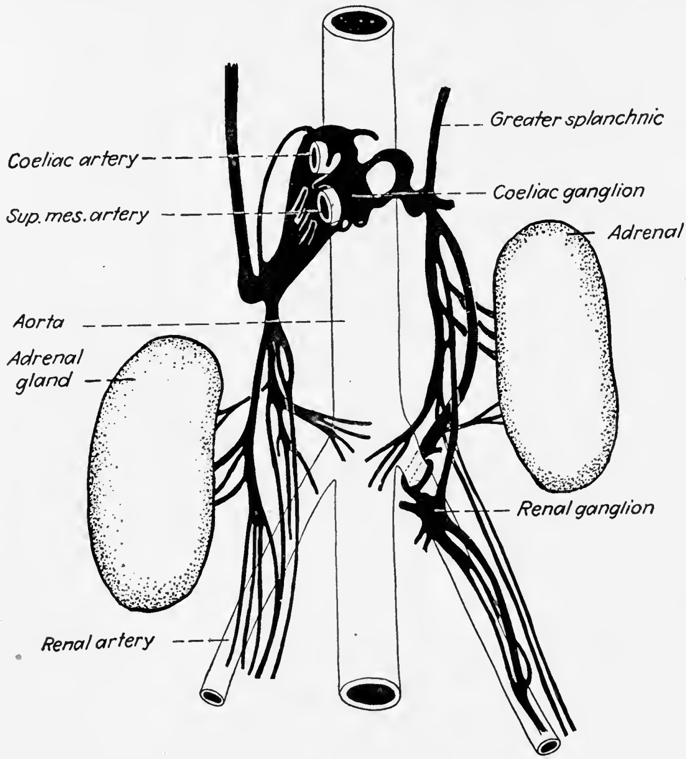


Fig. 30.—The sympathetic nervous system of the cetacea (white whale).

the adrenal influence in the behavior of infancy, childhood, and adolescence.

Although the following fact may not greatly reinforce the significance of this observation in the fetal life of man, it presents an analogy.

The thoroughbred horse is the result of a cross between Arabian stallions and English mares. In the Arabian stallion the thyroid gland is larger than the adrenal glands. In the thoroughbred horse the adrenal glands are larger than the thyroid gland. In the fetus of the thoroughbred, however, the thyroid gland is larger than the adrenal glands, as we have found in an examination of thirty-four

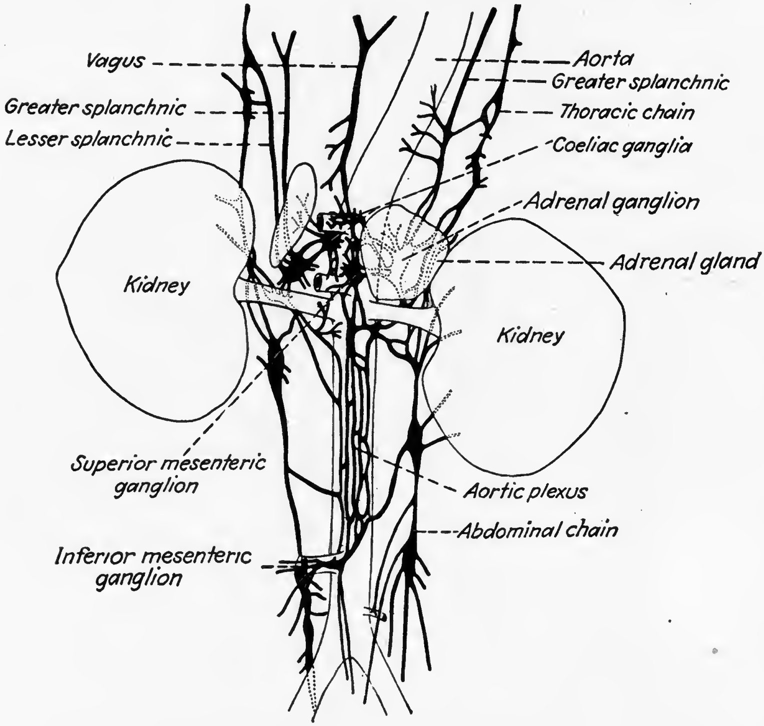


FIG. 31.—The sympathetic nervous system of the primate (chimpanzee).

thoroughbred fetuses and fifty-three newborn foals. Thus the fetus of the thoroughbred betrays its thyroidized ancestor, the Arabian horse, as we may venture to assume the fetus of man betrays its adrenalized ancestor, the ape.

The long period of adolescence of civilized man and the long period of training and education that he requires is correlated with a larger brain, a larger thyroid gland, and smaller adrenal glands, as may be seen in the following comparison of the energy formula of an Australian aborigine and a chimpanzee, taken by us in the wild.

Anthropoid	Sex	Body weight, pounds	Brain weight, grams	Thyroid weight, grams	Adrenal weight, grams	Heart weight, grams
Chimpanzee...........	Male	126	440	4.85	8.93	250
Australian aborigine....	Male	169	1,348	36.5	4.2	

The absolute and relative size of the brain, the thyroid, and the adrenal glands fixes a gulf between the thyroidized aborigine and the adrenalized ape. Let us now compare the brain, the thyroid gland, and the adrenal glands of the Australian aborigine with the brain, the thyroid gland, and the adrenal glands of a Scotch laborer. In the case of the Australian aborigine and the Scotch laborer, we have a comparison between two thyroidized mechanisms differing only in size. In the comparison between the Australian aborigine and the chimpanzee, we see the gap between the thyroidized human formula and the adrenalized ape formula.

Anthropoid	Sex	Body weight, pounds	Brain weight, grams	Thyroid weight, grams	Adrenal weight, grams	Heart weight, grams
Scotch laborer.........	Male	111	1,480	48.47	14.96	325
Australian aborigine....	Male	169	1,348	36.5	4.2	

In comparing these three energy formulas, it would appear that intelligence, power, and personality are due primarily to the absolute and relative sizes of the brain, the thyroid gland, and the adrenal glands. However, we must consider the contributory system that circulates the blood adaptively, that digests food adaptively, that eliminates waste adaptively, and that transfers glycogen from the liver

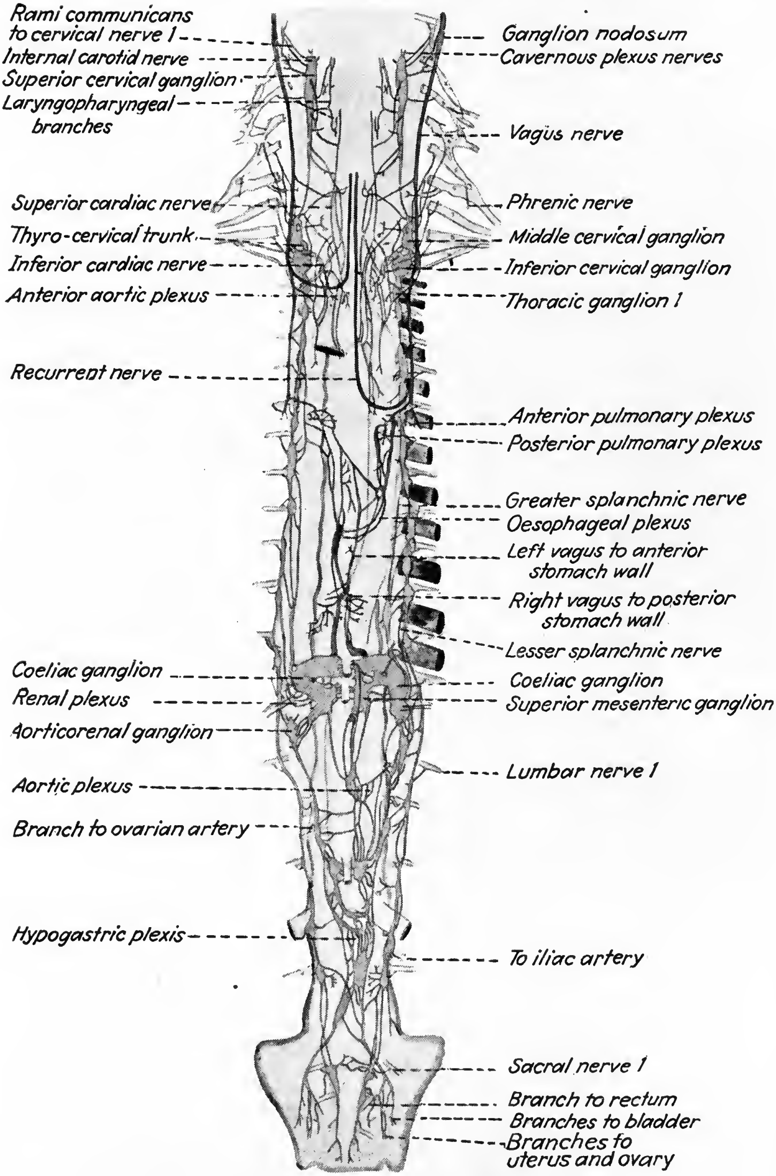


FIG. 32.—The human sympathetic nervous system.

to the blood adaptively, namely, the celiac ganglia, the celiac plexuses, and the sympathetic system.

As we have shown, the celiac ganglia, the celiac plexuses,

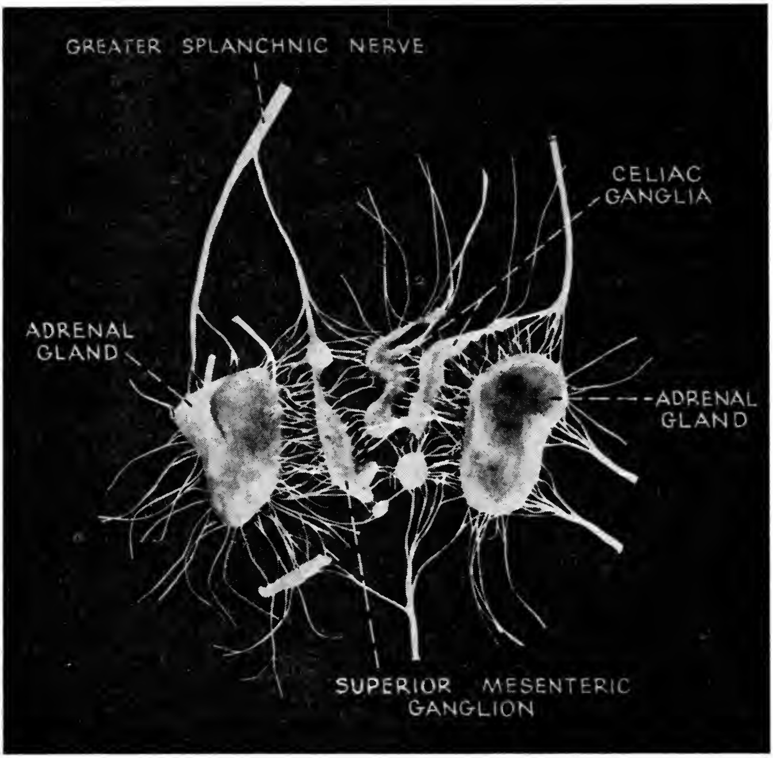


Fig. 33.—The sympathetic nervous system of the lion, showing the most highly developed sympathetic complex known.

the aortic plexus, and the splanchnic nerves, as well as the adrenal glands, vary greatly according to the energy characteristics of various animals.

Much evidence tends to show that the variation in the size of the sympathetic power station among humans indicates variation in the characteristic power and personality of the individual. Some individuals have larger than normal celiac ganglia and plexuses.

Just as the inheritance of a unique thinking brain and a uniquely large thyroid gland expresses itself in a high degree of intelligence and at times in exophthalmic goiter,

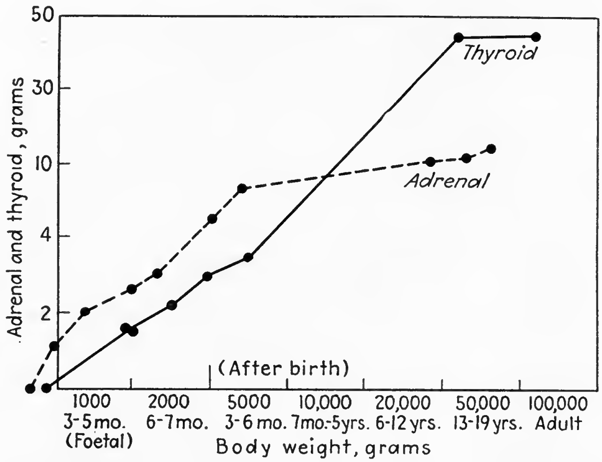


FIG. 34.—The adrenal-thyroid cross. This chart shows that between birth and the age of twenty-one years, the relations of the thyroid and adrenal glands become reversed.

so the inheritance of a unique thinking brain, large adrenal glands, celiac ganglia and plexuses, and heart expresses itself in a high degree of intelligence, great activity, and, at times, in essential hypertension and coronary disease.

It was natural selection that endowed man with a large thinking brain and a large thyroid gland. There is no such thing as chance in natural selection. It was not chance but natural selection that endowed all apes with large adrenal glands. It was only by chance that the large, agile, adrenalized ape came down from the tree and survived.

How did the ape exchange the large adrenal glands for the large thyroid gland and, coincidentally, build up a thinking brain? This change could not have occurred except for an advantage. It would have first appeared when some great ape ventured upon the ground, where he found food in greater abundance and prospered. Life on the ground represented greater difficulties; therefore greater intelligence was required and the more intelligent ape survived; so the thinking brain and the thyroid gland became a little larger and the adrenal glands a little smaller. Thus, slowly, a more intelligent ape, with a larger thyroid gland and a manipulative hand, came into being, one that used a stick and stone, that lived in groups for common defense. Could one place, hand in hand, five hundred of one's ancestors, allotting one hundred years to each, the last hand would be that of a hardy ancestor, guarding the entrance of his cave against the leopard and the snake. That dawn man, our remote ancestor, followed the herds that his intelligence finally controlled. That dawn man used the club and the arrow; he found fruits and nuts and birds' eggs and wild grain; he hunted and fished; he fashioned skins to keep himself warm; he found shelter in caves; he discovered the control of fire; he tamed the wolf puppy to be his companion the dog; he made dugouts and navigated the streams.

Today, as in the long yesterday, man hunts and fishes, finds fruit and nuts, and lives upon the flesh of animals, milk, eggs, honey, and grains. Today the brain of thinking, working man is so highly organized, so hourly taxed, that there are more institutional beds in the United States for adults suffering from mental and nervous diseases than there are for adults suffering from general diseases, and vast numbers of the so-called "general" diseases are due to the abnormal activity that is the result of inheritance through the mutations of the brain, the thyroid gland and the adrenal sympathetic system.

The mind of civilized man is a very powerful instrument. Its power is that of the switch that explodes the mine. The mind of man has transformed the animate and inanimate earth. It has multiplied, cajoled, and glorified man. It has protected man against many diseases, against cold, against hunger, against wild animals; it has enslaved animals and plants and fellow man. In its phylogenetic recapitulation, the mind of man has invested competition with his fellow man as if it were an ancestral fight or flight.

Even today wild man, the distant ancestor that came over the protoplasmic bridge, lives within civilized man. Around this wild man the matrix or thinking brain has woven the web of religions, of laws, of customs, of education, restraining and limiting man in the exercise of his wild behavior. But civilized man is unable to sever himself completely from the law of the jungle. Man has conquered everything but himself. The only enemy of civilized man is civilized man.

23. THE LAW OF ENERGY RELEASE: THE LIFE LINE

In the preceding pages we have discussed whether or not the intelligence, power, and personality in wild and domestic animals are created by the work of the brain, the heart, the thyroid gland, and the adrenal-sympathetic system. We have found that whether the animal is warm-blooded or cold-blooded, whether the habitat of the animal is the tropics, the arctic, the land, the air, or the sea, the variation in the size of the brain, the heart, the volume of the blood, the thyroid gland, and the adrenal-sympathetic system is the only cause of variation in the intelligence, power, and personality.

Since, throughout the animal kingdom, the primary role of the brain is to maintain the body temperature and to drive the muscles and organs in attack and escape and since, in the warm-blooded animals, 75 per cent of the food intake is required for the maintenance of the warm-blooded state, we searched for some fundamental regularity or general law underlying the release of energy in all animals that would be expressed by the ratio of the weight of the thyroid gland to the gross weight of the animal. A trend, but no law, was found.

We next searched for a law that would express the ratio of the weight of the adrenal glands to the weight of the animal. Again a trend, but no law, was found.

We then attempted to find a law based on the ratio of the weight of the brain to the body weight of the animal. Once more a trend, but no law, was found.

The ratios of the combined weights of the brain, the thyroid glands, and the adrenal glands to the body weights of the various animals were next tested. Here, too, a trend, but no law, was found.

Finding that the relationship of the brain, the thyroid gland, and the adrenal glands to the body weight could not be expressed in a law, we turned from anatomy to physiology to see if a fundamental law could be found to express

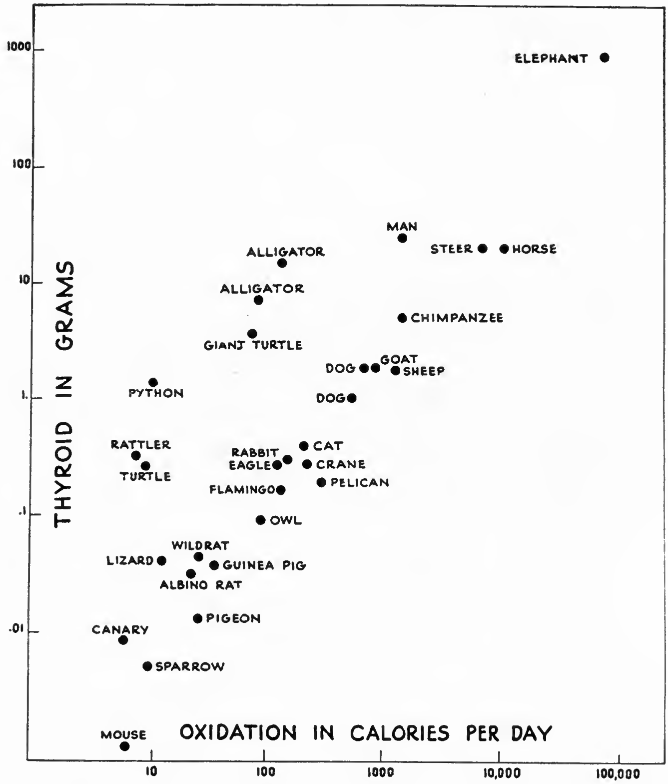


FIG. 35.—In relation to metabolism the weight of the thyroid gland shows a trend but not a law.

the relationship between the weight of the thyroid gland and metabolism, the weight of the adrenal glands and metabolism, and the weight of the brain and metabolism.

We plotted the weights of the thyroid glands against the number of calories (oxidation or metabolism) generated in 24 hours in the animals that we had studied, including insects, fish, reptiles, birds, rodents, hoofed animals, carnivores, monkeys, baboons, anthropoids, and man.

The ratios of the weights of the thyroid glands and of the adrenal glands to the metabolism of the various animals showed a trend, but not a law.

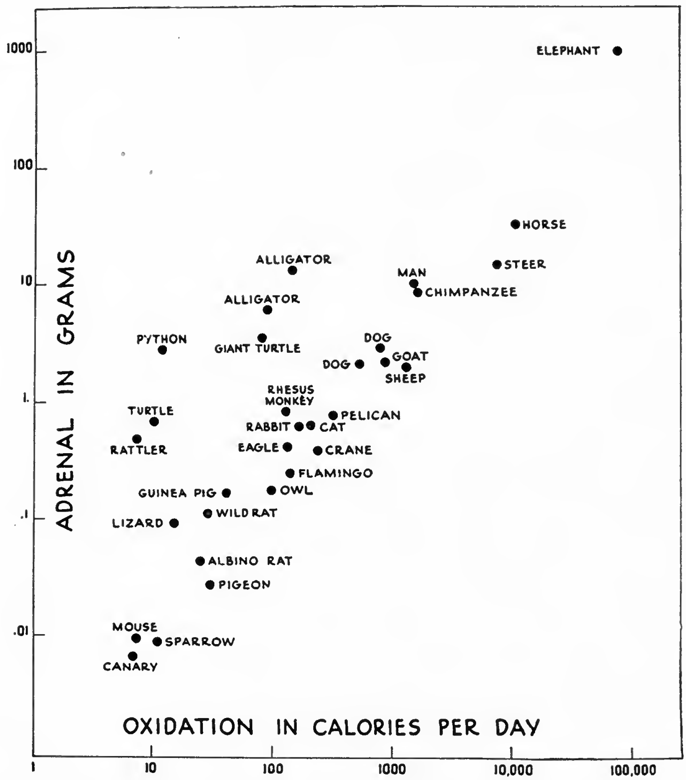


Fig. 36.—In relation to metabolism the weight of the adrenal glands shows a trend but not a law.

At this point it will help to clarify the relative role of the various organs of the energy-controlling system if we recall that the brain in the higher animal is the exalted analogue of the nucleus of the amoeba; hence the brain is the one and only executive or controller of energy in an animal. Therefore, since it is the function of the brain alone to execute the oxidation or metabolism of the body for the long and the short rhythms of both the thyroid and the adrenal glands, we endeavored to find a law that would express the relation between the weight of the brain of an animal and the metabolism of that animal in 24 hours.

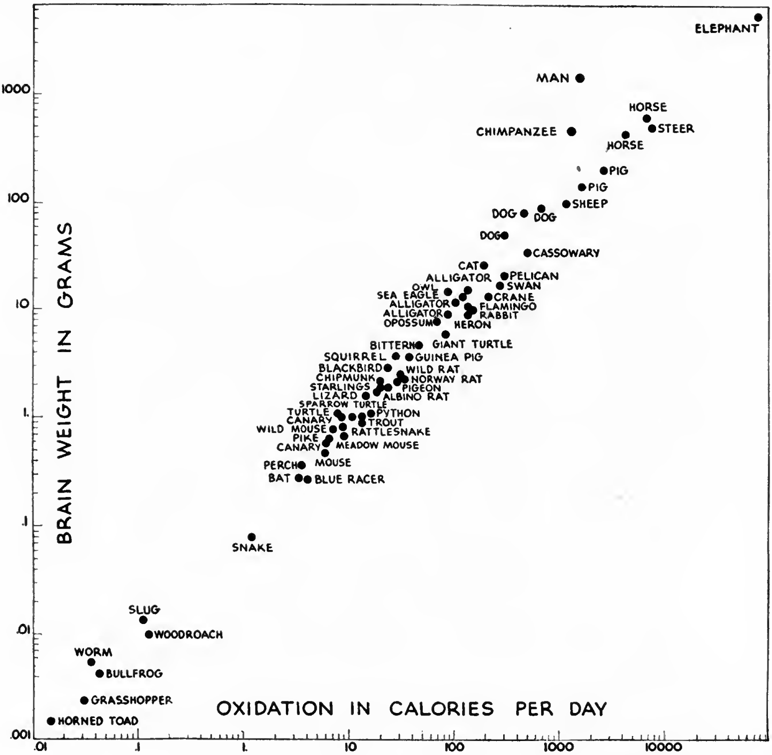


FIG. 37.—In relation to metabolism the weight of the brain shows a law.

We found a law, so fundamental that it embraces insects, fish, reptiles, birds, rodents, ungulates, and carnivores, but not higher apes and man. This law is expressed by the ratio between the weight of the brain of an animal and the number of calories produced by that animal in 24 hours.

We found that 1 gram of brain is required to produce 12,115 small calories in 24 hours; that is, the ratio of the weight of the brain to the heat production in small calories is 1 to 12,115. Into this brain metabolism law or "life line" all animals fall except those animals whose "thinking" brains enable them to use strategy or energy outside of themselves to aid them in effecting their survival. This dividing line brings us to the primates.

Why do not man and the higher apes fall into this "life line?" At this point we must bear in mind that from the worm to the elephant every animal that exhibits adaptive response possesses to a varying degree the mechanism of thinking, but the mechanism by which thinking is executed consumes little oxygen. The mechanism of thinking consists of patterns of action.

When the mechanism of thinking is advanced to such a degree that the possessors are able to use either strategy of survival value or energy outside themselves, whether it is the energy of a club, of fire, or of another animal, the brains of such animals will be larger than the brains of the animals that execute energy entirely within themselves. The higher the order of intelligence the larger is the portion of the brain required for thinking, that is, for memory, reason, and imagination, or "mind."

Lower animals possess little "mind" and much energy. In the lower animals most of the cells of the brain are used to execute the total energy utilized in 24 hours. In man, a larger part of the brain is required for "mind," and the remaining portion of the brain in man is comparable to the simple energy brain of the lower animals. Thus, the "mind" brain of man, added to the energy brain of man, raises the total weight of the brain of man to a unique size.

What constitutes the "mind" brain of man? Why, in the life line does the brain of man deviate from the brains of the wild and the domestic animals that have been studied?

The mass of the brain of both man and animals consists of two parts, the gray matter and the white matter. The gray matter consists of units of energy transformation, or cells. These cells are dynamos. Within these 9,200,000,000 cells or dynamos in the cortex or gray matter of the brain, through the process of oxidation, is generated the energy required to operate such mental processes as memory, reason, and imagination, the emotions, and such acts as walking and working.

The white matter of the brain contains no cells; it is not a dynamo. No driving force is generated within it. The white matter of the brain is a matrix in which, by electric charge generated within the cells of the gray matter, an infinitely delicate network of conducting pathways of action is laid down, and, with the passage of each electric charge, these molecular paths of conductance, or "action patterns,"[1] become facilitated.

Francis Benedict states that abstract thinking requires little oxidation or metabolism. In a critical study of the effect of mental work on metabolism (oxidation), Benedict measured the rate of oxidation while the subjects performed mental work and found that if there was any change in metabolism, it was slight.

The respiration, the circulation of the blood, the digestion of food, the work of the kidneys, and the minimum amount of oxidation necessary to maintain the life of the brain cells—all these are included in what is called basal metabolism. Basal metabolism does not include the oxidation required for walking and running, thinking, hearing and speaking, seeing and smelling.

The evolution of the brain, from those animals in the life line to civilized man, consisted of an increased specialization involving both the white matter, or thinking brain, and the gray matter, or cortex. In the evolution of the brain from the level of that of wild animals, there were added many new mechanisms, each of which had survival value. The mechanism of balancing upon the hind feet, of walking, bending, kneeling required not only a great increase in the units of the gray matter but also an increase in the units of the white matter.

No wild or domestic animal possesses so complicated a

[1] Crile, George W., "A Bipolar Mechanism of Living Processes," The Macmillan Company, New York, 1926.

mechanism of locomotion as man. Evolution conferred survival value upon the mechanism of balancing and the upright posture, because it released the forelegs to become the priceless heritage possessed by no other animal, namely, the manipulative hand. In its ceaseless activity the manipulative hand required the evolution of brain cells and a corresponding evolution of action patterns in the white matter. No lower animal possesses a comparable mechanism in the gray matter or in the white matter. However, the upright posture and the manipulative hand could have little survival value without the collaboration of the eye.

The retina of the eye is a specialized part of the brain, projected through a hole in the skull, whose rods and cones, or antennae, are exposed directly to light. In the retina of the eye there are about a hundred million individual photoelectric cells, each one of which communicates with one or more of the hundreds of millions of brain cells that constitute the mechanism of seeing.

The vital role of the eye, in thinking, reading, walking, and working, is indicated by the great number of diseases of the eye found in civilized man. With its millions of units of energy and its infinite numbers of communications to every other part of the brain, the eye has conferred great survival value upon man himself.

Through the eye man has been made aware of the distance of one object from another. This physical fact alone has great survival value. Through the eye man has also been made aware of all the colors of the rainbow. Through the eye the brain of man has been made aware of the distance and contour of objects, of the speed of movement, and of the ground about him. The eye is the most important sense organ. With it man sees the written page and through the written page secures his education.

The upright posture with its vast mechanism and the manipulative hand with its vast mechanism owe their survival value largely to the mechanism of seeing, which brings awareness to the mechanisms of locomotion and manipulation.

From the organ of Corti, the nerve mechanism of hearing, there are communications with millions of brain cells constituting the center of hearing in the cortex of the brain. From each of these brain cells a fiber communicates with the infinitely intricate mechanism of the thinking brain. From the thinking brain these impulses of hearing are broadcast to the motor centers in the cortex and, from these, to the various muscles and glands of the body.

A mechanism possessed by no other animal except in rudimentary form is the unique gift to man of the evolution of speech. The speech center, although related to the ear primarily, also consists of millions of brain cells in the cortex of the brain. The brain cells constituting the speech center are connected by nerve fibers with the mechanism of the thinking brain. By this means the work of the thinking brain, or thought, is expressed in spoken or written language.

Upon analysis, it will be seen that the mechanism of hearing, like the mechanism of speaking and, to a large extent, common sensation supplement the other mechanisms. Coincidentally with these mechanisms, as an axis partner, there was evolved a corresponding rise in the expansion of the mechanism of the brain for thinking that has little or no counterpart in the wild and the domestic animals. Thus the brain of the lowest order of man is separated by a wide gulf from that of the highest apes.

In the course of the vast evolution from ape to man, there is no corresponding change in the mechanism of respiration, in the action of the heart and the circulation of the blood, in digestion, in the function of the kidneys, or in the mechanism of procreation. These organs and tissues are necessary to the maintenance of life itself. By these organs and tissues basal metabolism is effected.

With respect to these organs and tissues there is parity between man and the wild and the domestic animals.

A civilized man weighing 150 pounds would require 135 grams of brain to execute his basal or animal metabolism. The remaining part of the brain of such a civilized man would appear to consist of the vast evolution of the special mechanisms cited and of a still greater evolution in the white matter of the brain of the mechanism that executes memory, reason, and imagination, or thinking.

Thus in civilized man we find that the thinking brain is 780 per cent larger than is essential to execute his simple basal metabolism. This 780 per cent represents the gift of evolution to civilized man. It represents the weight of the complicated mechanisms in the driving cortex or gray matter of the brain and the weight of the infinitely complex white matter of the thinking brain. It represents the difference between the intelligence, power, and personality of civilized man and the intelligence, power, and personality of the wild and domestic animals that obey the life line.

24. THINKING BRAIN AND MORAL CODE

IN THE nature of evolution an animal or a plant cannot be made more fit than just fit enough to survive. Animals and plants, therefore, have an uncertain tenure of life. All animals, including man himself, were evolved to the tiptoe of chance and left in partial peril and partial safety. Since it was in the brain of early man that his evolution took place, it was in the brain that there were created action patterns, called knowledge, by means of which man excelled his fellow animals.

In the brain of early man were included those action patterns denoting how to domesticate animals and plants, how to make from these shelter and clothing, and how to obtain food from them. These action patterns had survival value. It was the superior thinking mechanism of the brain that enabled early man to secure these advantages over the competing animals. But in this sensitive recording and thinking mechanism were also laid down the dangers that beset man. In the brain of early man were recorded the danger of the lion, the rush of the elephant, the fury of the buffalo, the sting of the serpent. In the brain of early man was recorded the fact that many animals injure or destroy man and that, although some animals were good, some were bad, and that even good animals were sometimes bad and bad animals sometimes good.

Thus, early man, like man today, existed on the unstable boundary of chance. Like the feather that drifts on the breeze and is never carried beyond contact with the forces that convey it, early man, left on the beach of time, where, alternately, the waves and the sun reached him—in the twilight zone of chance, within the reach of both safety and peril—evolved through the favorable mutations of his thinking brain amidst the forces of nature of which he was a part.

Early man, like primitive man and man today, had much to fear. An animal possessing no fear and living in the midst of danger would not have survived. It is only the alert animal, quick to fear and quick to attack or escape, that survives and has offspring.

Fear has survival value. Fear exists in all animals that have enemies. Who, in observing the dynamic gazelle, the fleet zebra, or the alert wildebeest would not know that these animals had dangerous enemies? Just as the carnivores, through natural selection, gave to the gazelle its acute hearing, its quick eyesight, its keen smell, so, through natural selection, the dangerous competing animals gave to early man his organ of strategy, the brain. These competing animals also gave to man his fears, as necessary to man for escape and survival as to the gazelle.

Having never been out of the domain of the forces of evolution, early man found good and evil in everything about him. Since, in the early stages of his evolution, the action patterns of early man were laid down by his fellow animals, his simple mind considered everything in animal terms. He found that by giving food to the animals that he had domesticated he could control them. He found that by giving something to his young and his relatives, whether it were food, shelter, a skin, or hospitality, he could win the good will and favor of his people.

Thus, after he had passed the first stage of worship and fear of the natural forces and animals about him, it followed that early man began to worship and fear unseen beings, and, since the most powerful animal for good or for evil in the life of early man was his early fellow man, it is natural that the gods and the devils that he created should have been created in the image of himself. Since man has never been evolved out of the struggle for existence, the word "struggle," even today, just as in the long yesterday, indicates good and bad and life and death. Thus, in the moral codes, both phases of the struggle—the good and the bad, a god and a devil, heaven and hell—have been represented.

In material and structure the brains of all animals, wild or domestic, are identical with the brain of man, differing only in the matter of size and organization. Except in the development of that part of the brain which we designate mind, the brain of a lion, an elephant, or a dog is as efficient within its scope as the brain of man, and in the control of the special senses the brains of wild animals are far more efficient than the brain of man.

Unlike man, wild animals do not appear to think about themselves. Therefore they do not think in error about themselves. Unlike man, wild animals are not able to reason that because their minds can review the past, they can project a future, and because they have imagination, therefore they are made up of two parts, their bodies and their spirits.

The elephant would not make such an error, since he does not possess the mechanism for making the reaction. Could the elephant have such a reaction, his god would undoubtedly be a luscious leaf and his devil a mouse. Early and primitive man seems to have made a similar reaction.

Suppose that today we did not know that there was such a sensitive structure as the brain within the skull and we believed that the brain was inert material, like the hump of a camel. Yet if the brain of man could function as it does, might not man today, then, believe that a spirit inhabited him, governed him, made his decisions, directed him in his tasks and that when it became inactive he slept, when it became a little too active he dreamed, when it was displeased he became angry, when it was satisfied he was happy? Might he not believe that it taught his hand its cunning, that it guided his footsteps to school, that it was a beneficient spirit and did his lessons, or that it erred and he failed? Might he not believe that when it was a good spirit, it made him brave and truthful and when it was a bad spirit he was a coward, a cheat, and a liar? He could believe that a good spirit gave him the attributes of love and affection, that it stood by and found for him a wife, that it led him through the trials of bringing up a family, that it taught him industry and thrift, and that when he died it took its flight. If I were a jungle man today and were not aware that I have a brain, I would willingly acknowledge a spirit and attribute to it all the movements of my life.

It is significant that in the moral codes of man no function assigned to the spirit is not clearly the function of the brain. Therefore the idea of the spirit found so often among the faiths and beliefs of native people is a natural error of confusing a functioning brain with a spirit. A functioning brain accounts for the action patterns of man and animals just as completely as the mechanism of an adding machine accounts for the mathematical patterns that it performs.

The difference between the brain of man and that of the lower animals is not in the structure itself but in the further development in man of that part of the brain which exercises memory, reason, and imagination. The dog, the lion, the elephant, the ape, and the simple native have identical mechanisms, with varying degrees of development. This variation is expressed in the "life line."

It is this dominating mechanism, this thinking brain, which gives man his language, his science, his invention, his law and his religion, his hopes and his passions, his libraries and his laboratories, his schools and his universities. This mechanism, composed of nothing more remarkable than lipoids, proteins, and electrolytes, has been invested with mystery since early man.

In our experience in Tanganyika among the various highly disciplined tribes of Africa, there seemed to be a standard of moral codes suitable for their degree of civilization. Discipline is the basis of moral codes. The teaching of the parent, the teacher, the medicine man, the priest, the force of public opinion, and, finally, the punitive influence of the tribe or state are strong factors in establishing the code of behavior in both native man and civilized man.

Part III

CIVILIZED MAN

25. TRAINING AND EDUCATION

What is civilized man, and what is he not? A leopard can mobilize greater outburst energy than man. An antelope can run faster than man. The wolf can cover a greater distance in a day than man. Man's eyesight is less acute than the eagle's. Man's sense of hearing is less acute than the deer's. Man's sense of smell is inferior to that of wild and domestic animals. Man's teeth are inferior to the teeth of every wild animal. Man's digestion is inferior even to that of his domesticated animals. Man has monopolized gallstones and kidney stones as well as peptic ulcer. The skin of man, in comparison with the skin of wild and domesticated animals, is soft, velvety, and vulnerable. Man is the only animal that becomes bald. Man's blood cells are subject to great fluctuations. Only man has pernicious anemia. The bones of man are not so hard as the bones of wild or domestic animals. The milk of civilized woman is not equal to the milk of the wild and domestic animals. Neither the wild nor the domestic animals have insanity or psychoses or neuroses. For this array of powerful facts we must seek a biological interpretation.

Among all wild and domestic animals man is unique. He is inferior in bones and joints, muscle, teeth and digestion, skin and hair, sight, hearing, smell, and mother's milk. As if this were not sufficient to establish his physical inferiority, man is poised on his hind feet and possesses apelike hands that have lost their power to assist him in running. This impossible posture has existed so long that the breast has been moved to a comfortable position to nurse his helpless young; and the young of man are totally helpless for a longer time than the young of any other wild or domestic animal.

Despite this large category of fundamental inferiorities, man is more widely distributed over the earth than any other large animal. This fact alone proves that the animal man must have evolved advantages which had survival value so fundamental that swift and powerful muscular action, a more nearly perfect sense of sight, hearing, and smell, perfect digestion, a complete equipment for running with the herd at the time of birth, and body covering of hair or wool or fur had no survival value for man. Yet man possesses no organ or tissue not possessed by other animals.

The equipment by which man rose from the level above that of the great ape was provided through a further development of the factors by which the great ape differentiated from the lion, the wolf, and the antelope.

What, then, is the net result of the subtractions and additions of this analysis of man compared with other animals? It is that through the unique evolution of three organs—and three organs only—acting in synthesis, there was conferred upon man his superior position among all animals. These three organs conferred upon man so great a survival value that muscular power alone, teeth and claws alone, fur and hair and wool alone, sight and hearing and smell alone, the heart and blood alone and the adrenal medulla alone lost their survival value. It was this creative trinity—the brain, the thyroid gland, and the upright posture—that yielded the manipulative apelike hand that had survival value to the great-ape ancestor of man who came down from the trees. The long legs and arms of the distant ancestor provided a larger surface for regulating his internal temperature, thereby permitting the evolution of a larger brain and a larger thyroid gland and, in consequence, a greater intelligence, power, and personality.

It was through this creative trinity—the brain, the thyroid gland, and the manipulative hand—that man was enabled to utilize energy external to himself. In this single characteristic man is distinguished from other animals. This new formula placed at the disposal of man the immeasurable living and nonliving energy in the world.

At the time of birth few of the offspring of animals are equipped to adapt themselves to environment; the simpler the reaction of a species the earlier is its mechanism for adaptation completed.

For the young of each species we find that the methods as well as the intervals necessary for completing the adaptation for adult life differ, varying from the simple adaptations of the fish that never know their parents to the birds, whose parents protect, feed, and give them their simple training; of the beaver, whose offspring are taught to play at making dams; of the gregarious animals, whose young remain with the flock or herd and are taught by example; of the Carnivora, which train their young to kill; and of the young monkeys, who receive from their parents a training in strategy.

From the periods of training and education received by the young of anthropoids we pass to the progressively longer periods required for the training of the Bushman, the cave man, the semicivilized man, and, finally, civilized man.

The brain of a human being may be likened to a moving-picture film that runs from birth to death. Among the vast number of images thrown upon the film, only a few obtain possession of the final common path of action. These become patterns of action. The action-pattern equipment of an individual produces the only acts he can perform. Training, therefore, consists in making action patterns. Action patterns make conduct. Training, not education, is the creator of behavior.

Man's action patterns reflect his environment as in a mirror. If a colt grows up in the wild it becomes a wild horse; if it is trained by man its action patterns and its behavior are domestic. The young of all animals are plastic, but the child is most plastic. If the child lives in a savage web, he becomes a savage; if he lives in a civilized web, he becomes a civilized man. Thus the action patterns formed in the plastic brain constitute the personality of the individual and make the reactions of the human mechanism as inevitable as are the reactions of a man-made machine.

The steam roller cannot perform the work of the automobile, but the difference between the steam roller and the automobile is less than the difference between the savage and the scholar. The essential difference between the philanthropist and the African native, like the difference between the teacher and the pupil, is in their action patterns.

The white matter of the brain is not a passive mechanism like the matrix of the phonograph record or the beeswax that produces the piezo electric effect. In the white matter of the brain there is a constant electric strain, as is indicated by the presence of an electric potential. The origin of the electric strain is the generation of positive electric charge in the brain cells by oxidation. The rate of oxidation in the brain cells is governed primarily by the secretion of the thyroid gland. The thyroid gland is governed by the adrenal-sympathetic system. The adrenal-sympathetic system is governed by the brain, and the brain is "sparked" by sight, hearing, touch, taste, and smell, thus forming an automatic mechanism. In this intricate physical system of the pupil, the parent and the teacher lay down new patterns of action that, by training, increase the capacity of the brain cells of the child to generate radiant and electric energy.

The Protoplasmic Bridge

The parent and the teacher do not need to give instruction in such racial acts as sucking, walking, hunting, fighting, mating, drinking, and eating, the patterns of which the child brought over the protoplasmic bridge. Those action patterns came to present-day man not by contemporary external integrative action of the nervous system but by a repetition of the integrative actions transmitted over the protoplasmic bridge from parent to offspring. Affection between mother and child, protection of the young, a taste or distaste for food, hunger, thirst, seeking shelter from rain and wind, trust and distrust, attraction and repulsion, pity, cruelty, cheating, lying, stealing, killing—these inherited integrations of the nervous system not only had such survival value in the long ascent of man as to be transmitted from one generation to another over the protoplasmic bridge but are even today an integration to civilized man. We call them "instincts," but they are merely integrations of the nervous system laid down as action patterns in the long upward evolution of man. Those that benefitted man became a part of the action patterns laid down in the mechanism of his phylogeny. Those that had no survival value to man did not pass over the protoplasmic bridge. Thus in all the natural tastes and appetites, in fears, in dislikes and attractions in animals as well as in man, the reconditioning of this or that phylogenetic or racial memory awaits refacilitation by the receipt of an adequate stimulus through the special senses.

It is especially in infancy, childhood, and adolescence that we can see more clearly what came over the protoplasmic bridge. Over the protoplasmic bridge there came to the female the care of the baby, as is seen universally in the play of little girls with their dolls. Over the protoplasmic bridge there came to the male the struggle of tribal man with his fellow man, as expressed in boys in fighting with each other and playing at fight in competitive games. Over the protoplasmic bridge there also came the once lifesaving necessity for ancestral hunting, trapping, and snaring of animals, alone or with the tamed puppy of the wolf, the dog. Over the protoplasmic bridge there came the loyalties, cooperation, and sympathies, all of which had survival value in the family and the tribe. Throughout the vicissitudes of man all that came over the protoplasmic bridge from the apelike ancestors to the present day would seem to have had survival value at some stage in man's evolution.

Thus the parent and the teacher have no problem in establishing the emotions of fear, anger, love, and hate in the child. These came over the protoplasmic bridge. The problem of the parent and the teacher is to place patterns in the matrix of the child while the phylogenetic wild animal is playing and fighting and courting and growing. It is while the child is still a wild animal and there is only a prospect of his becoming a civilized human being that the parent and the teacher must etch the way.

Physical Factors That Govern Mental Processes

Life, normal and pathological, is a function of protoplasm, and education is a special process of changing protoplasm. Protoplasm is a dynamic not a static system. The protoplasm of a plant is identical in principle, though not in pattern, with the protoplasm that executes the heartbeat in man, that executes the movements of the football player, that sings a song, that reproduces offspring, that executes an emotion, that fabricates fever, that is altered by shock and injury, that is attacked by infection, or that has its action exalted or depressed or suspended by anesthetics, narcotics, and stimulants. It is the same protoplasm upon which the educator etches the action patterns of learning and discipline; it is the same protoplasm that is built up by a properly balanced diet and by a proper balance between work and play, between activity and sleep, by the contributions of normal ductless glands, the hypophysis, the thyroid and adrenal glands, the gonads, the pancreas, and the liver. Each of these glands fabricates and throws into the blood stream specific molecules, and from the blood stream upon protoplasm everywhere are showered like drops of rain on the green fields countless millions of organic molecules, each organ and each tissue appropriating what it needs of those specific molecules required for its growth and activity until finally the protoplasm grows old and breaks down in death. Thus it is that on this swiftly moving protoplasmic film there are etched the patterns of life. The parents etch behavior, the teachers etch education, the church etches religion, and all the other good and evil patterns of parents, teachers, and playmates as well as those of the web of life—the radio, the movie, the newspaper—are etched upon this film of protoplasm of youth.

From this standpoint we can understand that the behavior—that is, the action patterns—of each individual changes with each moment of conscious life. We can see that the total number and kinds of action patterns contained in the matrix of each individual constitute his training, his judgment, his tolerance or intolerance, and his ability or inability to adjust himself to a complicated environment, since every action pattern that has been laid down effectively remains forever as a part of the equipment of the individual.

In but a limited mass of the brain are laid down the commanding action patterns of a dictator. So delicately poised are the component parts of these master tissues that were one to anatomize them and place them under the microscope nothing would be seen. The electric flash that releases empires of energy is the power of this mechanism. The master tissue of the brain of the leader is the trigger action that stimulates the brains of millions of his followers, since, just as energy in the brain passing down nerves "fires" countless muscle cells in the body to action, so the brain of the leader, be he a ruthless tyrant or a great benefactor, "fires" the brains of his followers.

How does the brain of a great leader cause such reaction in his followers? The great leader creates in the brains of his followers action patterns identical with his own action patterns. In this way only can the action patterns of the great leader activate those of his followers at his will. This is the method of propaganda of all kinds. The best example is that seen in religious organization, where action patterns, whether relating to a supreme being, greater or lesser gods, prophets, holy persons, medicine men, superstitions or fetishes, are placed in the minds of little children, where they obtain possession of the final common path and there remain until, in turn, the process is repeated generation after generation. Thus is it that political, religious, and scholastic leaders, long after their death, remain as leaders in the minds of their followers.

In civilized life the most difficult task is to overcome the inherited action patterns etched by phylogeny. Our ancestors were beset by innumerable dangers. Great animals attacked homeless man, who lacked shelter as well as the protection of weapons. With naked body and naked hands he met the attack of his enemies. His chance for survival rested in quick action for himself alone and, if possible, for his family. This tormented ancestor of ours survived by being an individualist, "a liar and a thief." Had he been kind and gentle, trusting and philosophical, instead of being fierce in fight, swift in flight, a convincing liar, a successful thief, and a sly strategist, we might not exist today.

The great primitive virtues—fighting, stealing, lying, the means by which man's early existence was made possible—theoretically are not now required. It is only in the fierce struggle among nomadic people in the desert or among the primitive people that these traits have survival value.

In Africa today native man lives as do the wild and powerful animals. To secure his survival he makes use of every animal sense he possesses. He bands with his companions to spear the lion that carries off and crunches the bones of his fellow. He tricks the great elephant and rhinoceros into pits. He lives as unprotected a life as any of his fellow animals. Endowed with a thinking brain, but with eyes unadapted to penetrating the darkness, feet less fleet, ears less acutely attuned to sound, and a sense of smell less sensitive than that of the animals about him, native man, toothless compared with his enemies, multiplying by a slower process and burdened for many years with his helpless young, lives in the midst of his cutthroat enemies. His only superiority is a brain in which his stern environment has laid down a greater number of action patterns than in the brain of his fellow animals. Man, when in the role of a hunting animal, like man in war, must be elusive, resourceful, adaptive, deceitful, brave, and persistent. Through the action patterns handed on from parent to offspring from one generation to another, native man makes use of fire, the club, the spear, and the simple means by which he is able to enslave animals, making them labor for him. He steals from them the milk to which, by abstract law, their own young are entitled. He slays the animals that trust him and eats their flesh.

These are facts, not fancy. They do not belong to ancient time. They form our world today. Not only does our own so-called "Christian" civilization demand furs of trapped animals, plumage of birds, but today not alone in the jungles of Africa does the relentless struggle between naked man and beast exist, for our civilized world is rocked by the greed of individualistic civilized man.

In some religions such traits are called "original sin," but at the time of the founding of such religions little was known of the imperfect record of man's ascent along a crimson trail. The founders of various religions were usually solitary individuals. None was an exponent of the science of his day. They were enthusiastic and willing to meet the battle of life with naked hands. In the jungle they would not have survived. The concept of "original sin" is the inheritance from the days of struggle of the individual for himself.

The present-day development of science and invention and of the wide control over the forces of nature by which man has taken legs of steel and wings for flight has allowed solitary man to be succeeded by collective man. The action patterns laid down in the brain of children today by parents, teachers, and preachers are of truth and honesty, unselfishness, industry, fairness, and generosity. With such patterns of action, together with a trained mind and a store of knowledge, skilled hands and a maze of tools, and control over the forces of nature, what better equipment could man have for survival than cooperation?

The shoemaker consecrates his talents to making shoes only because he has knowledge of the common honesty of his fellow man, for he knows that in exchange for his shoes the tailor will give him a coat. Thus present-day man has for his background a community action pattern. This standardized form, this community thinking, this common action pattern is the profitable way for man in his present estate. The individualized jungle brain is today antisocial. Civilization means cooperation.

Let us see how well we can interpret modern-day action patterns. The average child begins as a prototype of his wild ancestor. He is "a liar and a thief" and an individualist. He is governed by his phylogeny. Later, as innumerable action patterns are implanted by the parents, the teachers, and friends and as, in his ontogeny, intelligent action patterns of his more recent ancestors become facilitated and predominate over the phylogenetic action patterns of his ancient ancestors, the child becomes cooperative and so progressively gregarious that in school and college he possesses the herd instinct and can hardly be prevailed upon to be different from his fellows, even to the slightest detail of dress, manners, or opinion. At this period the occasional boy or girl who stands out obstinately as an individualist invites group opposition, since the student body possesses the collective spirit.

In later life the man who deplores the herd opinion, the standardized way of living, be he scholar or politician, libertine or outlaw, scientist or religious fanatic, prefers a life of contention to a life of accord, and these individualists, although they differ violently from their rivals in independent philosophy, often soar to great heights. These individuals may become great successes or great failures. Chance mutation perhaps came their way.

It was not so many years ago that man lived by piracy, stole his neighbor's pastures, and seized his enemies' wives. We might as well criticize the hunger and thirst that sent the lion forth on his depredations as criticize such a struggling ancestor of long ago. The critics of our forebears judge them as of today. One might as properly criticize them for not having a university degree.

Obviously morals and behavior are the creatures of the times, not the creators of the times. Mathematics and physics and the forces of gravitation have the same "morals" today as in ancient times, but not history, literature, geography, and religion. These, like morals, change with the times.

26. THE INFLUENCE OF CLIMATE UPON MAN

Two basic biological principles have limited the evolution of man in the tropics. The first principle is Berthelot's law. Because of the operation of this law, protoplasm, like the nitroexplosives, is detonated at a fixed temperature level; therefore it is the sensitive nitro group in protoplasm that limits the temperature in warm-blooded animals. It would follow that the human being who evolved in the tropics, with its intense external heat, would be limited to a smaller brain, a smaller thyroid gland and blood volume than the human being who became adapted to the colder temperatures. As a corollary, the average basal metabolism of man of the tropics is lower than that of man of the temperate zones, and the basal metabolism of man of the temperate zones is lower than the basal metabolism of man of the arctic.

The second biological principle that has interfered with the evolution of the thinking brain to higher levels in man in the tropics as compared with man in the temperate zones is the principle of struggle and survival. The thinking brain, like other organs, owes its size solely to its survival value. In the tropics, where food, shelter, and clothing are at the lowest requirement for man, the thinking brain has the lowest survival value, in contrast to the highest survival value in the temperate zones, where there is an abundance of food in the summer that the thinking brain of man must cultivate and store against the lifeless winter.

What about man in the arctic? In the arctic, with the extreme cold, evolution centered upon protection of the warm-blooded state by lessening the surface area through an evolution of a short thick-set body in contrast to the usual tall, lithe, fat-free native of Africa. The brain of the Eskimo is relatively larger than any other human brain.

Is the Eskimo, therefore, the most intelligent of human beings? A large brain is required in man in the arctic for the same reason that a large brain is required in the warm-blooded whale in the arctic, in the warm-blooded walrus, the warm-blooded seal, the warm-blooded caribou, and the Shetland pony—as a defense, through high oxidation, to maintain the warm-blooded state. On the biological principle that Dr. Quiring and I established, that 1 gram of brain is required to execute 12,115 small calories in 24 hours, the Eskimo, despite his igloo, despite the furs he wears, is in need of an intense fire, that is, a high metabolism burning within his own protoplasm to maintain his body temperature at 98.6°F.

The large brain of the Eskimo can be accounted for on the basis of the higher requirement for the maintenance of the warm-blooded state in the cold arctic. What of the thinking part of the brain of the Eskimo? The size of the thinking part of the brain is in ratio to its survival value. In the Eskimo the survival value of the thinking brain is higher than in the Negro of the tropics because the Eskimo must control fire, clothe himself, build igloos, construct kayaks, and fashion tools by which to hunt and fish under more difficult conditions than the Negro in the tropics. The thinking brain of the Eskimo, therefore, would have greater survival value than that of the Negro in the tropics. But the survival value of the thinking brain of the Eskimo is not so high as the survival value of the thinking brain of civilized man in the temperate zones, where food, clothing, and shelter must be man-made in contrast to the natural food in the flesh of the arctic and the fruit of the tropics.

Thus it may be seen that the extremes of cold in the arctic and of heat in the tropics have profoundly influenced the evolution of the brain, the thyroid gland, and the blood volume of man. The gift of a large brain and a large thyroid gland to man of the temperate zones provided the background of constant energy at a high level for mastering the conditions of survival under contrasting seasons of plenty and of dearth and seasons of warmth and of cold and storm. These extreme variables in climate present conditions for the highest survival value of the thinking part of the brain as well as of the energy part of the brain and also for a thyroid gland sufficiently large to maintain a high level of constant oxidation. Has evolution created as large a thinking brain, as large a thyroid gland, celiac ganglia and plexuses, and as large a blood volume as the limits of safety will permit? In other words, can civilization advance indefinitely?

The answer is now appearing in the diseases peculiar to civilized man. The brain-thyroid axis is destroying many of our most brilliant men and women in a pathologic physiology of oxidation called "exophthalmic goiter," in which death is due to what is called "heatstroke" and also in neurocirculatory asthenia, or soldier's heart. As for the great driving brain, its limit is indicated by the existence of 606,394 hospital beds for mental and nervous diseases in the United States. The axis partner of the brain that maintains the negative potential, the faithful heart, is reaching its ceiling of possibilities, as shown by the fact that in 1938 50 cents out of every dollar paid in death claims by the insurance companies of the United States and Canada was for deaths from diseases due to overwork of the heart and the vascular system, such as hypertension, coronary disease, and the cardiorenal syndrome. The ceiling limiting the further advance of civilized man's possibilities is seen also in the increasing incidence of peptic ulcer, indigestion, Raynaud's disease, neurasthenia, and psychoses.

We can see now why these diseases are peculiar to civilized man and why neither the native of the tropics nor the native of the arctic can acquire our civilization or, as a corollary, the diseases peculiar to civilized man. Modern civilized man and the diseases of civilized man could have developed only in the temperate zone.

The fact of the influence of climate on civilization, so ably set forth by Ellsworth Huntington, Clarence A. Mills, and William F. Petersen,[1] has afforded us the foundation that we required to offer a simple explanation in physics of the breakdown of the brain, the positive generator of energy in the bipolar mechanism, and of the heart and arterial tree, the negative generator in this system.

As stated, overwork of the controller of oxidation, namely, the thyroid gland, is expressed by simple goiter and by exophthalmic goiter. Owing to the ceiling of heat-stroke, the load carried by the brain, the heart, the arteries, and the thyroid gland is lighter in the tropics than in the north temperate zone. In the tropics there are few, if any, diseases of overwork of the brain, the heart, and the blood vessels or of the thyroid gland. In the temperate zone, where there are variable temperature, great humidity, and wind and storm, the load on the energy-controlling system—the brain, the thyroid gland, the heart and arteries, and the sympathetic system—becomes too great, and the failure in adaptation we call disease.

Mills shows[2] that fluctuation in climatic averages brings changes in the basic factors of human dynamics. He shows that with the " . . . marked changes in the mean temperature level that have taken place both in the distant geologic past, with its alternating ice and warm ages and with the human past since the last ice age . . . with those centuries of warmth man receded markedly in stature and matured several years later, tending more closely toward

[1] Huntington, Ellsworth, "Civilization and Climate," Yale University Press, 1924.

Mills, Clarence A., "Medical Climatology," Charles C. Thomas, Publisher, Springfield, Illinois, 1939.

Petersen, William F., "The Patient and the Weather," Edward Bros., Inc., Ann Arbor, Michigan, 1938.

[2] "Medical Climatology," Charles C. Thomas, Publisher, Springfield, Illinois.

present tropical standards." He calls attention to the fact that " . . . people living in a climate where body heat loss can be readily accomplished have a higher internal combustion level, grow more rapidly, mature earlier, reach a larger stature, are more resistant to infectious disease, and have a greater abundance of both physical and mental energy than do those living under conditions of moist warmth. Health in temperate-zone countries has thus a more dynamic quality than in tropical warmth. But with this push and vigor goes a much greater rate of body breakdown from the more stressful existence."

Three factors make up climate: the variables of temperature, the variables of humidity, and the variables of storm. The zone of greatest variation in temperature is seen not in the tropics or in the arctic but in the temperate zone.

Temperature alone has an influence on the size of the brain, the size of the thyroid gland, the size of the heart, and the volume of blood of all warm-blooded animals. Temperature has no influence upon the size of the adrenal glands. Dr. Quiring, by applying the power formula, has exhibited graphically the powerful influence of cold itself upon the brain, the thyroid gland, and the heart.

When we recall that 75 per cent of the food intake in warm-blooded animals is required to maintain the warm-blooded state and take into consideration the abrupt changes in temperature and the variable factors in climate seen in the temperate zone, it is clear that the factor that raised and maintained the high-energy state of civilized man is no more mysterious than the fact that a larger heating plant is required in winter than in summer to maintain adequate temperature in a house. To the simple brain-thyroid formula and to the variables of climate and storm, civilized man owes the basis for what he is.

Let us now consider the variables that affect the heating plant of man.

If the heating plant of man burns too intensely his protoplasm will disintegrate in heatstroke, and if it burns so low that the temperature falls much below the normal his protoplasm will be killed by freezing, since, according to van't Hoff's law, each degree centigrade of temperature change is followed by a corresponding 10 per cent rise or fall in chemical, hence electric, activity. Therefore, it is between these two dead lines that the brain, the thyroid gland, and the heart of man, like a bird balancing itself on a wire during a storm, maintain their equilibrium.

In the preceding pages we have called attention to the fact that evolution took from man the hairy covering of the ape. A rabbit loses heat 35 per cent faster when shaved of its normal furry covering. Therefore, man, shorn of the furry covering of his arboreal ancestor, could sustain greater activity without succumbing to heatstroke than the ape.

Evolution has also endowed man with the greatest surface area of any other animal of his size. Thus the long legs and arms of man, the hands and long fingers permit a relatively larger heating mechanism—brain and thyroid gland—for man than for any other warm-blooded land animal of comparable size without death from heatstroke.

In addition, evolution endowed man not only with the power to modify his internal heat through sweating but also with a vasomotor mechanism that transfers blood to the surface for cooling. The horse and man are the only animals that sweat all over.

These mechanisms evolved for adaptation to internal heat have enabled man, with his larger-than-ape brain and thyroid gland, to survive the stagnant warmth of the tropics as well as the cold of the ice age and to make alternating adaptation to the hot summer and the cold winter of the north temperate zone.

The thinking brain and the versatile hand constitute the greatest gift of evolution to man, for the brain and the hand gave to man the substitute for hair, fur, fat, and blubber in the form of clothing, shelter, and the use of fire, enabling him to live without freezing.

In the winter the internal heating plant of man is stepped up. Recall the high muscle tone in winter in contrast to the inertia and diminished muscle tone in summer. Recall the thyroid-gland enlargement in winter and its demobilization in summer. Recall the high incidence of deaths from cardiovascular disease in winter and the fewer number in summer. Recall the aggravation and higher incidence of diabetes in winter than in summer and the aggravation and the higher incidence of death from exophthalmic goiter in the autumn and winter compared with that of spring and summer.

Thus far in our analysis we have attributed only to the thinking brain and the thyroid gland the task of providing sufficient external supplementary heat to man in winter to prevent death from freezing and sufficient loss of heat in summer to prevent death from heatstroke.

The mere maintenance of the warm-blooded state taxes man beyond all other energy requirements, because 75 per cent of the food intake of man is required to maintain his warm-blooded state. But heat and cold are two of the factors that make up variability in climate to which man must make adaptation.

Another factor to which man must make adaptation is humidity. When there is an increase in the humidity great suffering from depression and heat ensues. Although being naked increases man's heat loss by 35 per cent, heat loss is in direct ratio to the amount of moisture that the air will absorb. Therefore, the absorption of heat from the skin of man is diminished in proportion to the amount of water vapor in the air.

In a steam room a maximum of depression is experienced, because the skin loses little heat, and the rate of heat produced by the large brain, the large thyroid gland, the large heart, and the large blood volume of civilized man is so great that heatstroke becomes imminent.

Consider how rapidly the temperature of man rises in a bath which is higher than body temperature. Civilized man is so highly energized that unless he can lose heat at a high rate his temperature will rise to the critical level of heatstroke.

The studies of the basal metabolic rate of Eskimos, made by Dr. Quiring, Dr. Thomas Melling, and me, showed the Eskimos to have a basal rate about 22 per cent higher than civilized man in Cleveland, Ohio. In the tropics Francis Benedict found the metabolism lower than that found in man of the temperate zone. These values express the size of the brain, the thyroid gland, the heart and blood volume as an adaptation to external temperature. Thus the cycles of humidity in the north temperate zone interfere vitally with the needed loss of heat to the surrounding air, hence to the tendency to heat prostration and death from heatstroke.

In addition to the variables in temperature and the variables in humidity, a third factor has an important bearing on the energy factors of man. This factor is the variability of the barometric pressure.

The influence of oxygen tension on metabolism is so important that in metabolic observations it is necessary, among other conditions, to have barometric readings, and the influence of barometric changes is expressed in the metabolism. Thus we can now understand why a rapidly falling barometer brings universal depression to a population.

In the preceding pages we reported our studies of the varying influence of oxygen tension upon the brain and the thyroid gland in fish. In our studies we collected many fish and reptiles in habitats of variable oxygen tension, such as the still tropical waters, the shallow shoals of sandy beaches, bubbling with air and oxygen, and the cold arctic sea with its rich supply of oxygen. What did we find?

We found that the gameness of the fish—that is, its energy pattern, the brain, and the thyroid gland—corresponded with the concentration of oxygen of its natural habitat.

In the still, landlocked water in the tropics, fish are slow and inactive. Oxygen tension in the water is low. In the cold, bubbling water of the northern mountain streams, where there is a rich mixture of oxygen, game fish are found. A perfect example is seen in the case of the sting ray, which is found in the richly oxygenated waters of the sandy beaches. The brain in the cold-blooded sting ray approaches the size of the brain in warm-blooded land animals of equal weight.

When the barometer falls, the oxygen pressure is diminished, and, accordingly, the energy of the body is diminished. The falling barometer and consequent rarefied oxygen concentration exert an effect on civilized man comparable to taking a trout from the high concentration of oxygen found in a cold, bubbling mountain stream and placing it in a warm, stagnant pool. A drop in barometric pressure of 1 inch exerts an effect comparable to an altitude of 968 feet.

What would happen to an advanced case of heart disease, an incurable case of diabetes, a serious case of exophthalmic goiter, and a case of essential hypertension if these cases were transferred to Pikes Peak? A death toll all the way!

Thus it is clear that the depressing influence of the falling barometric pressure in a storm is due to the attenuation of oxygen, just as, in ascending a mountain, the loss of energy and the breathlessness are due to the attentuation of oxygen. The three factors of climate, warmer temperature, humidity, and low oxygen tension usually occur at the same time, or at least overlap each other.

Having interpreted our viewpoint of the implications of the variables of climate upon the energy-controlling system of civilized man as they bear upon the diseases peculiar to him, we quote the following statements from "Health and

Disease as Influenced by Climatic Environment," by C. A. Mills:[1]

"Diabetes mortality is related to climatic stimulation, the disease becoming a major medical problem only in those regions having invigorating climates.

"In North America its relative importance as a cause of death is greatest in the region of Iowa with the disease in the storm zone of our Northern States being much more prevalent and troublesome than in the South.

"Diabetes patients from the North almost invariably find their disease less troublesome and easier of control when they migrate to tropical or subtropical climates.

"Negroes show most strikingly this increasing severity of the disease toward the North, their death rate from it rising even more markedly than does that for the white population.

"In Europe too and in Australia this relation of diabetes mortality to climatic drive is just as definite as in North America.

"Errors in diagnosis cannot be responsible for these observed differences, for highest rates are not always found where medical practice is supposed to be best. With diabetes, it cannot be the level of sugar consumption. Rather would it seem to be the level of bodily activity demanded of the population in these areas.

. . . .

"There can be little doubt that human blood pressure and stress on the circulatory mechanism are lower in tropical regions than in stormy temperate areas. People going from west central Europe or central North America to the tropics nearly always suffer a marked fall in blood pressure within a year or two, even though no debilitating disease or infection has occurred.

. . . .

[1] *International Clinics*, Vol. 2, pp. 143–167, 1936.

"Most important for cardiac load, however, is the fact that body *efficiency* declines as the combustion rate increases. During winter cold a given amount of physical work costs more in terms of oxygen consumed and heat and energy expended than it does in summer heat. A hyperthyroid person pays a higher metabolic price for the execution of a piece of work than does a normal person. Tropical natives are far more *efficient* physically than are the energetic northerners, remembering that *efficiency* refers to the energy cost per unit of work accomplished. Differences in energy cost may be quite striking and play an important part in making heart failure so much more common during the colder portions of the year. These findings on the metabolic cost of work have failed to receive the attention they deserve in regard to the growing problems of the heart. People not only feel more energetic in cold weather and move around more quickly to keep warm, but each move they make carries a higher metabolic and heart work cost.

"Herein lies the main reason why cardiac failure is so much more common in winter than in summer.

"Of particular interest in this connection was the widespread fall in blood pressure and oxygen consumption level that took place during the severe and prolonged heat afflicting the Middle West in the summer of 1934. In a goodly proportion of the population blood pressures dropped about 30 per cent from whatever level had previously obtained. Relief from cardiac symptoms was especially marked in hypertension cases as the general body metabolism fell to low levels. This experiment on climatic effects, staged by Nature, gave striking substantiation to our ideas previously stated, and indicated in no uncertain way the shift toward tropical metabolism that can be brought about in a highly energetic population mass by only a few weeks of severe warmth."

William F. Petersen, in his study of "The Patient and the Weather,"[1] which we quote (reproductions of maps come from Volume I entitled "The Foot Print of Asclepius"), refers to ulcer of the stomach and the duodenum

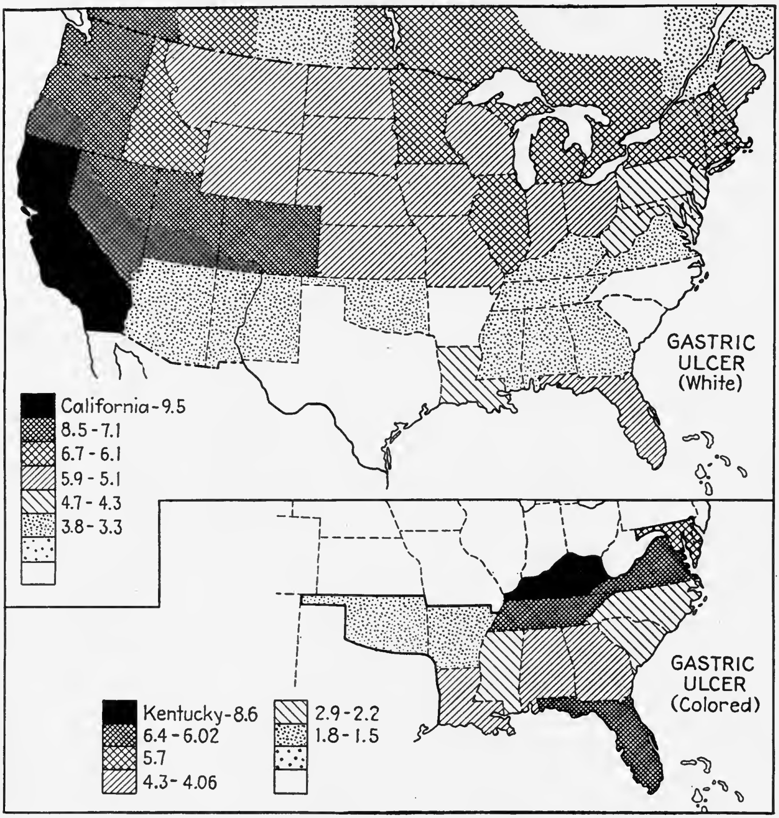


FIG. 38.—Gastric ulcer (American mortality). (*Reproduced from William F. Petersen, M.D., "The Patient and the Weather."*)

as a "distinctly northern disease," which rarely occurs in the tropics. He points out that certain types of individuals, the autonomically more unstable ones, are predisposed to ulcer and that the ulcer will develop more often if such individuals live in the region of storm tracks.

Referring to the mortality map revealing the high rates of

[1] "The Patient and the Weather," Edwards Bros., Inc., Ann Arbor, Michigan, 1938.

gastric ulcer on the West coast, Petersen says, "The entire west coast, including California as a focal state, reveals high rates, this time including Nevada, Utah, and Colorado.

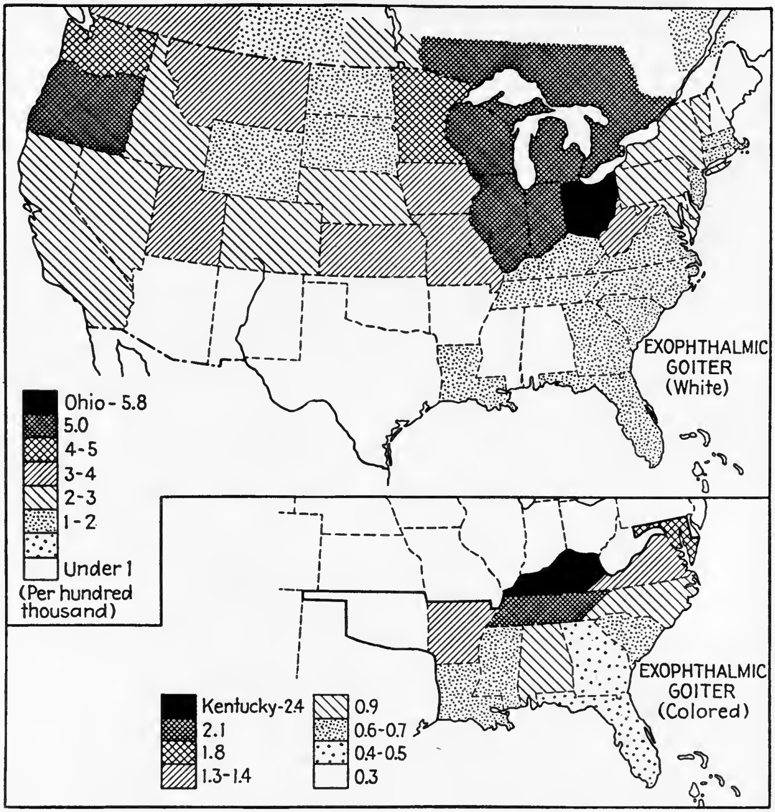


FIG. 39.—Exophthalmic goiter during 1920–1930 (American mortality). (*Reproduced from William F. Petersen, M.D., "The Patient and the Weather."*)

The South is relatively free but does reveal a light increase in Louisiana and Florida, regions that are somewhat more unstable. In the North the Negro dies more often from ulcer of the stomach, though the environment of Florida, as we observe for the white race, seems somewhat more precarious for the colored individual, too.

"Newfoundland, out of the region of the major storm tracks, has a mortality of only 1.8, but Hawaii is relatively high, with 7.2."

Referring to the mortality map showing the distribution of *exophthalmic goiter* during the decade 1920–1930, Petersen states, "This is so characteristic that it deserves emphasis. Region 1 has Oregon as the focal point, then lower rates occur in the dry highlands of the Northwest but along the southern fringe of the cyclonic tracks (Colorado, Kansas, Missouri) an accentuation occurs until we come to the region of the Lakes (2) and now we find Ohio as the focal point. The high rates actually begin with Minnesota, Ontario, Wisconsin, and Illinois. Again the northeastern states are spared, and New Hampshire and Maine show a low mortality.

"And the Negro, as he moves north into the turbulent atmosphere, becomes ill with exophthalmic goiter.

"In Newfoundland exophthalmic goiter is practically non-existent, and in Hawaii, too, the mortality is only 0.8 for 100,000 inhabitants."

Of *cardio-vascular-renal disease*, Petersen says, "Heart disease leads as the cause of death. It is estimated that there are some two million people in the United States who are so afflicted. But unfortunately, our statistical material is by no means satisfactory. . . . When we examine the map for deaths from heart disease for a single year we find the storm tracks clearly outlined. New Hampshire is high with a rate of 323 (per 100,000) approximately three times as many deaths from heart disease as is shown for Arkansas. The statistician examining this distribution will be interested primarily in observing that the rate is a reflection of the old-age grouping."

It is interesting to contrast Petersen's maps of the incidence of the various diseases of civilized man with his map showing the distribution of variability of temperature for 1925.

Of *arteriosclerosis instability*, Petersen says, "There can be no question but that undue meteorological disturbances, with their reflection in tissue stimulation (lessening of blood pressure) will often be followed by overcompensation,

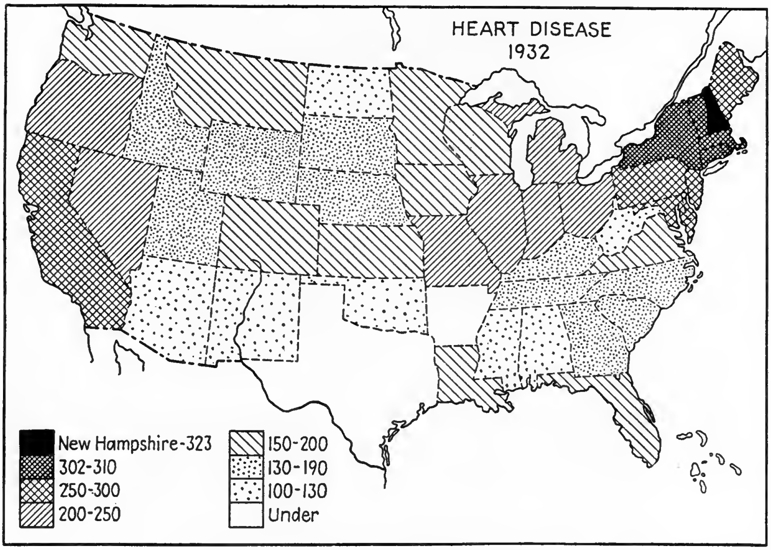


Fig. 40.—Death from heart disease [American mortality, 1932 (per 100,000 population)]. (*From J. S. Whitney, "Heart Disease Mortality Statistics," American Heart Association*, 1934. *Reproduced from William F. Petersen. M.D., "The Patient and the Weather."*)

with spasm, and with increased blood pressure. In the unstable person this may ultimately, along with other factors, lead to the hypertension that we see in young individuals. In scientific terminology we discuss the underlying change as an arteriolosclerosis and speak clinically of malignant hypertension." Petersen's map shows the incidence of hypertension found in the United States draft.

In the foregoing discussion of the relation of climate to disease, it will be noted that the diseases mentioned are peculiar to civilized man. In the preceding pages we have shown that the highest development of civilized man appeared in the temperate zone, where the conditions were most favorable to the highest development of the brain, the thyroid gland, the heart and blood volume and, in consequence, to the highest degree of physical and mental activity.

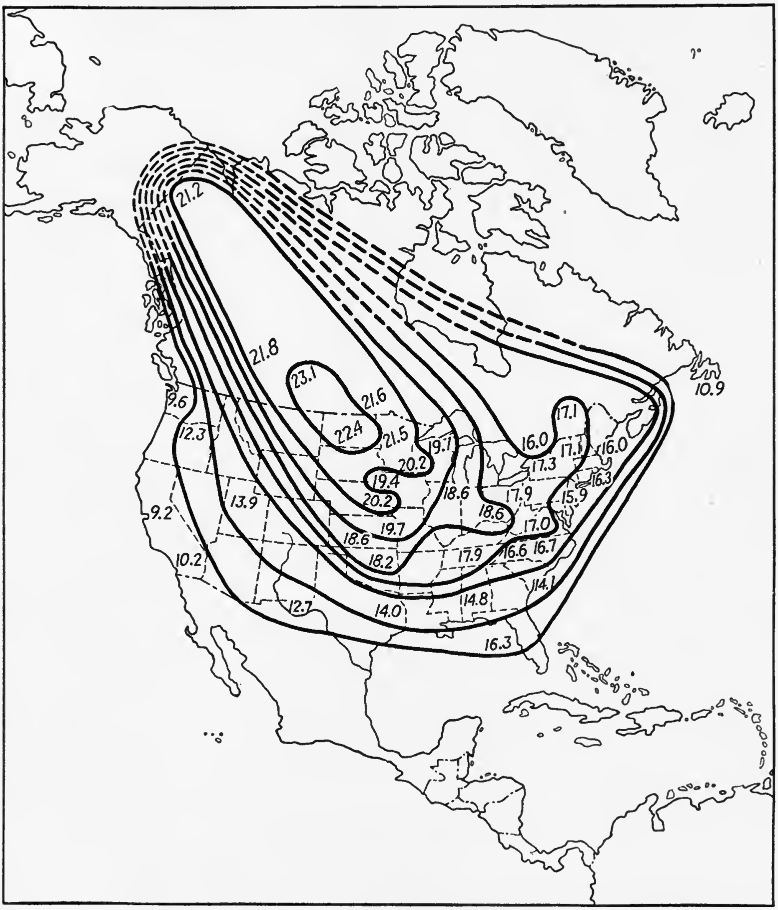


Fig. 41.—Temperature variability or storminess over North America. (*Base map courtesy of Denoyer-Geppart Company, Chicago. Reproduced from Clarence A. Mills, Ph.D., M.D., "Medical Climatology."*)

High physical and mental activity, as will be shown later, is the common basis of both civilization and the diseases that are peculiar to civilized man. They are tied to each other by the common basis of high energy. In terms of milleniums of time, both civilization and such diseases of civilization as nervous and mental disease, cardiovascular disease—essential hypertension, coronary

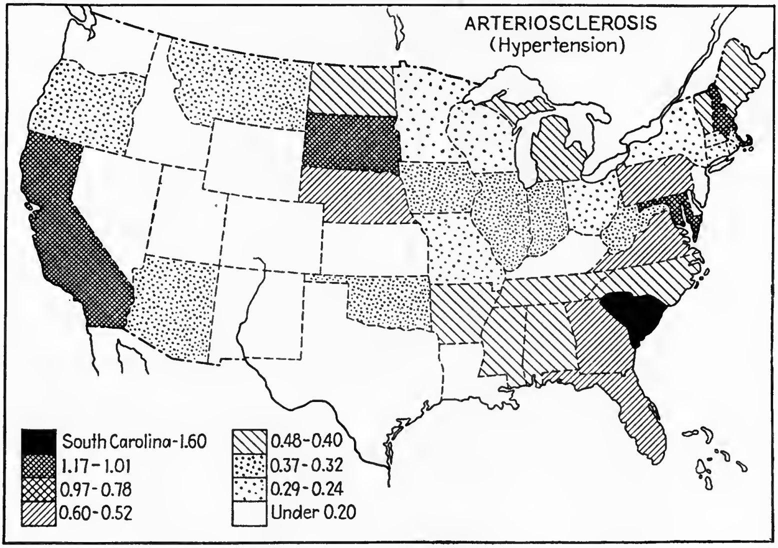


FIG. 42.—Arteriosclerosis (hypertension). United States draft. (*Reproduced from William F. Petersen, M.D., "The Patient and the Weather."*)

disease, and the cardiorenal syndrome—exophthalmic goiter, neurocirculatory asthenia, diabetes, peptic ulcer, and Raynaud's disease may be regarded as due to mutations in certain units of the energy-controlling system.

27. THE HAZARDS OF LIFE

Mutation

As described by De Vries, mutation consists of a variation in the size of the organs or tissues from parent to offspring due to changes in the chromosomal constituents of the germ cells. Mutation often modifies individual man and animals. Natural selection, according to De Vries, incorporates and stabilizes the favorable mutations into the permanent equipment of the species.

Mutation is most common in hybrids and least common in line breeding, as seen in herd animals. In civilized man and the thoroughbred horse out-crossbreeding is common. We should therefore expect to find the highest incidence of mutation in civilized man and in the thoroughbred horse.

The instabilities of civilized man, in contrast to native man, appear to indicate that the civilized state is so new that inheritance exhibits striking mutations. In the operation of the bipolar mechanism in both the thoroughbred horse and in civilized man, mutation of certain energy-controlling organs may be so excessive as to defeat normal function and become a pathologic physiology and even a disease.

Influence of Mutations on Behavior as Exemplified by a Thoroughbred Horse and a Gangster

In Chap. 17 we saw how, through breeding by man, such mutations in the brain, the heart, and the adrenal-sympathetic system have occurred as to render predictable and unpredictable certain behavior characteristics. Among the many thoroughbred horses studied we cited the example of Brown Eyes, a thoroughbred of great promise that, due to mutation, was a failure in behavior.

As stated above, mutation in animals appears most frequently and in the greatest extremes in those animals that are most highly hybridized. Therefore, the greatest incidence of mutations is found in civilized man and in the thoroughbred horse. Mutations are rarely seen in line-bred animals in the wild state. In the case of civilized man the principle of natural selection is suspended. In the case of the thoroughbred horse the principle of natural selection is also suspended, not by the horse but by the mind of man.

In civilized man there is seen the extreme development of the thinking brain, the thyroid gland, and the manipulative hand. Through mutation the mechanism that has empowered man to develop energy outside himself has evolved to the highest degree, as seen by the ceiling of energy diseases that interferes with the further progress of civilized man. Since civilized man depends on animals and machines to do much of his work, the mechanism of man for outburst energy has diminished, whereas the thoroughbred horse, in order to win a race, has been evolved by man for the highest degree of outburst energy. Thus these two most highly hybridized animals, civilized man and the thoroughbred horse, have been developed to a high degree but toward opposite energy principles, the thoroughbred horse in the equipment for the wild state, civilized man in the equipment for the machine age of the civilized state.

Mutations are usually most striking in the organs that have the greatest significance to the animal. In man the organs of highest significance are the thinking brain and the central nervous system. In the thoroughbred horse the organs of highest significance are the brain, the heart, and the adrenal-sympathetic system. In the case of man the mutation of the brain is shown by the fact that there are over half a million hospital beds for nervous and mental diseases in the United States alone.

Brown Eyes, a thoroughbred horse, was as well bred as the famous racing stallion Equipoise. Brown Eyes had been trained in one of the outstanding racing stables in Kentucky. All that care and skill in training could bestow had been lavished on Brown Eyes. This thoroughbred horse was so abnormally energized and possessed such an excitable temperament that it was impossible for her to be started in a race. Through this fact alone we were able to collect the energy-controlling organs.

The disappointing behavior of Brown Eyes was due to a mutation in the size of the adrenal glands. These glands were so abnormally large and the supply of the powerful adrenalin that an animal must possess to have outburst energy was so excessive that this animal failed through mutation of the adrenal glands. Brown Eyes had the largest adrenal glands found in 231 horses dissected by us. Let us now turn to an analogy in the human race.

A gangster twenty-five years of age, convicted of murder, had been as impossible to control as was Brown Eyes to train. The home, the school, the church, the law, and the customs of civilization itself were as powerless to make this abnormal man conform to the conditions of civilized life as were the breeding, the skill, and the training of the famous racing stable to make the thoroughbred Brown Eyes conform to the conditions of a race.

The adrenal glands of this gangster were twice the weight of the average normal human adrenal glands. The pathologic behavior in both the thoroughbred horse and the gangster would seem to be due to a mutation in the size of the adrenal glands.

In the case cited of mutation in the horse we have other examples; in the case of the gangster we have no other example. A single fact may depend only on chance and may not be a forerunner of a law. Therefore, standing alone, this case offers only a suggestion.

Equipoise achieved the greatest racing success of his time; Brown Eyes was the greatest failure. In civilized life the Scotch laborer was a normal member of society; the gangster was a failure.

Type of man or horse	Body weight, pounds	Brain weight, grams	Thyroid weight, grams	Adrenal weight, grams	Heart weight, grams
Scotch laborer	110	1,480	48.47	14.96	325
Gangster	130	1,310	31.00	24.65	308
Equipoise	1,149.95	808.5	33.40	46.62	4,455
Brown Eyes	1,204.52	650.	26.45	60.78	4,435

In civilized man, and particularly in the most advanced members of the civilized group, the high energy drive of the brain-heart-thyroid-adrenal-celiac-ganglion-sympathetic system endows civilized man not only with his high degree of intelligence, his great ability for sustained work, his valor, his inventiveness, his control over plants and animals, and his setting up of a complex civilized life but also with certain diseases.

The following discussion of the hazards of civilized man in infancy, childhood, adolescence, and adult life is presented solely in its biological aspect, for it would seem that heretofore the biological significance of these diseases peculiar only to civilized man has not been fully recognized.

At the time of fertilization of the ovum there exists probably the highest metabolism per unit of mass that ever appears in the life of the individual. The speed of growth of the fetus is unique. The source of the energy that controls this growth is identified by the increased size of the thyroid and adrenal glands of the mother due to the showering by these glands of growth-producing hormones upon the fetus. In addition, there is a very early marked development of the adrenal glands in the fetus itself.

Dr. Quiring, who has studied the subject extensively, reports that in the third month of fetal life the adrenal glands weigh 0.06 gram, giving a ratio of the adrenal weight to the body weight of the fetus of 1:238. At birth the weight of the adrenal glands is 8.6 grams, giving a ratio of the weight of the adrenal glands to the body weight of the infant of 1:384. In the adult the weight of the adrenal glands is approximately 11 grams, the ratio of the weight of the adrenal glands to the body weight of the adult being 1:5,000.

The thyroid gland in the fetus is smaller than the adrenal glands. Dr. Quiring states that whereas the adrenal glands weigh 8.6 grams at birth the thyroid gland weighs only 3.2 grams. This adrenal-thyroid relation becomes reversed sometime before the twenty-first year, when the thyroid gland weighs approximately 2½ times the weight of the adrenal glands.

In a comparative study of the thyroid and adrenal glands in 747 wild animals in which data regarding different age periods were available, Dr. Quiring and I found that the adrenal glands were from 24 to 450 per cent larger in their relation to the body weight in the infants than in the adults. In the human being the adrenal glands in the newborn are twenty-one times larger in their relation to the body weight than in the adult.

From the anatomical facts that during the third month of human fetal life the adrenal glands are twenty-one times larger in their relation to the weight of the fetus than are the adrenal glands in the adult in relation to the adult body weight and that even several months after birth the adrenal glands in relation to the weight of the infant are smaller than the adrenal glands in relation to the weight of the fetus, we must conclude that there is a unique factor during fetal life that is not present in adult life. The fact that the adrenal glands are relatively larger in the young child and in the adolescent than in the adult would also seem to indicate that some extraordinary activities are present during the first twenty-one years of life.

The brain-to-body-weight ratio in the infant and the young child is higher than the brain-to-body-weight ratio in the adult. In our studies in comparative anatomy the brain-to-body-weight ratio of the infant wild animals was from 91 to 630 per cent higher than the brain-to-body-weight ratio in adults of the same species: in juvenile wild animals the brain-to-body-weight ratio was from 6 to 221 per cent higher than the brain-to-body-weight ratio in the adults of the same species. In humans the brain-to-body-weight ratio of the newborn is 560 per cent higher than the brain-to-body-weight ratio in adults; in a child of ten years it is 250 per cent higher than in an adult; and in an adolescent of fifteen years it is 160 per cent higher. Thus the anatomical characteristic of the fetus, the infant, and the child is the relatively large size of the brain and the adrenal glands. This also is the formula of the fetus, the infant, and the juvenile wild animal.

The gift of evolution to man by which man has achieved his dominance in the world is the thyroid gland and the brain, with its large and infinitely delicate matrix, in which are written the action patterns that guide and govern him.

Not only is the brain of man characterized by the greater mass of recording matrix, but almost as significant, lying at the very basis of training and education, is the fact that in the case of the lower animals the available recording matrix has all or nearly all its recordable capacity filled with simple animal action patterns at the time of birth, and there is but a small amount of blank matrix upon which stimuli after birth may be recorded. This would appear to be the physical reason why animals can be trained and educated to but a limited degree. During human fetal life only the patterns of our wild ancestors are established in the matrix of the brain. None of the patterns of actions of man's civilized state is established in fetal life. In the process of procreation man and other animals differ fundamentally in the amount of recordable matrix that each brings from one generation to the next generation across the protoplasmic bridge. The bird comes over the protoplasmic bridge with almost all of its action patterns established in its governing matrix. The infant comes over the protoplasmic bridge with a blank matrix. This enables the infant, the child, and the adult to acquire action patterns from their environment.

In correlating the anatomical facts of the energy systems of the infant and the child with their behavior, we find that the infant and the child, like the young of all wild animals, are highly cephalized and adrenalized. The infant and the child show emotionalism and quick response to fevers. It is not enough to say that these phenomena occur because the individual is an infant or a child. We must conclude that the behavior of the infant and the child and the phenomena that they exhibit are due to a far greater development of the brain and adrenal glands than is present in the adult.

Through phylogeny—racial experience—the energy-controlling system is an inherited energy pattern. Evolution endowed the young of wild animals with as large a brain, thyroid gland, and adrenal glands as was possible for survival without heatstroke.

When a child has reached ten to twelve years of age, the adrenal glands and the thyroid gland approximate each other in weight. This changed relation in the size of the thyroid and adrenal glands is expressed in the behavior of the child. During this time the child is an energy machine, and, significantly, this period of childhood often points to the fact that the child is "father of the man." On the one hand, a child may be too highly energized, too incessantly active for his future safety. In that event, his physical powers should not be unduly developed in school lest in adult life he develop such diseases of civilized man as essential hypertension, coronary disease, or the cardiorenal syndrome.

On the other hand, a child may possess so high an equipment for mental work as to endanger his safety in another direction. Child prodigies should be restrained rather than stimulated. They should be trained to offset mental and emotional work by interests other than mental lest in adult life they develop hyperthyroidism, neurocirculatory asthenia, or nervous breakdown.

The Adolescent Pupil

In the adolescent pupil there is a crescendo of activity of the ductless glands expressing itself in a rapid growth of the body and the development of the organs of procreation.[1] Rapid growth is hard work, overwhelming the organism not only with the novelty and strangeness of the development of the procreative mechanism but also by the magic change in the entire anatomy as well as in the entire emotional state. The changes of senility are as nothing compared with the transformation enacted in adolescence. Fortunate it is that the process of adolescence is spread over several years. What if it occurred in a night!

Not only is the physical fact of this transformation a heavy load on the organism of the adolescent boy and girl but the dominating organs themselves, new to their tasks, may be in one instance too active, in another too inactive, thus adding to the overload of general growth and procreation growth the disturbance of organs and emotions gone wild. Therefore, in training the mind of the adolescent, the hard work of growth and the hard work of the fabrication of the mechanism of procreation as well as the hard work in the expression of the excessive emotion of this period should be taken into account in terms of competition for energy required in the process of training the mind.

Because the female has a greater need for sustained energy in her role of reproduction, the thyroid gland that controls the rate of oxidation and metabolism is larger relatively to the body weight in the girl than in the boy; therefore, as one might expect, the female is more subject to simple goiter and exophthalmic goiter during adolescence than the male.

[1] Crile, George, "The Phenomena of Life," W. W. Norton & Company, New York, 1935.

During adolescence the fighting side of the partnership is developed in the male, who becomes more muscular, likewise more aggressive, pugnacious, and individualistic.

The hazard of adolescence is an unequal development of the various ductless glands, the sympathetic system, and the brain. Such an outburst of growth activity may result in the skeletal muscles and the body as a whole being built up with such speed that there is less energy for other functions of the body. We see Nordic boys, especially, growing so rapidly that they become inattentive and fail in their lessons, although they may excel in athletics.

There is also the hazard of pathological habits that may result from the rapid sex differentiation that is taking place in the neutral boy or girl from ten to fourteen years old, a transformation that brings with it many strange feelings that may lead to the development of abnormal sex habits.

Then there is the adolescent girl who, lacking the development of the hormones estrin, gonadotropic pituitary hormone, and corporin, may, as a result, develop social and sexual indifference and become a recluse.

On the other hand, there is the hazard of such an outburst of activity of the ductless glands, especially the adrenal glands and the hypophysis, that obesity, hirsutism, striations, and tachycardia—the telltale symptoms of polyglandular disease—may develop. This disease occurs in the adolescent girl or the young woman.

We also see as another hazard in adolescence, during the abnormal activity of the energy system, disturbance of the pancreas that may result in diabetes.

The Superintellect

Through mutation, the occasional boy or girl exhibits an abnormal activity of the brain and an abnormal capacity for the acquiring of knowledge.

The superlative mind may carry danger to itself. There is little danger in the brain mechanism of the pupil who, by virtue of his capacity for continued intensive application, becomes the intellectual leader of his class. There may, however, be a defect in the training and education of the pupil with the super intellect in that he may not grasp the advantage of training and coordinating the wild man within him. Thus he may lack an introduction to the human passions and emotions that the average human possesses, missing the advantage of the commingling of civilized reactions in the fighting, playing, mating man. The drudge sometimes develops a deformed personality, or he develops his wild man out of season; but neither of these conditions is so vital as the state of the brilliant student with brain so abnormally keen that a high scholastic record is achieved without effort. In these brilliant personalities excessive brain activity may finally reach the physical state of a breakdown. In certain instances an early senescence occurs from which there is no recovery.

Adult Life

Individuals successful during middle life are characterized, as a rule, by a capacity for high sustained mental and physical activity. It is characteristic of this group that the first forty years are those of ease of achievement, great activity, rarely with fatigue, and quick restoration. Whereas the brain is very active and almost tireless in this successful group during the first forty years, the driving of the body at an abnormal speed taxes such organs as the heart, the blood vessels, and the kidneys.

Anyone can tell when his brain is tired because through the brain his personality is expressed. No one can tell when his heart, his blood vessels, or his kidneys are tired. These organs are mute, and the first warning of possible impairment is a diminished function. After that warning comes, one of these organs may soon fail, and when one of these vital organs fails it will bear down the life of the man.

Exophthalmic goiter, or hyperthyroidism, is a disease seen in the adult life of civilized man. It may be regarded as a mutation of the brain and the thyroid gland. Exophthalmic goiter involves primarily two organs the large size of which endows civilized man with the distinguishing features of civilization, that is, a high order of intelligence and an equally high order of physical, mental, and emotional activity.

Exophthalmic goiter could occur in no animal whose brain and whose thyroid gland are so small that the animal could not acquire the civilized state. This is sufficient reason why, in the mortality statistics of Frederik L. Hoffman, in which are tabulated the causes of death in 1928 of native man throughout the world, in 2,500,000 deaths among a native population aggregating 1,125,000,000 people, not a single death from exophthalmic goiter is noted. Nor would there have been a single death from exophthalmic goiter noted among the deaths of billions of horses, cattle, sheep, and swine, or among the deaths of billions of fish, reptiles, birds, and mammals in the wild state. Exophthalmic goiter is found only where there is the highest development of the brain and the thyroid gland, namely, in civilized man, the product of the stimulating climate of the temperate zone.

In certain adult individuals there occurs, through mutation, a state of unbalance resembling exophthalmic goiter. In these individuals the heart palpitates without obvious cause from the environment, the victims vacillating between intense mental and emotional excitability, exhaustion, and complete breakdown. This condition is known as neurocirculatory asthenia, or "soldier's heart." In this group are to be found some of the brilliant and interesting invalids of history. During the First World War many such cases were seen. The army mule could not acquire neurocirculatory asthenia. Neurocirculatory asthenia is a mutation of the brain-adrenal-sympathetic system. Victims of neurocirculatory asthenia exhibit all the symptoms of exophthalmic goiter but two: there is no exophthalmos and there is no increased metabolic rate.

Significantly, in these mutants the celiac ganglia are smaller in cases of exophthalmic goiter and in cases of neurocirculatory asthenia than in normal individuals, whereas in cases of exophthalmic goiter the thyroid gland is larger than in normal individuals.

In support of this statement, that these two diseases may be regarded as mutations, is the discovery that exophthalmic goiter may be cured by breaking this universal energy system by denervating the adrenal glands. This alone causes the brain to return from its pathological activity to the normal state and the thyroid gland from its state of hyperplasia and excessive vascularization to its normal state. Equally does the rapid heartbeat return to its normal rhythm. In neurocirculatory asthenia, denervation of the adrenal glands restores the excited brain to its normal state, the excited sympathetic system to its normal state, and the excited heart to its normal state.

Of great significance is the fact that excision of the thyroid gland, which cures exophthalmic goiter, has no effect upon neurocirculatory asthenia. Therefore, one may suppose, the mutations involve different organs. In exophthalmic goiter the mutation appears to involve the brain and the thyroid gland, whereas in neurocirculatory asthenia the mutation appears to involve the brain-adrenal-sympathetic system, the thyroid gland remaining normal.

The childhood, the school and college days of the hyperthyroid patient show a brilliant scholastic record and an active, colorful personality. The victim of neurocirculatory asthenia exhibits a greater degree of instability and nervousness than the victim of exophthalmic goiter but does not show so high a scholastic record as that of the exophthalmic goiter mutant.

The equipment of the large brain and thyroid gland is characteristic of warm-blooded man and animals in the cold north. Therefore, the native of the tropics could not develop exophthalmic goiter or neurocirculatory asthenia, nor is he likely to attain the high rank in scholarship.

There is a third energy synthesis, or mutation, seen only in civilized man. This third mutation is equally defined, equally individual. The victims suffering from this mutation have larger hearts, greater volume of blood, constant but not abnormally active brains, normal thyroid glands, and normal or slightly larger than normal adrenal glands. These individuals also possess uniquely large celiac ganglia and celiac plexuses and normally are under a high constant internal drive. Whereas the hyperthyroid and the hyperadrenal subjects tend to sweat and tremble, the individuals belonging to this third energy synthesis have dry skins and rarely tremble.

The victims of this third mutation are not so brilliant scholastically as are those prone to exophthalmic goiter, but they range in the upper third of their class. In grade school and college they are leaders in athletics, and active in clubs, whereas the candidates for exophthalmic goiter and neurocirculatory asthenia are leaders in the classroom. These individuals are more stable and possess sounder judgment and more courage than the mutants predisposed to exophthalmic goiter and neurocirculatory asthenia. These highly energized, tireless, but stable mutants, in addition to being successful leaders in industry, finance, the professions, in public affairs, and in war, particularly as pilots in aviation, are also candidates for essential hypertension and coronary disease.

Another mutation that is seen in adult civilized man, particularly in the north, is peptic ulcer. This fourth energy mutation is not so clearly defined as are the three previously mentioned, but it has a common characteristic with them in that its members are also highly energized and carry a high order of achievement. It would seem that the inherited mechanism of this group escaped the thyroid dominance of the exophthalmic goiter victim and the dominance of the celiac ganglia, plexuses, and heart of the victim of essential hypertension and coronary disease.

In this fourth group we see an example of a competent thinking brain, driven to a high level of activity by a well-balanced thyroid gland and adrenal-sympathetic system. The individuals of this group are more prone to ambition and worry than is the more stable candidate for essential hypertension and coronary disease.

Peptic ulcer occurs more commonly in men, particularly in those who are under stress because of their occupations or in individuals who, struggling under conditions of conflict, discouragement, or maladjustment, are especially subject to worry, anxiety, and fatigue. Exophthalmic goiter occurs more commonly in women. Peptic ulcer appears in the midst of the active careers of ambitious men. Exophthalmic goiter appears in the midst of the domestic worry and the social drive of women.

The fifth mutation, diabetes, is a synthesis of an active brain and a high normal thyroid-adrenal-sympathetic system. It is most commonly found among active and successful individuals. The childhood of a diabetic is characterized by a brilliant scholastic career and, on an average, a diabetic child is two years ahead of his grade. Diabetes does not produce brilliant minds, but brilliant people may tend to acquire diabetes. Many of the outstanding personalities in history have been diabetics.

In this connection it is interesting to note that in exophthalmic goiter the incidence of diabetes and disturbed carbohydrate metabolism is far higher than in the population.

The victims of these five mutations are characterized by the highest qualifications seen in civilized man. These mutants represent the most progressive, the most inventive, the most valorous fraction of civilized man. They are conspicuous in the professions, in government, in business, in finance, in public life, and in war. They appear as great leaders and great failures.

In the size of the thinking brain, the heart and the volume of blood, the size of the thyroid gland, adrenal glands, celiac ganglia and plexuses, these mutants appear to be evidence of the lack of uniformity and fixation of characteristics in civilized man. Civilized man has appeared upon the scene so recently and in breeding has been subjected to so many out-crosses that inheritance is not stabilized, and mutations appear frequently.

Since the diseases and disasters in the life and career of many individuals in the high tension of civilized life are due largely to worry and emotionalism, it would seem logical to substitute for the emotions the greatest gift of evolution to civilized man, namely, reason. If, in childhood, adolescence, or young-adult life, the inherited tendencies of these mutants could be detected and the danger of their high endowment glimpsed, the pathologic physiology of these superlative energy-controlling systems might, through training and education, be minimized or avoided.

Part IV

SUMMARY AND DISCUSSION

28. TEN BIOLOGICAL PRINCIPLES

THROUGHOUT our studies relating to the force that energizes man and animals and accounts for their intelligence, power, and personality, we have found that the relation of the living processes to the genesis of civilized man and his diseases may be expressed by the following ten biological principles:

1. The pattern of the unicellular organism, with its dominating positive nucleus and negative cytoplasm, is the universal energy formula for animals and man.

2. In higher animals the positive pole of the bipolar mechanism is generated by the brain; the negative pole is generated by the heart and the red blood cells. Oxidation, as in the carbon lamp, completes the arc.

3. In both cold-blooded and warm-blooded animals, from the grasshopper to the elephant, with the exception of the higher primates and man, 1 gram of brain is required to execute 12,115 small calories in 24 hours.

4. In man, the brain and the thyroid gland rose together, the brain as the universal executive and the thyroid gland as a universal controller of constant adaptive oxidation. The thyroid gland is relatively larger in man than in any other land animal. Both the thyroid gland and the brain exhibit the peak of their dominance in civilized man.

5. The adrenal glands are larger than the thyroid gland in virtually all the wild land animals, including the ape. In contrast to man the adrenal-gland control is especially marked in the ape.

6. Intelligence, power, and personality are dependent on the absolute and relative size of the brain, the thyroid gland, the heart and blood volume, the celiac ganglia and plexuses, and the adrenal-sympathetic system.

7. Haeckel's law, that ontogeny repeats phylogeny, interprets the unique behavior of the human being during childhood, adolescence, and the adult stage.

8. The rise of man to his civilized state has been so recent and so rapid and man has been subjected to so much out-crossbreeding that in order to account for the many variations in the size of the energy-controlling organs we have evoked De Vries' law of mutation.

9. Temperature, humidity, and storm profoundly influence the size of the energy-controlling organs.

10. The thinking part of the brain of man has unique survival value.

These ten biological principles, we believe, account for the unique and variable intelligence, power, and personality of animals and man.

The first biological principle is that the universal energy pattern of animals and man is the pattern of the unicellular organism. In the higher animals the brain and all other nerve tissue follow the pattern of the nucleus of a primordial unicellular organism and, like the nucleus of the unicellular organism, exhibit a positive sign of charge: all the other organs and tissues of animals follow the pattern of the cytoplasm of a primordial unicellular organism and, like the cytoplasm of the unicellular organism, exhibit a negative sign of charge.

The second biological principle is that the bipolar theory of the operation of man and animals offers an interpretation of the mechanism of metabolism.

When we dissect an animal or a man we see three great systems: first, the brain and the infinite network of voluntary and involuntary innervation extending to the most distant capillaries, muscle cells, and gland cells; second, the heart, the blood vessels, and the capillaries extending to every microscopical unit of living tissue in the body; third, a system as essential as the other two, namely, the great voluntary muscular system, which constitutes the greatest mass of the body and is the mechanism by which adaptive energy of the body is executed.

There are millions of units of energy transformation to which each of these three systems contributes an essential part. These units of energy transformation consist of a voluntary muscle fiber, or furnace, a nerve end plate on the wall of the muscle fiber representing a positive pole, and red blood cells in the capillaries representing a part of the negative pole. These energy units in delicate electric balance between the positive and the negative poles await the nerve stimulus from the brain. This nerve stimulus of the end plate on the wall of the muscle fiber closes the arc by oxidation. Thus are heat and muscular action adaptively produced.

The brain and the heart are axis partners in maintaining the constant electric force in the metabolic arc that keeps alive the animal and the man. These two tireless organs, working day and night, respond to every changing stimulus from the special senses, common sensations, the emotions, to the stimulus required for labor in the fields, for executive work in industry, for the duties required of a president of a bank or of a professional man.

The thyroid gland has the unique power of controlling the level of activity of this energy team, higher in the north, where the climate is cold, higher in the winter as compared with the summer. The constant working tempo is controlled by the thyroid gland, and the outburst energy required for the expression of the emotions is executed by the brain and the heart through flash oxidation controlled by the adrenal glands.

In civilized man we find a larger brain, a larger thyroid gland, and a larger heart and volume of blood than in native man in the tropics. The hard-working brain, the lead horse in this energy team, is so overworked that there were in the United States, in 1939, 606,394 beds for mental and nervous diseases. This is eloquent testimony of the role of the brain in civilized man.

The brain and the heart muscle have a higher metabolism than any other organ of the body. They perform the greatest amount of work per mass. The heart muscle itself with its unique blood supply is maintained at such a high level of activity that the greatest percentage of deaths in the United States is caused by cardiac disease.

Thus we see that the varying potentials required to change the rate of oxidation for all the purposes of civilized man depend on the two axis partners, the brain and the heart.

The third biological principle, that in the habitat temperature of an animal 1 gram of brain is required to execute 12,115 small calories in 24 hours, offers a unique opportunity for estimating that part of the brain for animal requirements and that part of the brain for distinctly human requirements.

The brain-oxidation law expresses the basal metabolism common to all animals, including man. The "animal brain" represents the requirements of energy for growth, for the maintenance of the protoplasm of the body, for the maintenance of the warm-blooded state, for the digestion of food, for procreation—in fact, for all the basic energy required in the wild and domestic state of animals and man.

Since man has been differentiated from the lower animals by a significant development of a thinking brain and since the critical study of metabolism by Francis Benedict revealed that little or no oxidation is required for abstract thinking, we now have a method by which we are able to estimate the weight of the thinking part of the brain of man.

In the consideration of the thinking brain we include the vast numbers of brain cells whose oxidation supplies the electric energy that etches in the white matter of the brain the many patterns of action of the human being, especially those established through the use of the manipulative hand, the erect posture, and the vast numbers of mental, physical, and emotional acts that civilized man executes in the course of his life. In the large brain of civilized man there are infinite numbers or combinations of patterns of action, each of which must be executed by brain cells that supply the energy for thinking, for the expression of the emotions, and for the vast number of muscular acts performed by civilized man.

An analogy to civilized man's requirement of a large brain for the execution of the many separate acts that he performs was seen in the size of the brain of the sting ray that we collected at Key West. The sting ray has ninety-four pairs of muscles that must coordinate and contract rhythmically in many vicissitudes of orientation on the shallow, sandy beaches. In the sting ray the brain is accordingly relatively larger than that seen in any other fish or reptile, since in the brain of the sting ray there must exist not only the patterns of action of the ninety-four pairs of muscles but also the necessary number of brain cells to execute these patterns of action.

This conception explains the large size of the brain of man compared with that of the ape and the large size of the brain of civilized man, whose thinking brain drives his hands and the feet so continuously in the operation of the web of life, compared with that of native man.

The fourth biological principle, that in man the brain and the thyroid gland rose together, has been clearly established in our long study of the energy-controlling organs of the various species of animals and in certain racial studies of man.

The thyroid hormone controls the rate of oxidation in the billions of brain cells, including the cells of the center that sends impulses over the sympathetic nerves to the celiac ganglia and plexuses and adrenal glands, thus indirectly controlling the force and frequency of the heartbeat and, in consequence, the electric potential of the entire organism. Therefore, the thyroid gland may be considered to exert adaptive control of oxidation in the entire organism.

The fifth biological principle, that natural selection gave to each wild animal larger adrenal glands than thyroid gland, expresses the necessity of crisis energy mobilized by the hormone of the adrenal glands in addition to the constant energy mobilized by the hormone of the thyroid gland.

We have found the adrenal-gland-celiac-ganglion dominance to be most marked in the cat family and the rodents, in which both attack and defense depend on outburst energy. The adrenal-gland-celiac-ganglion dominance is less marked in animals requiring the long chase or long escape, such as the wolf, the deer, and the antelope.

In the evolution of wild animals, natural selection favored the adrenal glands, celiac ganglia and plexuses. In man, natural selection centered upon the thinking part of the brain and the thyroid gland. The formula of a large brain, large thyroid gland, absolutely and relatively smaller adrenal glands, and variable celiac ganglia and plexuses is that of a walking, thinking animal, namely, man.

The formula of a brain smaller than that of man, a large heart and volume of blood, large adrenal glands, and large celiac ganglia is that of the thoroughbred horse.

The formula of an extremely large brain, a large thyroid gland, comparatively small adrenal glands, a moderately large heart, and a strikingly large volume of blood is that of the whale or the porpoise.

The formula of a brain of lesser size than that of man or the ape, a heart not so large as in the high-powered, long-distance-running antelope, a moderate volume of blood, large adrenal glands in comparison with the thyroid gland, and celiac ganglia and plexuses as large as the adrenal glands is that of the lion.

Among the 284 species that we have dissected the lion possesses the largest and most complex celiac ganglia and plexuses. These structures we found to be the most distinguishing characteristic of the lion.

Inasmuch as the role of the celiac ganglia and plexuses has heretofore not been determined, it would seem that the lion explains it. The lion possesses the greatest power of outburst energy of any animal of comparable size.

The formula of a very small brain, a simple sympathetic system, small adrenal glands, white muscle, and a slight volume of blood is that of the alligator. Whereas in the lion there are eighty-two branches on each side of the celiac plexus, in the alligator there are but three.

In the Museum of Intelligence, Power, and Personality at the Cleveland Clinic Foundation we have illustrated the sixth biological principle, that intelligence, power, and personality are dependent on the absolute and relative size of the brain, the thyroid gland, the heart and blood volume, the celiac ganglia and plexuses, and the adrenal-sympathetic system. To exploit this interesting field properly will take many years, but as a beginning we can offer studies of 3,734 animals, representing 284 species and 60 human studies,[1] including 3 racial types and 15 nationalities.

In our seventh biological principle we invoked Haeckel's law, that ontogeny recapitulates phylogeny. Although we recognize the limitations of this law, Haeckel's principle would seem to account for the adrenal-gland dominance in the human fetus, in infancy, and in childhood, such as is exhibited in the ape of today. It was during the rise of man from the ape that through natural selection the adrenal-gland dominance gave way to thyroid-gland dominance.

At the time of birth the beginning of a gradual decline of the adrenal-gland dominance occurs. This decline continues until about the twenty-first year. At this time the thyroid gland is 2½ times the size of the adrenal glands, and the rule of reason should supersede the dominance of the emotions.

For our eighth biological principle we turned to the law of mutation advanced by De Vries. The rise of man to his

[1] See Appendix, Record of Body Weight and Certain Organ and Gland Weights.

civilized state has been so recent and so rapid, and man has been so extensively subjected to out-crossbreeding, that many mutations are seen in the size of his energy-controlling organs. We believe that this principle may also be applied to the size of the brain, the thyroid gland, the adrenal glands, the heart and blood volume, the celiac ganglia and plexuses.

De Vries pointed out that mutations occur more frequently in animals that are hybridized than in line-bred animals. In Africa we saw little evidence of mutation among the antelope, since the lion and the wild dog destroy the slow and the incompetent. The leader of the herd is the male that has defeated all rivals. For thousands of years the herd has been under line-breeding, which is itself an evolution to the advantage of the species. In the antelope the senses of smell, of hearing and seeing, the size of the brain, the thyroid gland, the adrenal glands, the heart, the blood volume, the celiac ganglia and plexuses—all the units of the mechanism of these beautiful animals—are uniform compared with the mutations of the brain, the thyroid gland, the adrenal-sympathetic system, the heart and the blood volume seen in the thoroughbred horse and in civilized man.

The ancestry of civilized man includes the weak as well as the strong, the incompetent as well as the competent, and the unfit as well as the fit. For this reason we should expect to find a higher percentage of mutations in civilized man than in the line-bred wild animals.

In civilized man there is greater variation in the size of the brain, the thyroid gland, the adrenal glands, the heart and blood volume, the celiac ganglia and plexuses, resulting in great variations in intelligence, power, and personality, and the incidence to certain diseases.

In our ninth biological principle we have invoked Berthelot's law of nitroexplosives and van't Hoff's law expressing the effect of temperature on chemical activity.

These principles interpret the evolution of the warm-blooded animals.

Through van't Hoff's law one can understand why there is a critical temperature, or ceiling, of about 108.5°F., beyond which detonation or heatstroke occurs. This universal menace of heatstroke not only limits the size of the brain, the thyroid gland, the adrenal glands, the heart and blood volume in man and animals in the tropics but, since the speed of chemical activity of the body is increased 10 per cent with each degree of rise of temperature, the higher the temperature of an animal the greater its speed and power. In consequence, natural selection has endowed animals and man with a larger brain, a larger thyroid gland, a larger heart and blood volume in the arctic than in the tropics.

In the foregoing argument, from an energy point of view, we have differentiated man from the lower animals, and civilized man from native man. Let us now consider our tenth biological principle, that the thinking brain of man has a unique survival value, which illuminates the diseases peculiar to civilized man in the temperate zone.

Among the Eskimos in the far north, the thinking brain has much less survival value than in the temperate zone. In the arctic there are no agriculture and no manufacturing. The Eskimo lives on raw flesh. Intelligence can serve him only to the extent of making him more crafty than the whale, the seal, the walrus, or the bird and enabling him to clothe himself with skins and to build an igloo, a sledge, and a kayak.

The thinking brain has less survival value, also, in the tropics than in the temperate zone. In the tropics the native needs only to fish and to gather fruit, berries, bird's eggs, and nuts. Agriculture is rudimentary, and the production of small grains cannot be successfully carried on because of the intense heat.

But even in the arctic and the tropics the survival value of the thinking brain is not comparable to the survival value of the thinking brain of man who has created the machine age, developed science, art, agriculture, invented methods of communication, and devised educational systems, philosophies, and government.

The mind of man has its greatest survival value in the temperate zone, especially in that part of the temperate zone where there is an abundance of coal, oil, iron, farming and grazing land, where storms and a change of seasons invigorate man and endow him with greater muscular, emotional, and mental energy. In this zone of change and storm we find not only the highest development of civilized man but also the highest incidence of diseases peculiar to civilized man, for the genesis of each depends upon a large brain, a large thyroid gland, a large heart and volume of blood, a large celiac ganglion and plexus and adrenal-sympathetic system. As stated previously, we also find particularly effective for both civilized man and his diseases the application of the law of mutation, which, on the one hand, produces scholars and philanthropists and, on the other hand, mental defectives and criminals.

From these considerations it is clear that neither the Eskimo nor the African native nor wild animals could achieve civilization, nor could they acquire any more easily the diseases peculiar to civilized man. It is clear, also, that civilized man is approaching the ceiling of safe further development of his energy system.

We recognize the fact that we have not given final proof of any one of the applications of the several biological laws that we have evoked in our attempt to define the mechanism of civilized man. Even the principle of evolution cannot be proved, though it is accepted. Nevertheless, Darwin's principle of struggle and survival, Haeckel's principle of ontogeny and phylogeny, De Vries' principle of mutation, Berthelot's law, which we have applied to explain the limitations of temperature and heatstroke among warm-blooded animals, van't Hoff's law, which we have evoked to interpret the biological advantage of the warm-blooded state, and the brain-metabolism law that enabled us to open the way to ascertain the weight of the thinking part of the brain—all these harmonize the data that we have collected.

From the foregoing we offer a neuroendocrine formula for civilized man. Civilized man possesses no organ not possessed by native man or wild and domestic animals. Civilized man, when evaluated by the power formula, possesses a larger thinking brain and thyroid gland than any other animal, coupled with an upright posture, a manipulative hand, and in comparison with wild and domestic animals, small adrenal glands, celiac ganglia, and plexuses.

The brain of civilized man possesses a greater number of energy units or brain cells than is possessed by native man or any other animal of comparable size. It possesses also a greater number of lines of communication among the various parts of the brain itself as well as to the muscles, especially those of the hands and feet, for executing the many activities of civilized man.

In man, when there is a break in continuity between the driving brain and the adrenal-sympathetic system—in other words, when there is a physiological bisection—the power to express the emotions is lost.

In my service with the American Ambulance at Neuilly, France, during the First World War, in 1914 and 1915, a ward of eighty soldiers who had suffered cross lesions of the spinal cord was placed in my charge. The personality of each of these soldiers was bisected by a bullet that divided the spinal cord high up. Although these unfortunate men were paralyzed from the point of injury down, they remained calm, placid, and intellectual in spite of their incapacity, in spite of their dilemmas, and in spite of air raids. Their minds had been severed from their adrenal-sympathetic nervous systems. "The line was down." They had lost the power to worry or to fear.

In surgical operations under spinal anesthesia the personality of the patient likewise is bisected. The mechanism of intelligence is left in one sector, the mechanism of the emotions in another. The brain loses its means of communication with the mechanism for the expression of the emotions.

The brain of civilized man generates a high electric potential of the entire organism. Conversely, a high electric potential of the body is accompanied by a continuous high electric stimulation of the brain and other organs and tissues of the body. When this electric stimulation of the brain becomes excessively high and there is a corresponding stimulation of the mechanism of the emotions, a pathologic physiology and even disease may occur. A successful life is dependent upon a balance between the brain-thyroid and the brain-adrenal systems.

When civilized man realizes that his dominance has been gained through the evolution of the brain-thyroid formula, which superseded the brain-adrenal formula of his wild ancestors, he may, through training and education, lessen the exercise of the emotions by raising the exercise of reason, thereby protecting the survival value of the organs that endow him with intelligence, power, and personality.

Appendix

A RECORD OF THE BODY WEIGHT AND CERTAIN ORGAN AND GLAND WEIGHTS OF 3,734 ANIMALS

GEORGE CRILE AND DANIEL P. QUIRING

The weight data presented in the following table are offered in the hope that they may be of value to the biologist, physiologist, and particularly to the student of growth phenomena.

With few exceptions, marked with an asterisk, our own data represent fresh weights taken immediately after the animal was sacrificed. The larger animals were weighed on a Chatillon scale of 600 pounds capacity; in the case of the heaviest animals this necessitated quartering or cutting the body into sections to fit the scale. The smaller animals were weighed either on a Chatillon autopsy scale, a Cenoco triple-beam balance, or an Ohaus beam balance. The glands and organs, likewise, were weighed on these scales except for the very small glands that were weighed on an analytical balance.

It will be noted that some records are more complete than others; this is due in part to changes that were made in our program over a period of some ten years and in part to the impossibility of getting complete records for many of the animals. No attempt has been made to arrange the groups in order of relative development. A rough alphabetical listing has been made.

In connection with the degree of accuracy of the weights, these have, in some instances, been carried beyond the limits of error. Generally, however, we have attempted to hold to an accuracy of 1 per cent. In the case of animals that were weighed in pieces, we allowed 5 per cent for loss of blood and body fluids. All weights represent the body weight plus whatever mass was present in the stomach and intestine.

Under the heading "Remarks," we have given chiefly the locale or country from which the animal was obtained. In certain cases, other pertinent information has been included. Thyroid glands suspected of goiter were examined by Dr. Allan Graham.

The scientific names have been checked by us and have been examined by Arthur B. Fuller, of the Cleveland Museum of Natural History. If any errors have occurred in naming, the authors take responsibility for them.

We wish to acknowledge in particular the excellent assistance of Mr. James Barrett, Mr. Owen Reeves, and Mr. Paul Bade, of The Division of Anatomy, Cleveland Clinic Foundation, in making some of the dissections to obtain these data.

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INVERTEBRATES

Catalogue number	Number of animals	Sex	Common and scientific name	Body weight, kilograms	Brain, grams	Thyroid, grams	Adrenal, grams	Heart, grams	Liver, grams	Eyes, grams	Kidney, grams	Lung, grams	Spleen, grams	Stomach and intestines, grams	Remarks
			ANNELIDS												
....	10	....	Earthworms............ *Lumbricus terrestris*	0.00609	0.0214		(Ganglia and ventral nerve cord)					......	......	....	Cleveland, Ohio
			INSECTS												
....	5	....	Cockroach............. *Periplaneta americana*	0.000092	0.000195		(Ganglia and ventral nerve cord)					......	......	....	Cleveland, Ohio
....	54	....	Grasshopper........... *Melanoplus femur rubrum*	0.000458	0.00233		(Ganglia and ventral nerve cord)					......	......	....	Cleveland, Ohio
....	35	M and F	Wood Roach........... *Blaberus cranifer*	0.004727	0.0097		(Ganglia and ventral nerve cord)					......	......	....	Winter Park, Fla.
			MOLLUSK												
....	5	....	Slug.................. *Limax maximus*	0.00417	0.0133	(Ganglia)		....	....	......	......	......	......	....	Cleveland, Ohio

VERTEBRATES

AMPHIBIA

Catalogue number	Number of animals	Sex	Common and scientific name	Body weight, kilograms	Brain, grams	Thyroid, grams	Adrenal, grams	Heart, grams	Liver, grams	Eyes, grams	Kidney, grams	Lung, grams	Spleen, grams	Stomach and intestines, grams	Remarks
650	1	M	Bullfrog............... *Rana catesbiena*	0.339	....	0.033	0.06	1.37	6.42	2.23	1.73	1.81	......	....	North Carolina
1179, 1180, 1181, 1182, 1183, 1184	6	M	" "	0.5199	0.4625	0.0336	0.1342	1.65	14.77	2.57	1.421	2.76	0.373	24.56	Louisiana

			Birds												
702	1	M	Blackbird............. *Quiscalus quiscula aeneus*	0.082	2.92	0.0116	0.0133	1.159	2.63	1.917	1.299	1.743	0.051	6.38	Little Mountain, Ohio
261	1	F	Bluebird.............. *Sialia sialis sialis*	0.034	1.281	0.006	0.022	0.383	......	.....	......	......	.....	....	Little Mountain, Ohio
262	1	M	" " "	0.029	1.392	0.0093	0.013	0.493	......	.....	......	......	.....	....	Little Mountain, Ohio
168	1	F	Bustard, Greater........ *Choriotis kori struthiunculus* (Neumann)	5.540	12.94	0.44	0.33	60.25	98.61	40.25	22.09	70.48	.....	490	Athi Plain, Africa
169	1	M	" "	10.00	15.63	0.91	0.87	97	200	52.45	66.42	100	.....	655	Athi Plain, Africa
136	1	F	Bustard, Lesser......... *Haliaoetus bociter bociter* (Daubin)	1.100	7.62	0.213	0.237	11.93	17.63	10.18	6.07	14.35	.....	120	Maji Moto, Africa
15A	1	M	Buzzard, Steppe........ *Buteo vulpinus vulpinus* (Gloger)	0.560	7.9	0.18	0.26	4.58	10.87	.....	3.36	4.64	.....	....	Maji Moto, Africa
24F	1	M	Buzzard, Turkey........ *Cathartes aura septemtrionalis*	0.495	9.32	0.115	0.156	10.24	20.99	7.95	10.11	14.73	.....	170	Key West, Fla.
266	1	F	Catbird............... *Dumetella carolinensis*	0.033	1.412	0.004	0.004	0.327	......	.....	......	0.607	.....	....	Little Mountain, Ohio
706	1	M	Canary............... *Serinus canarius*	0.0171	0.966	0.0193	0.0059	0.2854	1.010	0.336	0.2673	0.2516	0.0184	2.296	Cleveland, Ohio
1258	1	F	" "	0.0153	0.564	0.009	0.007	0.133	0.738	0.230	......	......	.....	1.74	Cleveland, Ohio
265	1	F	Cowbird.............. *Molothrus ater ater*	0.066	2.693	0.014	0.017	1.06	......	.....	......	......	.....	....	Cleveland, Ohio
55A	1	F	Crane, Crested......... *Balearica pavonina*	4.071	13.54	0.34	0.38	41.21	125	12	30.34	46.21	.....	....	Lake Manyara, Africa
56A	1	M	" "	4.825	12.85	0.265	0.30	32.37	86.1	11.2	21.62	42.05	.....	....	Lake Manyara, Africa
60	1	M	Crane, Gray........... *Crus canadensis*	1.651	8.58	0.14	0.248	19.01	29.34	10.97	11.71	15.33	0.67	78.59	Key West, Fla.

BIRDS.—(*Continued*)

Catalogue number	Number of animals	Sex	Common and scientific name	Body weight, kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and intestines	Remarks
241	1	M	Crow.................. *Corvus brachyrhynchos*	0.337	9.3	0.038	0.077	3.2	......	......	......	9.97	......	....	Little Mountain, Ohio
50F	1	F	Dovekie.............. *Alle alle*	0.102	1.93	0.008	0.015	1.24	2.51	1.94	1.88	1.41	......	6.60	Key West, Fla.
51F	1	M	" "	0.104	1.92	0.009	0.037	1.24	4.34	2.00	2.31	1.91	......	6.74	Key West, Fla.
646	1	M	Duck.................. *Nyroca affinis* (Eyton)	1.041	....	0.133	0.152	13.4	58.3	2.9	18.1	17.6	......	....	Willoughby, Ohio
29	1	F	Duck, Pintail.......... *Dafila acuta tzitzihoa*	0.670	4.95	0.0559	0.0818	8.34	30.33	1.70	8.14	17.13	0.89	99.43	Churchill, Canada
154	1	F	Eagle, Fish............ *Haliaetus vocifer vocifer*	3.500	12.93	0.28	0.40	32.23	46.28	22.28	18.43	47.33	......	150	Maji Moto, Africa
5, 22	2	F	Eagle, Tawny.......... *Aquilla rapax rapax* (Temninick)	2.625	14.09	0.19	0.45	18.54	48.45	32.84	14.16	......	......	....	Maji Moto, Africa
88	1	M	" "	1.670	13.62	0.12	0.35	9.24	42.73	30.20	3.82	27	......	150	Maji Moto, Africa
11, 12	2	M	" "	2.438	13.91	0.31	0.50	14.17	37.55	30.96	13.57	23.18	......	....	Maji Moto, Africa
114A	1	F	Egret, Great White..... *Casmerodius albus melanorhynchos* (Wagler)	1.03	6.12	0.13	0.21	9.25	33.02	......	8.16	33.10	......	135	Maji Moto, Africa
113A	1	M	Egret, Yellow-bill....... *Mesophyox intermedia brachyrhyncha* (Brehm)	0.525	4.7	0.07	0.14	5.0	16.53	5.16	3.72	5.35	......	50	Maji Moto, Africa
109, 110, 111	3	F	Flamingo.............. *Phoeniconaias minor* (Geoffroy)	1.483	6.99	0.27	0.34	14.68	40.27	2.97	17.02	21.35	......	248	Maji Moto, Africa

16 / 17	2	M	" "	1.598	8.05	0.57	0.59	13.53	40.91	3.82	19.0	23.32	......	....	Maji Moto, Africa
718 / 719 / 720 / 721	4	F	Fowl, Leghorn.......... *Gallus gallus domesticus*	1.263	3.916	0.2153	0.186	....	....	......	10.05	10.48	2.20	90.99	Cleveland, Ohio
....	7	F	" "	0.0437	0.9971	0.0038	0.0095	....	1.8524	......	......	......	......	....	6 days old
....	13	M	" "	0.0464	1.0556	0.0036	0.0147	....	1.6242	......	......	......	......	....	6 days old
....	6	F	" "	0.0682	1.2107	0.0063	0.0163	....	3.4482	......	......	......	......	....	13 days old
....	14	M	" "	0.0801	1.3378	0.0083	0.0185	....	3.1548	......	......	......	......	....	13 days old
....	15	F	" "	0.1197	1.5001	0.0094	0.0198	....	4.2529	......	......	......	......	....	20 days old
....	15	M	" "	0.1197	1.5411	0.0089	0.0263	....	4.2091	......	......	......	......	....	20 days old
....	12	F	" "	0.1719	1.7148	0.0132	0.0228	....	5.1676	......	......	......	......	....	27 days old
....	8	M	" "	0.1601	1.7039	0.0113	0.0254	....	5.0124	......	......	......	......	....	27 days old
....	10	F	" "	0.2231	1.9261	0.0167	0.0305	....	6.1386	......	......	......	......	....	35 days old
....	10	M	" "	0.2273	1.9173	0.0143	0.0368	....	6.6918	......	......	......	......	....	35 days old
....	12	F	" "	0.2951	2.1168	0.0233	0.0390	....	8.4172	......	......	......	......	....	48 days old
....	8	M	" "	0.3168	2.1142	0.0198	0.0441	....	9.0164	......	......	......	......	....	48 days old
....	6	F	" "	0.3978	2.3487	0.0300	0.0498	....	11.843	......	......	......	......	....	62 days old
....	11	M	" "	0.3918	2.3334	0.0294	0.0611	....	13.719	......	......	......	......	....	62 days old
....	10	F	" "	0.3596	2.3811	0.0689	0.0864	....	11.032	......	......	......	......	....	87 days old
....	10	M	" "	0.3532	2.4980	0.0536	0.1135	....	12.365	......	......	......	......	....	87 days old
....	10	F	" "	0.4907	2.5822	0.1097	0.0989	2.80	12.761	3.34	3.83	3.88	0.78	....	108 days old
....	10	M	" "	0.5007	2.8056	0.0631	0.1265	3.18	15.305	3.75	4.34	4.39	0.68	....	108 days old
....	16	F	" "	0.6151	2.7224	0.0762	0.0973	3.91	14.498	3.58	4.17	3.78	0.95	....	136 days old
....	8	M	" "	0.7331	2.9279	0.0894	0.0714	4.19	16.188	4.25	4.54	4.41	0.97	....	136 days old
602	1	M	Fowl, White Orpington.. *Gallus gallus domesticus*	2.200	3.55	0.140	0.250	8.78	45.9	6.39	12.9	13.17	......	325	Cleveland, Ohio
18A	1	F	Goose, Egyptian........ *Alopochen aegyptiaca*	1.935	7.64	0.34	0.42	18.51	34.31	......	9.75	35.2	......	....	Lake Manyara, Africa
186A	1	M	Guinea Fowl........... *Numida meleagris*	1.620	4.20	0.293	0.36	14.22	28.6	......	7.34	29.08	......	....	Maji Moto, Africa
25	1	M	Gull, Bonepartes........ *Larus philadelphia*	0.205	2.49	0.0216	0.0529	3.44	9.12	3.14	3.20	7.12	......	21.56	Churchill, Canada
44F / 10F	2	F	Gull, Herring........... *Larus argentatus*	0.535	5.08	0.040	0.133	5.24	27.33	7.74	......	......	......	....	Key West, Fla.

BIRDS.—(*Continued*)

Catalogue number	Number of animals	Sex	Common and scientific name	Body weight, kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and intestines	Remarks
53F	1	F	Gull, Ring-billed........ *Larus delawarensis*	0.720	8.73	0.051	0.12	7.35	23.51	8.74	7.45	9.13	......	154	Key West, Fla.
21F	1	F	Gull, Shearwater........ *Puffinus griseus*	0.268	3.01	0.031	0.049	2.46	10.03	3.27	3.23	2.45	......	18.21	Key West, Fla.
145 } 146 }	2	F	Hawk, Red-tailed....... *Buteo borealis*	....	....	0.107	0.114	....	....	......	1.216	....	......	....	Little Mountain, Ohio
681	1	F	" "	1.029	10.025	0.0656	0.2035	6.94	14.10	21.22	6.87	9.27	......	18.38	Juvenile, Willoughby, Ohio
229	1	F	Hawk, Sharp-shinned.... *Accipiter velox velox* (Wilson)	0.520	5.70	0.042	0.110	3.70	....	......	....	7.7	......	....	Little Mountain, Ohio
58F	1	M	Hawk, Sparrow......... *Falco sparverius sparverius* (Linnaeus)	0.112	2.51	0.016	0.028	1.12	2.52	3.30	1.11	1.52	......	7.43	Key West, Fla.
163	1	M	Hornbill, Ground........ *Bucorvus cafer*	3.250	26.25	0.23	0.25	56.61	57.78	35.45	23.30	52.27	......	260	Maji Moto, Africa
712	1	F	Hummingbird.......... *Amazilia tzacatl tzacatl* (De la Llave)	0.0048	0.1998	0.00045	0.00035	0.1138	0.2511	0.1201	0.0391	0.0951	......	....	Samayac, Guatemala, C.A.
55B	1	F	Loon, Red-throated..... *Gavia stellata*	1.530	6.12	1.33	0.223	22.72	60.87	5.47	22.71	22.62	......	97.42	Tavane, Canada
55A } 55C }	2	M	" "	1.568	6.38	0.210	0.219	22.24	74.02	4.89	27.61	22.31	......	106.27	Tavane, Canada
52F	1	M	Man-of-war Bird........ *Fregata aquila*	1.405	9.45	0.089	0.175	16.59	35.88	12.99	....	......	......	....	Key West, Fla.

26	1	F	Merganser, Red-breasted *Mergus serrator*	0.770	5.289	0.0657	0.1033	11.01	19.77	2.76	9.67	18.16	0.22	46.30	Tavane, Canada
90A	1	M	Ostrich, Masai *Struthio camelus massaicus* (Neumann)	123	42.11	17.33	23.01	1,205	2,050		920	2,900		23,133	Maji Moto, Africa
143	1	M	" "			5.5					256				Zoo Specimen, Cleveland, Ohio
225	1	M	Owl, Horned *Bubo virginianus virginianus*	1.177	13.70	0.085	0.165	8.60				10.7			Little Mountain, Ohio
6A	1	M	Partridge *Francolinus sephaena*	0.208	1.50	0.02	0.053	1.46	8.65		2.70				Maji Moto, Africa
7F, 23F	2	F	Pelican *Pelicanus occidentalis*	3.290	17.95	0.183	0.993	22.12	73.15	12.73		29.83		255	Key West, Fla.
1257	1	M	Pheasant *Phasianus colchicus*	0.625	3.289	0.051	0.12	5.61	9.115	5.32	4.82			56.5	Little Mountain, Ohio
263	1	M	Phoebe *Sayornis phoebe*	0.0181	0.793	0.006	0.005		0.207						Little Mountain, Ohio
264	1	F	" "	0.0175	0.750	0.0025	0.0055	0.165							Little Mountain, Ohio
271	1	F	Pigeon *Columba livia*	0.247	2.285	0.031	0.046	4.651				4.09			Little Mountain, Ohio
268, 269, 270	3	M	" "	0.282	2.694	0.028	0.0421	4.836				5.07			Little Mountain, Ohio
24A, 24C, 24D	3	M	Ptarmigan, Willow *Lagopus lagopus*	0.542	2.377	0.0255	0.0273	7.863	12.99	2.316	3.87	9.61			Churchill, Canada
24B	1	F	" "	0.540	2.800	0.017	0.036	9.46	13.405	3.022	4.870	10.74			Churchill, Canada
108	1	F	Raven *Corvus corax*			0.031					2.428				Catalina Mountains, Arizona
259, 260	2	M	Robin *Turdus migratoris migratoris*	0.0693	2.09	0.0105	0.0213	1.018				1.677			Little Mountain, Ohio

BIRDS.—(*Continued*)

Catalogue number	Number of animals	Sex	Common and scientific name	Body weight, kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and intestines	Remarks
28	1	F	Scaup, Greater........ *Nyroca marila*	0.787	4.7859	0.0855	0.1850	8.00	23.00	1.76	9.11	18.01	......	99.15	Churchill, Canada
....	11	F	Sparrow.............. *Passer domesticus*	0.02326	1.0185	0.0041	0.0069	0.3926	1.0873	0.5179	0.357	0.3996	0.0428	2.681	Cleveland, Ohio
....	75	M	" "	0.02357	1.0278	0.0042	0.0063	0.4077	1.2062	0.4591	0.345	0.3674	0.0426	2.698	Cleveland, Ohio
255	1	F	Sparrow, Song.......... *Melozpiza melodia melodia*	0.021	1.10	0.0145	0.005	0.235	......	......	......	......	......	....	Cleveland, Ohio
14A	1	M	Stork, Abdim........... *Sphenorhynchus abdini* (Lichenstein)	0.950	7.3	0.23	0.46	8.40	27.94	8.88	8.80	10.36	......	....	Maji Moto, Africa
84A	1	M	Stork, European........ *Ciconia ciconia ciconia* (Linnaeus)	3.350	16.24	0.43	0.49	28.75	71.4	18.30	26.24	27.2	......	....	Maji Moto, Africa
82A } 83A }	2	F	" "	3.350	15.78	0.40	0.44	32.12	61.06	16.5	19.84	42.26	......	....	Maji Moto, Africa
195A	1	M	Stork, Hammerhead..... *Scops umbretta*	0.3175	3.93	0.037	0.061	7.22	......	......	......	8.16	......	....	Maji Moto, Africa
107A } 108A }	2	M	Stork, Marabou......... *Leptoptilos crumeniferous* (Lesson)	7.130	30.14	0.64	2.06	55.24	110	27.89	42.94	72.23	......	692	Maji Moto, Africa
257	1	M	Swallow, Barn.......... *Hirundo erthrogaster*	0.0215	0.904	0.006	0.007	0.302	......	......	......	......	......	....	Little Mountain, Ohio
256 } 258 }	2	F	" "	0.021	0.879	0.0083	0.0085	0.283	......	......	......	......	......	....	Little Mountain, Ohio

27	1	F	Teal, Green-winged..... *Nettion carolinensis*	0.305	3.116	0.0281	0.0430	2.88	8.17	1.16	3.105	9.218	42.0	33.84	Churchill, Canada
....	10	F	Starlings.............. *Sturnus vulgaris*	0.05835	1.8248	0.0063	0.0113	0.8688	2.1952	1.056	1.080	1.089	0.0411	5.6575	Cleveland, Ohio
....	15	M	" "	0.05736	1.8701	0.0063	0.0147	0.9293	1.9874	0.8384	0.9829	1.0736	0.0665	5.2473	Cleveland, Ohio
9A	1	F	Vulture................ *Pseudogyps africanus*	5.270	19.60	0.40	0.46	37.85	70.20	16.24	35.80	......	......	....	Maji Moto, Africa
			CARNIVORES												
132	1	M	Bear, American......... *Euarctus americanus*	551.25	....	25.0	6.0	......	......	......	176.5	......	......	....	Zoo specimen, Detroit, Mich. (goiter)
600	1	F	Bear, Grizzly........... *Ursus horribilis*	142.88	233.9	53.6	65.5	1,132.5	......	......	547.8	......	304	....	Zoo specimen, Cleveland, Ohio
624	1	M	Bear, Polar............. *Thalarctos maritimus*	199.57	489	17.3	10.8	1,161	4,539	10.1	1,292	1,701	245	8,164	Zoo specimen, Cleveland, Ohio (goiter)
567	1	F	" "	317.50	507	21.5	29.8	1,220	4,126	......	730	2,580	......	....	Zoo specimen, Cleveland, Ohio
103	1	F	Cat, Civet............. *Spilogale arizonae arizonae*	....	6.0	0.028	0.086	......	......	......	3.78	......	......	....	Catalina Mountains, Arizona
99	1	M	" "	....	....	0.007	0.072	......	......	......	4.35	......	......	....	Catalina Mountains, Arizona
....	1	....	Cat, Domestic.......... *Felis domesticus*	0.576	16.0	......	0.5	3.0	31	......	7.5	7.5	2.5	....	Juvenile, Panama
....	2	M and F	" "	1.542	18.0	......	1	10	86	......	16.5	15	6.5	....	Adult, Panama
756, 48F	2	F	" "	2.885	23.46	0.21	0.639	12.38	92.67	10.06	22.07	32.6	6.48	355	Key West, Fla.
232, 1253, 1254, 632, 749	5	M	" "	3.778	28.37	0.408	0.571	16.82	126.8	9.67	44.5	42.7	11.7	33.4	Cleveland, Ohio
36F	...	M	" " (feralized)	5.025	28.23	0.460	0.795	19.61	184.2	11.86	49.94	28.47	11.02	....	Key West, Fla.

CARNIVORES.—(*Continued*)

Catalogue number	Number of animals	Sex	Common and scientific name	Body weight, kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and intestines	Remarks
10A, 67A	2	M	Cat, Genet	1.302	15.89	0.29	0.49	7.51	49.68	3.72	8.93	12.99	......	......	Maji Moto, Africa
			Genetta tigrina suahelica (Matschie)												
153A	1	F	" "	1.525	15.35	0.04	0.19	8.46	58.54	344	14.05	22.55	......	97	Maji Moto, Africa
104, 113	2	M	Cat, Ring-tailed	......	17.1	0.088	0.353	......	......	......	10.22	......	......	......	Arizona
			Bassariscus astutus												
152A	1	F	Cat, Wildcat	2.700	28.48	0.10	0.19	5.86	32.75	6.41	10.07	9.0	......	78	Maji Moto, Africa
			Felis ocreata												
148	1	M	Cheetah	22.20	2.449	1.09	......	......	......	82.5	......	......	......	......	Zoo specimen, Cleveland, Ohio
			Acinonyx jubatus												
1292	1	M	" "	40.82	......	13.05	2.91	159	1,000	49	145	360	47.2	......	Zoo specimen, Cleveland, Ohio (goiter)
......	1	......	Coati mundi	0.399	23.3	......	0.4	2.0	17.5	......	4.0	5.3	1.8	......	Adult, Panama
			Nasua narica panamaensis (Allen)												
714	1	M	" "	6.25	44.17	1.54	0.54	37.97	150	2.33	......	43	5.50	......	Guatemala, C.A.
667	1	F	Coyote	8.510	84.24	0.6901	1.049	72.71	292.5	11.11	80.07	61.28	14.21	......	Cedar Vale, Kansas
			Canis latrans												
89	1	F	" "	......	80.0	1.8	0.560	......	......	......	80.69	......	......	......	Kaibab Forest, Arizona (goiter)
213A, 214A, 216A	3	M	Dog	14.56	79.99	1.14	1.74	127	760	10.97	84.8	362	......	1,553	Maji Moto, Africa—African mongrel
			Canis familiaris												
180A, 212A	2	F	" "	12.47	81.14	1.35	1.45	120	665	13.11	88	288	......	1,430	Maji Moto, Africa
673	1	M	Greyhound	24.49	105.9	2.34	3.36	308.8	1,067	12.36	105.9	363.5	175	......	Memphis, Tenn.

35 57	2	M	Huskies	31.75	130.7	2.85	3.16	297	1,438	10.88	248	431	......	1,944	Churchill, Canada
276	1	M	"	26.94	79.3	11.3	10.6	......	......	......	216.2	......	......	......	Zoo—originally from Alaska (goiter)
8F 228F	2	F	Mongrel	14.75	66.53	1.11	1.09	95.4	300	9.73	44.65	108.1	......	712	KeyWest, Fla.
362 604	2	M	"	11.26	87.6	3.36	1.54	126.3	465.2	16.85	......	138.4	......	......	Cleveland, Ohio
120 369 370 367	4	F	Dog, Collie-Police	23.71	84.63	2.93	2.07	182.6	693	......	152	192.7	......	......	Cleveland, Ohio
......	1	......	" " "	19.28	90	8.6	7.0	......	......	......	......	......	......	......	Adult, Panama
615	1	M	Dog, Police	38.42	95.2	23.8	6.1	261	......	......	......	......	......	......	Cleveland (goiter)
134	1	F	Fox, Bat-eared *Otocyon megalotis*	3.335	26.09	0.49	0.49	24.65	125	4.65	31.91	35.05	......	660	Maji Moto, Africa
90 91	2	F	Fox, Gray *Urocyon cinereo argenteus scotti*	......	32	0.066	0.281	......	......	......	17.75	......	......	......	White Tank Mountains, Arizona
69F	1	M	" "	3.749	37.28	0.154	0.390	21.97	50.80	4.02	17.43	19.12	......	425	Miami, Fla.
92 95 100 115	4	M	" "	......	38	0.266	0.329	......	......	......	24.09	......	......	......	White Tank Mountains, Arizona
138	1	F	Fox, Red *Vulpes fulva* (Desmarest)	......	......	0.405	0.420	......	......	......	24.95	......	......	......	Little Mountain, Ohio
647	1	F	" "	4.625	53.30	0.1469	0.5285	41.75	......	4.18	......	......	......	......	Churchill, Canada
648	1	M	Fox, White *Vulpes lagopus innuitus* (Merriam)	3.385	44.50	0.763	0.353	......	......	5.8	......	......	......	......	Churchill, Canada
138A 28A	2	......	Hyena, Spotted *Crocuta crocuta*	62.37	175	6.68	15.08	447	3,194	40.42	400	6,809	......	6,804	Maji Moto, Africa
95A 140	2	M	Jackal *Thos mesomelas*	2.85	46	0.78	0.508	21.33	122.5	6.8	23.03	30.08	......	308	Lake Manyara and Kītete Plains, Africa—one thyroid enlarged

CARNIVORES.—(*Continued*)

Catalogue number	Number of animals	Sex	Common and scientific name	Body weight, kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and intestines	Remarks
678	1	F	Jaguar *Felis onca*	34.47	147	1.72	7.46	186	894	17.28	164.5	576	62.12	....	Zoo, Cleveland—Jungle bred, South America
709	1	F	Kinkajou *Potos flavus aztecus*	2.62	31.05	0.56	0.19	14.3	98.6	1.9	....	78.5	....	....	Guatemala City, Guatemala
608	1	M	Leopard *Felis pardus*	48	135	48.55	6.93	200	900	31.4	....	500	104.3	....	Zoo, Detroit, Mich. (goiter)
561	1	F	Leopard, Infant	8.618	121	1.3	2.3	52	278	....	86	183	....	....	Zoo, Cleveland, Ohio
131	1	F	Lion *Felis leo*	83.91est.	....	23.5	14.5	455	....	....	535	....	....	....	Zoo, Detroit, Mich. (goiter)
185	1	F	"	90.72est.	....	9.17	5.75	327.3	....	....	....	....	....	....	Beatty circus (killed in combat)
144	1	F	" (cub)	62.7 est.	....	7.41	7.24	....	....	....	325.4	....	....	....	Hearst Lion Farm, San Simeon, Calif.
267	1	F	" (cub)	50.9 est.	166.7	165	8.4	363.5	1,360	....	....	1,200	....	....	Zoo, Toledo, Ohio, (goiter)
1320	1	F	"	117.93	232	840	14 est.	810	3,825	52.40	624	2,425	265	....	Zoo, Cleveland, Ohio (goiter)
219	1	M	"	161.52	245.7	1,412	24.9	1,614	....	....	....	2,600	....	....	Zoo, Philadelphia, Penna. (goiter)
579	1	M	"	117.57	194.2	404.5	10.7	713	....	....	....	....	....	....	Zoo, Cleveland, Ohio (goiter)
689	1	M	"	94.86	247.82	95.37	21.34	743.2	2,095	51.8	477.6	1,580	157	....	Zoo, Cleveland, Ohio (goiter)
1450	1	M	"	126.08	248.5	1,285	14.72	1,078	3,510	55.14	684	3,838	....	....	Zoo, Cleveland, Ohio (goiter)

37A	1	M	"	195.4	261	22.52	34.64	1,175	6,000	54.72	1,610	2,000	825	......	Maji Moto, Africa
38A	1	M	"	186.36	255	18.62	30.82	860	5,450	63.74	......	2,600	265	......	Maji Moto, Africa
612	1	M	Lion, Mountain........ *Felis oregonensis*	28.79	106.7	2.20	9.6	184	1,255	9.2	131.7	326	......	......	New Mexico
106	1	F	" "	......	......	1.6	4.1	......	......	......	......	......	......	......	Catalina Mountains, Arizona
98	1	M	Lynx........ *Lynx baileyi*	......	......	0.35	0.60	......	......	......	24.6	......	......	......	Florence, Ariz.
159A	1	M	Mongoose........ *Ichneumia albicauda*	4.40	28.30	0.21	0.61	28.30	61	4.0	34.96	58	......	275	Maji Moto, Africa
571	1	M	Puma........ *Felis bangsi costaricensis* (Merriam)	26.25	129	1.40	10.2	......	......	......	......	......	......	......	Juvenile, Panama
......	1	......	Raccoon........ *Procyon lotor pumilis* (Miller)	5.175	40	1.33	3.22	......	......	......	......	......	......	......	Adult, Panama
64	1	F	" "	2.226	33.55	0.190	1.55	19.73	140	3.32	35.85	19.41	......	225	Key West, Fla.
563	1	F	" "	4.536	40.5	195	1.4	31.2	136	......	37	38	13.8	......	Zoo, Cleveland, Ohio (goiter)
562	1	M	" "	5.216	42.7	261	0.9	42.5	187	......	35.7	187	14.6	......	Zoo, Cleveland, Ohio (goiter)
168F	1	F	" "	......	......	0.222	1.651	......	......	......	......	......	......	......	Cumberland Island, Georgia
321	1	M	Skunk *Mephitis mephitis*	1.700	10.3	0.274	0.468	9.82	45.7	......	10.1	27.1	......	......	New York State
110, 127	2	F	" "	2.260	10	0.055	0.305	......	......	......	7.86	......	......	......	Cleveland, Ohio
102, 111	2	M	Skunk, Hog-nosed........ *Conepatus mesoleucus*	......	15.5	0.068	0.279	......	......	......	11.21	......	......	......	Catalina Mountains, Arizona
117	1	F	" "	......	16.0	0.054	0.211	......	......	......	7.51	......	......	......	Arizona
139	1	M	Serval........ *Felis capensis*	9.955	66.74	0.42	1.03	37.3	225	18.02	100	125	......	400	Maji Moto, Africa
87, 151	2	F	" "	5.819	53.16	0.33	0.40	28.45	86.18	10.23	40.34	50.72	......	350	Maji Moto, Africa
288	1	F	Tiger........ *Felis tigris*	160	225	68.2	16	432	1,818	......	......	1,020	915	......	Zoo, Cleveland, Ohio (goiter)

Carnivores.—(*Continued*)

Catalogue number	Number of animals	Sex	Common and scientific name	Body weight, kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and intestines	Remarks
216	1	M	Tiger........ *Felis tigris*	209	302	50.5	20.8	698	......	......	......	1,888	......	......	Jungle-bred captive
53A, 53B, 53C	3	M	Weasel, Arctic........ *Mustela arctica*	0.1693	5.64	0.108	0.015	2.83	9.67	0.153	1.80	3.85	0.713	......	Tavane, Canada
782	1	F	" "	0.121	3.47	0.015	0.030	1.95	5.5	0.110	1.81	3.60	......	......	Cleveland, Ohio
627	1	M	Wolf, Russian........ *Canis lupus lupus*	22.68	119	13	2.4	246	626	18.20	187	807	......	......	Zoo, Cleveland, Ohio (goiter)
672	1	M	Wolf, Timber........ *Canis lubilus*	29.94	152	3.49	3.37	315	925	16.84	223	379	44.3	......	Ely, Minn.
			Pinnepedia												
40	1	F	Seal, Bearded........ *Erignathus barbatus*	109.7	......	6.13	6.95	515	......	......	......	......	......	......	Chesterfield Inlet, Canada, Juvenile
39	1	F	" "	281	460	22.83	22.04	1,245	5,454	63.06	1,320	4,536	......	26,330	Chesterfield Inlet, Canada
613	1	M	Seal........ *Phoca richardi geronimensis*	107.3	442	10.02	6.27	1,435	4,485	60.72	894	1,880	520	......	California
149	1	M	" "	......	378	5.2	6.0	......	......	......	418	......	......	......	Zoo, Cleveland, Ohio
18, 31, 37	3	M	Seal, Ringed........ *Phoca hispida*	39.76	251	3.49	2.49	281	1,244	73.34	273	738	110	2,992	Churchill (2), Chesterfield Inlet (1), Canada
36, 41	2	F	" "	39.68	255	3.44	3.41	302	930	70.20	236	730	150	......	Chesterfield Inlet, Canada
45	1	M	Walrus........ *Odobenus rosmarus* (Linnaeus)	79.38	766	17.52	8.61	731	3,625	......	827	......	520	......	Churchill, Canada, 3 months old

38	1	F	" "	55.79	737	13.68	7.20	650	2,300	13.2	725	1,625	200	2,425	Chesterfield Inlet, Canada, 3 months old
43	1	M	" "	667	1,126	70.04	27.07	4,536	19,504	26.63	4,536	9,072	......	29,484	Tavane, Canada
46, 47, 48	3	M	" "	595.6	....	66.67	20.15	......	......	......	......	......	......	....	Walrus Islands, off Tavane, Canada
			Cetacea												
70	1	M	Porpoise................ *Phocaena phocaena*	142.43	1,735	18.29	10.41	738	2,962	57.19	....	5,250	53.02	13,255	Key West, Fla.
1, 32	2	F	Whale, White............ *Delphinapterus leucas*	303.23	2,354	65.94	29.23	1,722	4,825	22.01	1,857	7,936	153	9,296	Churchill, Canada
7, 19, 33, 34	4	M	" "	447.03	2,349	111.04	29.20	2,454	6,807	31.71	2,214	12,093	200	12,075	Churchill, Canada
748	1	....	Whale, Blue............ *Balaenoptera musculus*	58,059	6,800	3,450	1,385	......	......	......	......	......	......	....	Queen Charlotte Islands, Canada
5C	1	F	Whale, Finback*........ *Balaenoptera physalus*	59,394 (130,946 lb.)	....	......	......	......	......	......	......	......	......	....	Whaling Station, Fields Landing, Calif.
4C	1	M	Whale, Humpback...... *Megaptera nodosa*	37,195 (82,000 lb.)	5,288 (11.66 lb.)	3,237 (7.13 lb.)	....	214,000 (472 lb.)	476,000 (1,050 lb.)	......	192,000 (424 lb.)	....	6,045 (13.33 lb.)	....	Whaling Station, Fields Landing, Calif.
1C	1	M	" "	39,916 (88,000 lb.)	6,800 (15 lb.)	......	....	181,000 (400 lb.)	363,000 (800 lb.)	......	......	......	......	....	Whaling Station, Fields Landing, Calif.
2C	1	M	" "	40,823 (90,000 lb.)	7,229 (15.94 lb.)	2,960 (6.52 lb.)	1,210 (2.66 lb.)	193,000 (425 lb.)	635,000 (1,400 lb.)	980 (2.16 lb.)	......	......	......	....	Whaling Station, Fields Landing, Calif.
3C	1	M	Whale, Sperm.......... *Physeter catodon*	39,009 (86,000 lb.)	†	800 (1.76 lb.)	350 (0.077 lb.)	126,000 (277 lb.)	420,000 (925 lb.)	290 (0.64 lb.)	......	......	......	.. ....	Whaling Station, Fields Landing, Calif.

* See Addendum at end of Appendix.

† Preserved in its bony case, and shipped to Cleveland.

CHIROPTERA

Catalogue number	Number of animals	Sex	Common and scientific name	Body weight, kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and intestines	Remarks
....	5	M and F	Bat, Vampire........... *Desmodus rotundus muriunus* (Wagner)	0.028	0.936	0.028	0.012	......	......	......	......	......	......	......	Adult, Panama

EDENTATES

Catalogue number	Number of animals	Sex	Common and scientific name	Body weight, kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and intestines	Remarks
....	1	....	Ant Bear.............. *Cyclops didactylus dorsalis* (Gray)	0.086	4.11	0.15	0.72	......	......	......	......	......	......	......	Panama
....	1	....	Anteater.............. *Tamanduas tetradactyla chiriquensis* (Allen)	......	......	......	0.25	1.0	4.0	......	2.0	1.0	0.5	....	Infant, Panama
....	1	....	" "	1.409	23	......	1.0	2.0	23	......	12.5	16	1.5	....	Juvenile, Panama
....	2	M and F	" "	3.692	25	......	0.75	18.0	76.5	......	21.0	27.0	7.0	....	Adult, Panama
....	1	M	Armadillo.............. *Dasypus novemcinctus fenestratus* (Peters)	2.086	9.5	0.195	0.83	......	......	......	......	......	......	....	Adult, Panama
....	7	M and F	" "	0.471	6.0	......	0.56	2.3	22.3	......	5.6	5.64	1.6	....	Infant, Panama
....	4	M and F	" "	1.392	8.2	......	1.1	6.0	40.2	......	11.0	10.5	4.0	....	Juvenile, Panama
....	1	F	" "	1.818	8.5	0.16	0.71	......	......	......	......	......	......	....	Juvenile, Panama
....	1	M	" "	3.701	14.2	0.42	0.80	14.7	......	0.38	......	......	......	....	....
....	10	M and F	" "	3.401	7.5	......	1.2	9.0	106	......	16.3	24.0	7.4	....	Adult, Panama
....	1	....	Sloth, Three-toed....... *Bradypus griseus griseus* (Gray)	0.676	15	......	1.0	3.0	20	......	9.0	7.0	2.0	....	Infant, Panama
....	1	F	" "	1.115	14	0.07	0.20	......	......	......	......	......	......	....	Juvenile, Panama
....	1	M	" "	1.601	13.0	0.19	0.30	......	......	......	......	......	......	....	Juvenile, Panama
....	4	M and F	" "	2.005	....	......	1.1	6.1	42	......	12.5	27.4	6.4	....	Juvenile, Panama

....	1	....	" "	2.894	15	0.66	1.16	....	....	......	....	....	......	....	Adult, Panama
....	10	M and F	" "	3.121	15.1	....	0.94	7.5	64.1	......	16.4	29.9	8.0	....	Adult, Panama
....	1	F	" "	3.774	18.0	0.7	1.15	....	....	......	....	....	......	....	Adult, Panama
....	7	M and F	Sloth, Two-toed........ *Choloepus hoffmanni* (Peters)	4.825	23.07	3.307	0.6857	....	....	......	....	....	......	....	Adult, Panama
....	1	F	" "	5.271	26.0	0.30	1.03	....	....	......	....	....	......	....	Adult, Panama
			ELASMOBRANCH FISHES												
47F	1	M	Ray, Electric.......... *Torpedo torpedo*	0.345	0.78	0.029	....	0.22	6.9	1.3	12.9	....	......	....	Key West, Fla.
1F, 73F	2	M	Ray, Sting............. *Dasybatis sabina*	17.58	76.52	1.76	....	47.58	815	30.67	107.2	....	......	410	Key West, Fla.
9F	1	....	" "	2.675	6.03	0.084	....	6.83	....	......	....	....	......	....	Key West, Fla.
63F	1	F	Shark, Sand........... *Carcharias littoralis*	35.38	48.8	1.81	....	41.6	2,875	44.24	96.4	....	98.82	1,375	Miami, Fla.
4F	1	M	" "	35.83	50.03	2.57	....	40.14	2,925	52.21	....	....	150	750	Key West, Fla.
72F	1	F-P	" "	123	82.55	4.05	....	115	....	40.8	....	....	......	....	Miami, Fla.
74F	1	F	Shark, Tiger........... *Galeocerdo tigrinis*	200	107.5	12.73	....	291.5	40,370	88.43	....	....	......	....	Miami, Fla.
			BONY FISHES												
65F	1	F	Barracuda............. *Sphyraena barracuda*	4.803	1.34	0.064	....	7.78	38.93	25.25	....	....	......	260	Key West, Fla.
35F	1	M	" "	5.990	3.83	0.11	....	12.25	62.7	29.07	....	....	......	409	Key West, Fla.
59F	1	F	" "	8.675	2.70	0.060	....	11.60	80.31	45.21	....	....	13.37	430	Key West, Fla.
31F	1	M	" "	9.150	6.3	....	....	60.31	....	38.39	....	....	......	....	Key West, Fla.
1477	1	M	" "	11.33	3.93	....	....	19.27	....	52.54	....	....	......	....	Miami, Fla.
1480	1	F	" "	12.69	4.23	0.345	....	16.05	....	44.50	160	....	......	....	Miami, Fla.
25F	1	M	Bonita................ *Gymnosarda alleterata*	6.291	3.57	0.051	....	29.43	128	33.8	....	....	20.4	351	Key West, Fla.
1151, 1152, 1154, 1155	4	M	Carp.................. *Cyprinus carpio*	1.0421	1.2833	0.0089	....	1.617	....	2.865	6.779	....	2.544	96.44	Cleveland, Ohio
1153, 1156	2	F	" "	1.061	1.191	0.0080	....	1.554	....	3.142	4.88	....	2.32	70.10	Cleveland, Ohio

BONY FISHES.—(*Continued*)

Catalogue number	Number of animals	Sex	Common and scientific name	Body weight, kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and intestines	Remarks
1443, 1446	2	F	Carp. *Cyprinus carpio*	4.942	2.237	0.018	......	8.35	49.60	10.35	......	......	......	......	Cleveland, Ohio
7A	1	M	Catfish (Of genus *Clarias*)	2.900	1.84	......	......	6.1	17.65	......	16.75	......	......	......	Maji Moto, Africa
91A	1	M	"	10.78	8.2	......	......	52.2	......	3.67	76.41	......	......	......	Maji Moto, Africa
1188, 1189	2	M	Cisco. *Argyrosomus artedi*	0.1621	0.2995	......	......	0.39	1.592	1.08	1.81	......	0.155	10.78	Churchill, Canada
1193	1	F	Codfish. *Gadus callarias*	10.6	5.0401	0.620	......	15.90	161.4	60.36	19.93	......	10.09	580.0	Boston, Mass.
1194, 1197, 1205	3	F	" "	2.625	2.2180	0.0257	......	4.09	97.1	26.91	9.4	......	2.01	159.7	Boston, Mass.
1195, 1196, 1198	3	M	" "	2.518	1.9792	0.0476	......	3.90	96.2	26.73	11.40	......	2.15	179.2	Boston, Mass.
1478	1	M	Dolphin. *Coryphaena hippurus*	19.04	9.76	0.360	......	28.37	......	64.00	98.7	......	......	......	Miami, Fla.
2F	1	......	Eel, Green moray. *Gymnothorax funebris*	3.510	0.51	0.054	1.51	4.62	101.5	1.39	......	......	4.28	325	Key West, Fla.
619	1	M	Goldfish. *Carassius auratus*	0.00554	0.069	0.009	......	0.014	......	......	......	......	......	......	Cleveland, Ohio
618	1	F	" "	0.00952	0.097	0.004	......	0.026	......	0.140	......	......	......	0.98	Cleveland, Ohio
49F	1	M	Grouper, Black. *Mycleropercabonacixanthastica* (Jordan and Swaine)	2.712	2.001	0.032	......	2.08	11.66	13.19	......	......	......	55.47	Key West, Fla.

13F	1	M	Grunt, White.......... *Haemulon plumieri* (Lacepede)	0.300	0.81	0.01	......	0.31	3.55	4.47	......	......	0.18	5.19	Key West, Fla.
1199 1200 1201 1202 1203 1204	6	F	Haddock.............. *Melanogrammus aeglefinus*	3.275	2.0502	0.0692	......	5.71	132.6	26.16	11.08	......	2.64	291.5	North Atlantic Ocean
11	1	M	Hogfish............... *Lachnolaimis maximus*	0.480	0.91	0.014	......	0.452	3.70	4.97	......	......	0.35	5.02	Key West, Fla.
43	1	M	Jack, Common.......... *Caranx hippos*	2.305	2.97	0.031	......	4.87	18.7	33.25	......	......	2.66	......	Key West, Fla.
41	1	F	Jack, Yellow.......... *Caranx bartholomoei*	4.274	7.56	0.043	......	11.62	......	9.52	......	......	......	......	Key West, Fla.
22	1	M	" "	4.812	4.72	0.058	......	13.96	65.13	20.22	......	......	8.7	182	Key West, Fla.
3	1	M	Jewfish............... *Promoicrops itaiara* (Lichtenstein)	32.89	2.31	0.32	......	49.23	350	33.6	56.8	......	17	1200	Key West, Fla.
34	1	M	Kingfish.............. *Scomberomorus regalis*	2.43	2.18	0.037	......	5.33	......	......	......	......	......	......	Key West, Fla.
621	1	M	Mackerel.............. *Scomberomorus maculatus*	0.765	0.640	......	......	......	......	......	......	......	......	......	North Atlantic Ocean
19 649	2	F	" "	1.457	1.61	0.030	......	2.93	6.21	7.91	......	......	1.7	2.92	Key West, Fla.
1476	1	F	Marlin, White......... *Makaira albida*	24.94	3.41	0.450	......	47.60	......	171.02	225.0	......	......	......	Miami, Fla.
20	1	F	Muttonfish............ *Lutianus analis*	2.49	2.09	0.048	......	5.12	14.26	19.15	......	......	1.17	......	Key West, Fla.
61	1	F	Palometa.............. *Trachinotus glauous*	8.504	3.08	0.110	......	24.83	86.25	79.13	......	......	7.42	302	Key West, Fla.
623	1	F	Perch................. *Perca flavescens*	0.192	0.337	0.002	......	0.44	2.96	1.4	......	......	......	7.92	Lake Erie, Cleveland
1163 1164 1165 1166 1167 1168	6	M	" "	0.167	0.254	0.0035	......	0.3087	1.476	0.930	0.459	......	0.149	4.85	Lake Erie, Cleveland

Bony Fishes.—(*Continued*)

Catalogue number	Number of animals	Sex	Common and scientific name	Body weight, kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and intestines	Remarks
617	1	……	Pike…… *Esox lucius*	0.82	0.597	……	……	……	……	3.9	……	……	……	……	Lake Erie, Cleveland
1157, 1158, 1160, 1162	4	M	" "	0.3523	0.464	0.0047	……	0.660	3.55	4.88	1.777	……	0.421	21.67	Lake Erie, Cleveland
1159, 1161	2	F	" "	0.3738	0.535	0.0118	……	0.560	3.780	4.915	1.555	……	0.420	20.8	Lake Erie, Cleveland
1479	1	F	Sailfish…… *Istiophorus americanus*	25.20	2.74	……	……	49.15	……	116.32	……	……	……	……	Miami, Fla.
1207, 1208, 1209, 1211	4	F	Salmon…… *Salmo salar*	5.361	1.143	0.0170	……	10.72	96.56	8.014	39.59	……	11.71	230.9	Atlantic Ocean, off Maine coast
1210, 1212	2	M	" "	4.922	1.029	0.010	……	15.22	69.46	7.84	36.20	……	11.00	216.8	Atlantic Ocean, off Maine coast
695	1	M	" "	3.93	1.257	0.035	……	6.42	……	……	……	……	……	……	Atlantic Ocean, off Maine coast
694	1	F	" "	5.412	1.387	0.137	……	7.92	79.7	8.9	……	……	……	……	Atlantic Ocean, off Maine coast
1440	1	F	Shad…… *Alosa ohiensis*	0.615	0.527	0.010	……	2.21	……	1.91	4.25	……	……	……	Port Clinton, Ohio
1441	1	F	Sheepshead…… *Aplodinatus grunniens*	0.937	0.891	0.012	……	1.71	……	6.88	……	……	……	……	Port Clinton, Ohio
620	1	……	Smelt…… *Osmerus mordax*	0.04766	1.09	0.006	……	1.29	……	……	……	……	……	……	Lake Erie, Cleveland

14	1	M	Snapper, Vermilion...... *Rhomboplites aurorubens* (Cuvier and Valenciennes)	0.202	0.65	0.006	......	0.33	1.76	2.54	......	......	......	3.11	Key West, Fla.
1178	1	M	Trout, Brown.......... *Salmo trutta*	0.292	0.570	0.007	......	0.385	3.885	2.29	1.25	......	1.205	20.10	Castalia, Ohio
1213, 1214, 1215, 1216, 1217	5	F	Trout, Northern........ *Cristivomer namaycush*	3.24	1.323	0.0134	......	5.17	52.43	9.33	27.97	......	1.77	220.3	Manitoulin Island, Ontario
1218	1	M	" "	2.50	1.233	0.0095	......	4.34	36.00	7.26	20.92	......	2.16	154.7	Manitoulin Island, Ontario
1170, 1173, 1174, 1175	4	F	Trout, Rainbow........ *Salmo irideus*	0.2177	0.415	0.0044	......	0.280	2.156	1.519	1.093	......	0.585	19.35	Adult, Castalia, Ohio
1171, 1172	2	M	" "	0.2608	0.454	0.0074	......	0.307	2.598	1.809	1.443	......	0.54	25	Adult, Castalia, Ohio
1176e3	1	F	" "	0.1101	0.315	0.0022	......	0.155	1.415	1.13	0.485	......	0.265	8.00	Yearling, Castalia, Ohio
1177	1	......	" "	0.0428	0.178	0.0026	......	0.095	0.610	0.665	0.123	......	0.115	4.25	Infant, Castalia, Ohio
1185, 1186	2	M	Trout, Salmon.......... *Salmono gairdneri*	2.75	0.818	0.0163	......	6.22	40.74	4.35	20.64	......	2.86	89.38	Churchill, Canada
622	1	M	Trout, Speckied........ *Salvelinus fontinalis*	0.85	0.83	......	......	......	......	1.9	......	......	......	25.5	Pennsylvania
697	1	F	" "	0.255	0.439	......	......	0.99	5.86	2.02	......	......	0.22	16.01	Pennsylvania
696	1	M	" "	0.2301	0.466	......	......	1.15	3.75	1.94	3.32	......	0.17	28.24	Pennsylvania
26	1	M	Tuna.................. *Thunus secundodorsalis*	5.21	3.09	0.056	......	31.22	139	85.81	......	......	......	216	Key West, Fla.
15	1	M	Turbot................ *Balistes caroliniensis*	0.295	0.872	0.005	......	0.364	12.86	3.36	......	......	0.09	5.54	Key West, Fla.
1145, 1149, 1150	3	M	Whitefish............. *Coregonus clupeaformis*	0.7465	0.503	0.0153	......	0.892	8.84	2.34	7.98	......	0.75	42.88	Lake Erie

Bony Fishes.—(*Continued*)

Catalogue number	Number of animals	Sex	Common and scientific name	Body weight, kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and intestines	Remarks
1146, 1147, 1148	3	F	Whitefish............... *Coregonus clupeaformis*	0.7986	0.593	0.0091	...	0.973	10.61	2.69	8.2	...	0.60	38.67	Lake Erie
12	1	F	Yellowtail (fish)........ *Ocyurus chrysurus* (Bloch)	0.255	0.94	0.007	...	0.37	2.41	4.2	1.45	...	0.30	7.72	Key West, Fla.
			Insectivores												
631	1	M	Mole.................. *Scalopus aquaticus*	0.0396	1.16	0.0095	0.0175	0.272	1.548	...	0.629	0.737	...	...	Little Mountain, Ohio
...	39	F	Shrew*................ *Blarina brevicauda*	0.0163	0.3443	0.0021	0.0037	0.1723	0.8896	0.0011	0.2041	0.3575	...	...	Cleveland
...	29	M	" "	0.0188	0.352	0.0026	0.0048	0.1922	1.092	0.0018	0.240	0.4214	...	...	Cleveland
			Marsupials												
...	2	...	Opossum............... *Didelphis marsupialis etensis* (Allen)	0.215	4.5	0.14	...	...	...	...	...	...	...	...	Infant, Panama
...	3	...	" "	0.224	3.3	...	0.38	1.41	13.0	...	0.57	2.3	2.7	...	Infant, Panama
...	8	M and F	" "	0.666	3.8	...	1.01	3.4	...	5.6	8.0	2.83	...	...	Juvenile, Panama
...	4	M and F	" "	1.147	4.8	...	1.0	5.0	67	...	7.5	9.5	...	...	Adult, Panama
...	1	...	Opossum, Woolly....... *Philander laniger pallidus* (Thomas)	0.158	...	...	0.25	1.5	7.0	...	2.0	2.0	1.0	...	Juvenile, Panama
...	1	...	" "	0.222	...	...	1.0	3.0	9.0	...	4.0	3.0	1.5	...	Adult, Panama

PRIMATES

....	1	F	Baboon............... *Papio cynocephalus*	7.900	140	0.437	2.30	......	......	......	......	......	......	......	Juvenile, Department of Physiology, Yale University
23A	1	M	" "	19.51	175	1.8	2.05	79.94	367	13.18	70.92	175	......	......	Moto Umbo, Africa
93A	1	F	Monkey, Gray.......... *Cercopithecus mitis kibonotensis* (Lonnberg)	1.22	50.3	0.172	0.22	6.56	29.65	......	7.84	9.98	......	250	Maji Moto, Africa
92A	1	M	" "	2.9	61.46	0.39	0.41	7.59	50	9.94	8.71	14.39	......	350	Maji Moto, Africa
4A	1	M	" "	4.55	66.6	0.15	0.902	35.32	106.13	......	20.63	41.63	......	......	Maji Moto, Africa
....	10	M and F	Howler, Black.......... *Aloutta palliata inconsonans* (Goldman)	0.673	42.88	......	0.588	3.9	22.65	......	6.19	9.88	6.8	......	Infant, Panama
....	3	M and F	" "	2.683	48.1	......	0.67	14.1	84.9	......	15.4	22.7	36.75	......	Juvenile, Panama
....	28	M and F	" "	6.174	50.34	......	1.16	20.67	201	......	35.95	38.68	45.68	......	Adult, Panama
....	2	F	" "	4.309	54.25	0.45	0.8	......	......	......	......	......	......	......	Juvenile, Panama
....	2	F	" "	6.577	54.05	0.55	0.95	......	......	......	......	......	......	......	Adult, Panama
....	2	M	" "	7.938	53.45	0.55	0.95	......	......	......	......	......	......	......	Adult, Panama
....	2	....	Howler, Brown......... *Aloutta palliata palliata*..	0.429	37	......	0.45	1.9	13.3	......	3.2	6.5	1.7	......	Infant, Panama
....	5	M and F	" " "	1.209	37.6	......	1.6	8.0	41.9	......	12.5	11.5	2.8	......	Juvenile, Panama
....	6	M and F	" " "	3.119	42.3	......	1.5	7.8	118	......	21.33	28.3	3.33	......	Adult, Panama
224	1	F	Humboldt............. *Lagothrix humboldti*	5.26	86.2	0.45	1.2	48	......	......	......	63.5	......	......	Adult, South America
156A	1	F	Lemur................ *Galago senegalensis*	0.20	5.0	0.015	0.125	1.38	6.03	3.7	1.54	1.44	......	17.6	Maji Moto, Africa
221	1	F	Lemur, Ring-tailed...... *Lemur catta*	1.725	21.8	0.27	0.232	8.2	......	......	......	24.7	......	......	New York
405	1	F	Macaque, Rhesus....... *Macacus rhesus*	1.390	72.0	0.179	0.885	5.3	57.2	......	9.8	6.2	......	......	Juvenile, Cleveland Clinic laboratory

* Preserved weights.

PRIMATES.—(*Continued*)

Catalogue number	Number of animals	Sex	Common and scientific name	Body weight, kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and intestines	Remarks
....	7	F	Macaque, Rhesus....... *Macacus rhesus*	3.627	93.1	0.578	0.996	12.2	......	......	......	68.5	......	....	Yale University and Cleveland Clinic laboratory
....	4	M	" "	3.292	91.7	0.611	0.75	12.7	69	35	......	......	......	....	Yale University and Cleveland Clinic laboratory
....	1	....	Monkey, Night......... *Aotus zonalis* (Goldman)	0.212	....	....	1.0	1.5	8.0	......	2.0	2.0	1.0	....	Infant, Panama
....	18	M and F	Monkey, Night.........	1.926	88.6	0.785	1.06	7.65	74.5	......	11.6	17.3	8.6	....	Juvenile, Panama
....	11	F	" "	9.163	109	1.28	2.12	......	......	......	......	......	......	....	Adult, Panama
....	6	M	" "	8.89	118	1.42	2.23	......	......	......	......	......	......	....	Adult, Panama
....	19	M and F	Spider, Red............ *Ateles geoffroyi* (Kuhl)	1.029	74.79	....	1.04	4.49	42.77	......	7.76	11.98	14.5	....	Juvenile, Panama
....	11	M and F	" " "	2.805	103	....	1.06	14.52	98.97	......	16.97	26.99	29.32	....	Juvenile, Panama
....	63	M and F	" " "	7.63	107	....	1.75	32.5	213	......	31.2	51.38	40.8	....	Adult, Panama
....	5	F	" " "	0.860	64.0	0.175	0.585	......	......	......	......	......	......	....	Infant, Panama
....	5	F	" " "	5.143	110.6	0.798	1.65	......	......	......	......	......	......	....	Juvenile, Panama
....	3	M	" " "	4.999	94.7	0.64	2.0	......	......	......	......	......	......	....	Juvenile, Panama
....	6	M	" " "	7.787	117	0.90	2.05	......	......	......	......	......	......	....	Adult, Panama
....	14	F	" " "	8.912	102.9	1.04	1.95	......	......	......	......	......	......	....	Adult, Panama
....	2	....	Spider, Black.......... *Ateles dariensis* (Goldman)	0.407	58.0	....	0.75	2.75	19	......	4.5	6.5	2.0	....	Infant, Panama
....	18	M and F	" "	1.926	88.6	0.785	1.06	7.65	74.5	......	11.6	17.3	8.6	....	Juvenile, Panama
....	11	F	" "	9.163	108.8	1.28	2.12	......	......	......	......	......	......	....	Adult, Panama
....	6	M	" "	8.89	118.4	1.42	2.23	......	......	......	......	......	......	.....	Adult, Panama

....	133	M and F	Squirrel (Marmoset)..... *Leontocebus geoffroyi* (Pucheran)	0.191	9.67	....	0.56	1.34	9.33	......	1.87	3.13	1.16	....	Infant, Panama
....	4	F	" "	0.340	10.4	0.10	0.25	......	......	......	......	......	......	....	Juvenile, Panama
....	3	M	" "	0.453	11.1	0.133	0.23	......	......	......	......	......	......	....	Juvenile, Panama
....	19	M and F	" "	0.475	11.04	....	0.53	3.02	16.53	......	2.89	3.91	1.38	....	Juvenile, Panama
....	8	M and F	" "	0.793	19.9	....	0.63	3.91	25.41	......	4.24	8.48	1.65	....	Adult, Panama
....	8	M	" "	0.903	24.00	0.11	0.30	......	......	......	......	......	......	....	Adult, Panama
....	2	M	Sykes................ *Cercopithecus*	4.937	60.7	1.14	0.878	29.97	119.6	......	10.70	21.36	85.16	....	Maji Moto, Africa
69A } 70A }	2	M	Vervet................ *Cercoptihecus Aethiops centralis,* (Neumann)	4.185	57.75	0.175	0.735	19.98	94.40	8.82	15.89	17.01	......	....	Maji Moto, Africa
93A	1	F	" "	1.225	50.3	0.172	0.220	6.56	29.65	......	7.84	9.98	......	250	Juvenile, Maji Moto, Africa
....	4	F	Whiteface............. *Cebus capucinus linnaeus*	2.718	71.6	0.4	1.43	......	......	......	......	......	......	....	Panama
....	5	M	" " "	3.833	73.3	0.38	1.23	......	......	......	......	......	......	....	Panama
....	6	F	" " "	1.252	60.8	0.26	0.70	......	......	......	......	......	......	....	Juvenile, Panama
....	7	M	" " "	1.725	75.5	0.34	0.61	......	......	......	......	......	......	....	Juvenile, Panama
....	14	M and F	" " "	3.101	72.18	....	1.06	18.6	......	......	14.3	34.07	11.3	....	Adult, Panama
....	6	M and F	" " "	1.317	66	....	0.97	7.53	......	......	8.56	20.44	5.7	....	Juvenile, Panama
....	27	M and F	" " "	0.590	53.28	....	0.568	3.06	......	......	4.04	7.93	2.10	....	Infant, Panama
....	60	M and F	Yellow Titi........... *Saimiri orstedii orstedii reinhardt*	0.607	19.9	....	0.63	3.68	25.6	......	3.99	7.20	0.9	....	Adult, Panama
....	3	M	" "	0.907	25.3	0.15	0.447	......	......	......	......	......	......	....	Panama
....	2	....	" "	0.167	19.4	....	0.20	0.85	7	......	1.3	2.5	0.3	....	Infant, Panama
....	2	....	" "	0.24	22	....	0.45	1.25	12	......	2.5	4.9	0.65	....	Juvenile, Panama
....	3	F	" "	0.603	25	0.16	0.323	......	......	......	......	......	......	....	Adult, Panama
			ANTHROPOIDS												
....	1	F	Chimpanzee........... *Troglodytes niger*	....	....	....	3.8	......	......	......	......	......	......	....	Yale University Department of Physiology

ANTHROPOIDS.—(*Continued*)

Catalogue number	Number of animals	Sex	Common and scientific name	Body weight, kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and intestines	Remarks
....	1	F-P	Chimpanzee............ *Troglodytes niger*	....	....	8.0	8.9	......	......	......	......	......	......	....	Yale Univ. Department of Physiology
215	1	M	" "	25.75	430.5	10.1	5.0	184.6	......	......	......	......	......	....	Emaciated specimen from New York
218A	1	M	" "	52.16	440	4.85	8.93	250	1,210	......	210	600	......	6,200	Budonga Forest, Masindi, Uganda, Africa
219A	1	F	" "	43.99	325	4.55	8.4	219	......	......	......	......	......	....	Budonga Forest, Masindi, Uganda, Africa
....	1	M	Gorilla................. *Gorilla gorilla*	181	....	6 est.	35 est.	......	......	......	......	......	......	....	American Museum of Natural History, New York
1291	1	M	Chinese...............	57.2	1,248	21.54	10.1	......	......	......	......	......	......	....	Age: 70 years, Australia
1339	1	M	"	....	1,297	13.3	5.35	......	......	......	......	......	......	....	Age: ? Hawaii
1338	1	M	"	....	1,268	11.4	9.9	......	......	......	......	......	......	....	Age: ? Hawaii
1452	1	M	"	83.89	1,480	13.99	7.88	555	2,030	......	315	......	180	....	Honolulu, T. H.
1340	1	M	Hawaiian..............	95	1,235	16.7	....	430	......	......	......	......	......	....	Age: 36 to 40. Hawaii
755	1	M	Maya-Quiché Indian....	42	1,270	35	15	220	1,040	......	185	1,315	60	....	Age: 25. Death from Tuberculosis
757	1	M	" " "	43.4	1,375	80	14	210	1,270	......	170	755	80	....	Age: 35. Death from septicemia (goiter)
758	1	M	" " "	49.9	1,400	30	10	240	......	......	......	......	......	....	Age: 32. Death from double pneumonia

1169	1	M	" " "	36.3	1,260	11.1	5.6	155	......	......	......	......	......	......	Age: 45. Death from cachexia
1334	1	M	" " "	45	1,190	108	10	226	......	......	......	......	......	......	Age: 32. Death from pneumonia (goiter)
1336	1	M	" " "	37	1,100	10	5.0	159	......	......	......	......	......	......	Age: 17. Death from cachexia
1335	1	F	" " "	45.8	1,000	10	10	225	......	......	......	......	......	......	Age: 28. Death from cachexia
1341	1	F	Filipino..............	43.09	1,109	25.1	......	200	......	......	......	......	......	......	Age: 39. Hawaii
1337	1	M	"	40.83	1,513	16.8	9.3	......	......	......	......	......	......	......	Age: 53. Hawaii
751	1	M	Aborigine, Australian....	76.2	1,348	36.5	4.2	......	......	......	......	......	......	......	Age: 66. Australia. Death from pneumonia
1312	1	M	Negro, American........	86.2	1,265	19.8	16.7	365	1,520	......	......	......	......	......	Age: 41. American born
1255	1	M	" "	71.2	1,280	18.2	11.8	465	1,500	......	......	......	......	......	Age: 24.
1434	1	M	" "	72.57	1,050	34.2	11.4	320	1,980	......	178	......	......	......	New York
753, 754, 4, 8	4	M	" "	73	1,365	31.77	12.69	389	......	......	259	......	......	......	Age: 45. New Orleans, La. (2) and Cleveland, Ohio (2)
1316	1	M	White, American........	78.5	1,540	37.3	16.4	331	2,010	......	292	......	......	......	Age: 25. Czechoslovakian descent
1327	1	M	Dane.................	36	1,370	14	11	220	......	......	......	......	......	......	Age: 13. Denmark
1333	1	F	"	61	1,200	17	13	300	......	......	......	......	......	......	Age: 47. Denmark
1332	1	F	"	46	1,160	23	14	260	......	......	......	......	......	......	Age: 68. Denmark
1330	1	F	"	43	1,240	14	18	320	......	......	......	......	......	......	Age: 65. Denmark
1326	1	F	"	63	1,180	17	14	450	......	......	......	......	......	......	Age: 78. Denmark
1324	1	F	"	43	1,350	15	13	220	......	......	......	......	......	......	Age: 50. Denmark
1323	1	F	"	44	1,300	10	......	310	......	......	......	......	......	......	Age: 44. Denmark
1322	1	F	"	45	1,140	15	......	410	......	......	......	......	......	......	Age: 60. Denmark
1321	1	M	"	51	1,500	24	......	380	......	......	......	......	......	......	Age: 55. Denmark
1325	1	M	"	83	1,420	29	......	520	......	......	......	......	......	......	Age: 68. Denmark

ANTHROPOIDS.—(*Continued*)

Catalogue number	Number of animals	Sex	Common and scientific name	Body weight, kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and intestines	Remarks
1328	1	M	Dane..................	56	1,570	47	19	380	......	.....	......	......	.....	....	Age: 28. Denmark
1329	1	M	"	61	1,490	26	17	410	......	.....	......	......	.....	....	Age: 39. Denmark
1331	1	M	"	51	1,310	27	15	290	......	.....	......	......	.....	....	Age: 55. Denmark
1314	1	M	White, American........	81.6	1,350	42	12	370	1,200	.....	320	......	.....	....	Age: 22. German descent
762	1	M	" "	....	1,450	42.63	9.42	330	1,500	.....	110	1,280	100	....	Age: ? Irish descent
1311	1	M	" "	79.4	1,274	35	12.9	390	1,970	.....	......	......	.....	....	Age: 54. Polish descent
1313	1	M	" "	81.6	1,130	20	16.6	400	1,730	.....	......	......	.....	....	Age: 54. Polish descent
1459	1	M	" "	58.97	1,330	23	11.4	280	1,460	.....	310	......	130	....	Irish, New York
1444	1	M	" "	58.97	1,310	31	22.1	308	1,100	.....	208	......	.....	....	Jewish, New York
1445	1	M	" "	59.42	1,410	63.4	12.6	265	1,505	.....	251	......	.....	....	Bohemian, New York (goiter)
1433	1	M	" "	61.24	1,310	24.6	10.5	250	1,625	.....	208	......	.....	....	New York
1439	1	M	" "	63.50	1,390	18.21	7.9	310	1,330	.....	292	360	135	....	New York
1460	1	M	" "	65.77	1,350	31.7	13.3	270	1,310	.....	260	......	110	....	Irish, New York
1483	1	M	" "	68.93	1,475	11.84	12.5	......	......	.....	......	......	.....	....	Honolulu, T. H.
1461	1	M	" "	70.30	1,260	41.3	13.7	320	1,750	....	280	......	270	....	Italian, New York
1462	1	M	" "	70.30	1,240	27.3	12.9	310	1,730	.....	310	620	150	....	Jewish, New York
1463	1	M	" "	72.57	1,260	21	13.6	260	1,600	....	320	......	.....	....	Jewish, New York
610	1	M	Pole, immigrant........	74	1,377	23.92	10.94	382	......	....	......	......	.....	....	Age: 41. Cleveland, Ohio
759	1	M	White, American........	50	1,480	48.47	14.96	325	1,800	....	330	......	100	....	Age: 45. Scotch descent, New York
1315	1	M	" "	65.8	1,310	23.6	17.6	340	1,780	....	310	......	.....	....	Age: 30. Swedish descent

1319	1	M	" "	74.8	1,410	40	13.8	330	2,250	......	......	......	......	......	Age: 29. Ukranian descent
1318	1	M	" "	74.3	1,360	47.7	9.4	264	2,800	......	......	......	......	......	Age: 30. Ukranian descent
1484	1	F	" "	......	1,215	......	8.5	236	......	......	......	......	......	......	Age: 26
1342	1	F	" "	......	1,300	25.5	......	300	......	......	......	......	165	......	......
217	1	F	" "	57	1,229	22.9	12	340	......	......	......	......	......	......	Age: ? Adult
223, 227, 3	3	M	" "	72.9	1,325	22.77	9.29	331	......	......	......	......	......	......	Age: 41. Descent unknown
			Reptiles												
233	1	M	Alligator *Alligator mississippiensis*	0.105	......	0.35	0.40	1.39	......	......	......	......	......	......	Infant
1191, 1192	2	M	" "	0.351	1.61	0.176	0.076	1.62	6.99	1.73	1.52	2.97	0.211	13.83	Infants, Fla.
134	1	F	" "	......	......	3.50	4.00	......	......	......	161	......	......	......	Jacksonville, Fla.
628	1	F	" "	52.4	7.23	4.28	6.62	137	708	15.96	......	393	......	......	Great Lakes Exposition
171	1	M	" "	80 est.	......	3.11	12.85	......	......	......	......	......	......	......	Cumberland Island, Ga.
218	1	M	" "	109 est.	8.40	6.90	5.80	92.20	......	......	......	1,770	......	......	Musa Island, Fla.
71F	1	M	" "	173	11.20	8.83	5.40	255	900	30.86	......	1,400	......	2,800	Miami, Fla.
1251	1	M	" "	205	14.08	13.32	11.96	318	522	25.54	......	628	135	7,000	Florida
183	1	F	Crocodile *Crocodylus americanus*	90 est.	......	3.77	4.17	......	......	......	......	......	......	......	Musa Island, Fla.
186	1	M	" "	134	15.60	5.20	4.30	134	1,145	......	......	1,125	......	......	Musa Island, Fla.
670	1	F	Gila Monster *Heloderma suspectum*	0.514	0.729	0.152	0.056	4.17	35.00	......	......	6.45	......	......	Arizona
713	1	F	Iguana Lizard *Iguana iguana*	1.34	......	0.117	0.215	2.60	33.35	......	......	3.70	......	42.6	Guatemala, C.A.
68F	1	F	Iguana Lizard* *Amblyrhynchus cristatus*	4.19	1.44	0.040	0.090	21.51	60.40	1.06	11.60	64.4	......	610	Galapagos Islands
......	15	M and F	Lizard *Lacerta viridis*	0.050	0.121	0.008	0.020	......	2.50	......	0.58	......	0.080	......	Europe—data from Naccarati

* Preserved weight.

REPTILES.—(*Continued*)

Catalogue number	Number of animals	Sex	Common and scientific name	Body weight, kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and intestines	Remarks
59	1	F	Lizard................	0.024	0.134	0.005	0.004	0.091	0.628	0.144	0.21	......	......	....	Maji Moto, Africa
679	1	F	Snake, Black.......... *Coluber constrictor*	0.590	0.271	0.131	0.182	6.08	......	......	......	......	......	....	Little Mountain, Ohio
1190	1	M	" "	0.286	0.303	0.056	0.056	0.960	2.57	0.219	2.58	3.45	0.78	12.02	Laboratory specimen
616	1	F	" "	0.417	0.299	0.114	0.103	......	......	0.165	......	4.13	......	....	Little Mountain, Ohio
710	1	F	Boa Imperator......... *Boa imperator*	1.829	0.440	0.15	0.15	5.64	30.37	0.550	9.57	14.0	......	....	Guatemala, C. A.
668	1	F	Snake, Garter......... *Thamnophis sirtalis*	0.052	0.077	......	......	......	......	......	......	......	......	....	Willoughby, Ohio
680	1	F-P	" "	0.057	0.123	0.020	0.076	1.02	......	......	......	......	......	....	Willoughby, Ohio
1139 } 1140 }	2	M	Toad, Horned......... *Phrynosoma coronatum*	0.025	0.1383	0.0044	0.0093	0.1264	0.5705	0.3927	0.6397	0.5705	0.0311	....	Arizona
1137 } 1138 } 1141 }	3	F	" "	0.0249	0.1269	0.0070	0.0087	0.1001	0.8857	0.2761	0.2257	0.6174	0.0105	....	Arizona
178	1	M	Python............... *Python molurus*	6.140	1.123	1.33	2.68	18.50	......	1.12	......	......	......	....	Enguruka, Africa
....	20	M and F	Snake, Water.......... *Tropidonotus natrix*	0.070	0.1	0.01	0.035	......	2.80	......	0.88	......	0.12	....	Europe; data from Naccarati
66F	1	F	Water Moccasin........ *Agkistrodon piscovoris*	0.728	0.64	0.50	1.06	4.77	64.45	0.61	13.47	22.62	5.57	300	Everglades, Fla.
....	6	M and F	Snake, Green Water.... *Zamenis viridis flavus*	0.22	0.209	0.045	0.08	......	4.82	......	1.93	......	0.125	....	Europe; data from Naccarati
....	30	M and F	Turtle................ *Emys europea*	0.250	0.25	0.025	0.028	......	7.3	......	1.38	......	0.16	....	Europe; data from Naccarati

....	30	M and F	Turtle........	0.320	0.30	0.036	0.031	....	8.5	....	1.55	....	0.18	....	Europe; data from Naccarati
			Testudo graeca												
700	1	M	Turtle........	2.163	1.36	0.125	0.413	7.05	53.5	1.35	8.45	31.95	2.25	108.5	Thompson, Ohio
			Clemmys guttatus												
66A	1	F	Turtle........	5.125	0.98	0.48	0.62	13.43	160	0.72	24.50	85	....	....	Maji Moto, Africa
			Chelydra serpentina												
62F	1	F	Turtle, Green........	68.04	5.81	3.46	3.27	180	540	21.08	....	....	62.57	....	Key West, Fla.
			Chelonia midas												
6F	1	M	" "	114.30	8.60	24.55	3.84	435	775	66.20	840	2,650	250	8,750	Key West, Fla.
1252	1	M	Turtle........	0.185	....	....	....	0.57	....	....	0.20	4.40	....	....	Cleveland, Ohio
			Clemmys guttatus												
325	1	F	Turtle, Leatherneck.....	3.253	2.50	0.51	0.44	16.0	90.0	....	15	....	....	....	Key West, Fla.
			Amyda forex												
601	1	M	Turtle, Snapping........	1.848	1.01	0.59	0.51	12.88	184	1.21	15.9	34.90	16.41	....	Sandusky, Ohio
			Macrochelys lacertina												

RODENTS

....	1	....	Agouti, Brown........	1.400	15.00	....	0.5	10	60	....	14	10	5	....	Infant, Panama
			Dasyprocta punctata dariensis (Goldman)												
....	3	M and F	" "	2.059	12	....	0.48	9.2	63.22	....	10.7	12.89	5.23	....	Juvenile, Panama
....	2	M and F	" "	3.172	18.34	....	0.98	17.54	85	....	15.39	16.0	6.04	....	Adult, Panama
....	1	M	Agouti, Spotted........	0.891	20.5	0.101	0.40	....	....	....	....	....	....	....	Juvenile, Panama
			Cuniculus paca virgatus (Bangs)												
....	2	M and F	" "	1.373	10	....	1.4	5.5	65.0	....	10.5	16.5	5.00	....	Juvenile, Panama
....	3	M and F	" "	3.627	21.85	....	1.6	16.10	187	....	22.7	23.5	12.07	....	Adult, Panama
....	1	M	" "	4.559	48	0.82	3.1	....	....	....	....	....	....	....	Adult, Panama
1286	1	M	Beaver........	4.18	25.48	0.207	0.228	16.57	99.82	....	35.86	63.47	....	....	Michigan
			Castor canadensis												
1290	1	F	" "	5.83	29.52	0.644	0.752	27.0	203	1.50	72.60	33.3	4.75	....	Michigan
....	2	M and F	Capybara........	27.670	52.21	....	5.2	84.13	577	....	69.75	227	50.58	....	Adult, Panama
			Hydrochoerus isthimius (Goldman)												
....	1	....	" "	7.089	....	....	....	24.18	113	....	28.06	38.50	16.3	....	Infant, Panama

RODENTS.—(*Continued*)

Catalogue number	Number of animals	Sex	Common and scientific name	Body weight, kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and intestines	Remarks
....	3	M and F	Capybara	14.96	....	....	2.72	55.06	5.09	......	81.0	88.99	75.3	....	Juvenile, Panama
33, 49	2	F	Chipmunk *Tamias striatus fisheri* (Howell)	....	1.60	0.0021	0.0137	......	......	......	0.503	......	......	....	San Francisco Crater and Schultz Pass, Ariz.
703, 671	2	M	" "	0.075	2.22	0.030	0.070	0.597	5.55	0.556	0.756	0.719	0.222	4.65	Cleveland, Ohio
34, 35, 38, 51	4	M	" "	....	2.00	0.002	0.015	......	......	......	0.535	......	......	....	San Francisco Crater and Schultz Pass, Ariz.
52, 55, 57, 41, 44	5	F	Gopher, Pocket *Thomonys fulvus fulvus* (Woodhouse)	....	1.32	0.0041	0.012	......	......	......	1.15	......	......	....	Schultz Pass, Ariz.
53, 59	2	M	" "	....	1.35	0.0045	0.013	......	......	......	0.983	......	......	....	Schultz Pass, Ariz.
174, 175	2	F	Gopher, Pocket *Geomys cumberlandius)* (Bangs)	....	....	0.013	0.021	......	......	......	......	......	......	....	Cumberland Island, Ga.
170	1	M	" "	....	....	0.016	0.006	......	......	......	......	......	......	....	Cumberland Island, Ga. (hyperplastic thyroid gland)
173	1	M	" "	....	....	0.028	0.004	......	......	......	......	......	......	....	Cumberland Island, Ga.
775	1	F-P	Guinea Pig *Cavia cutleri*	0.351	3.63	0.070	0.375	1.72	10.94	0.88	2.79	5.86	0.52	....	Young adult, Cleveland, Ohio

1132, 1135	2	M	" "	0.361	4.10	0.053	0.334	1.27	13.80	0.93	3.43	4.62	0.71	....	Young adult, Cleveland, Ohio
773, 1134	2	F	" "	0.324	3.80	0.056	0.316	1.31	31.93	0.95	3.81	3.27	1.08	....	Young adult, Cleveland, Ohio
....	56	F	" "	0.21494	3.32	0.036	0.180	1.29	12.06	......	2.829	2.934	......	....	Cleveland, Ohio
....	46	M	" "	0.21457	3.28	0.035	0.135	1.291	11.73	......	2.821	2.563	......	....	Cleveland, Ohio
....	10	F	" "	0.432	4.00	0.071	0.348	1.67	16.7	1.04	3.72	4.63	0.925	....	Cleveland, Ohio
....	10	M	" "	0.456	4.23	0.096	0.402	1.86	21.17	0.84	4.16	5.12	0.750	....	Cleveland, Ohio
1435, 1436	2	F	Golden Hamsters.......	128.7	1.062	0.0074	0.0118	0.600	6.76	0.226	1.27	0.583	......	....	Cleveland, Ohio
1437, 1438	2	M	" " *Cricetus cricetus*	107.5	1.012	0.0088	0.0302	0.543	5.43	0.212	0.996	0.510	......	....	Cleveland, Ohio
135	1	F	Hare, African........... *Lepus capensis*	2.93	10.23	0.190	0.50	30.0	51.91	7.37	12.20	17.91	......	295	Maji Moto, Africa
248, 251	2	F	Hare, Arctic............ *Lepus arcticus arcticus*	1.901	14.36	0.160	0.240	28.45	66.11	4.59	19.29	43.79	......	....	Tavane, Canada
249, 250	2	M	" " "	2.640	13.90	0.099	0.191	28.87	65.22	4.75	25.44	44.04	......	....	Tavane, Canada
50A, 50C, 50D, 50E	4	F	Lemming, Brown....... *Lemmus trinucronatus* (Richardson)	0.0292	1.126	0.0058	0.0167	0.434	2.33	0.0230	44.04	0.804	......	....	Churchill, Canada
50B	1	M	" "	0.048	1.312	0.0046	0.0251	0.600	3.80	0.0242	0.525	0.740	......	....	Churchill, Canada
3, 4, 10B, 10E	4	M	Lemming, Rock......... *Dicrostonyx rubricatus richardsoni*	0.0521	0.8983	0.0042	0.0138	0.311	2.63	0.1451	0.774	0.827	0.210	....	Churchill, Canada
10A, 10C, 10D	3	F-P	" "	0.0552	0.8447	0.0089	0.0177	0.381	3.05	0.062	0.841	0.884	......	....	Churchill, Canada
171	1	M	Mouse, African......... *Mastomys coucha microdon*	0.0218	0.7132	0.001	0.0095	0.122	0.944	0.075	0.265	0.2408	......	2.63	Maji Moto, Africa
674, 630B, 630C	3	F	Mouse, Jumping*....... *Zapus hudsonicus*	0.0193	0.6961	0.001	0.008	0.1557	1.124	0.028	0.218	0.246	0.0261	....	Little Mountain, Ohio

* Preserved weights.

RODENTS.—(*Continued*)

Catalogue number	Number of animals	Sex	Common and scientific name	Body weight, kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and intestines	Remarks
630A	1	M	Mouse, Jumping*...... *Zapus hudsonicus*	0.0152	0.522	0.003	0.005	0.133	0.743	0.025	0.266	0.243	......	....	Little Mountain, Ohio
1A	1	F-P	Mouse, Dormouse....... *Claviglis saturatus* (Dollman)	0.0223	0.705	0.004	0.002	0.1132	0.851	0.063	0.192	0.205	......	....	Maji Moto, Africa
145	1	M	" "	0.0177	0.551	0.006	0.0042	0.116	0.308	0.052	0.091	0.272	......	0.75	Maji Moto, Africa
66 } 68 }	2	M	Mouse, Grasshopper..... *Onychomys*	....	....	0.0011	0.0237	......	......	......	0.374	......	......	....	Seligman, Ariz.
69	1	F	" "	....	....	0.0014	0.040	......	......	......	0.392	......	......	....	Seligman, Ariz.
....	67	M	Mouse, Meadow*....... *Microtus drummondi*	0.0237	0.6606	0.0032	0.0085	0.1612	1.082	0.0239	0.3634	0.4036	......	....	Churchill, Canada
....	42	F	" "	0.0229	0.6464	0.0031	0.0160	0.1609	1.129	0.0236	0.3814	0.3930	......	....	Churchill, Canada
....	4	F-P	" "	0.0325	0.6724	0.0037	0.0366	0.1999	1.754	0.0276	0.5357	0.5575	......	....	Churchill, Canada
....	42	F	Mouse, Meadow*....... *Microtus pennsylvanicus pennsylvanicus*	0.0252	0.7166	0.0046	0.0164	0.1973	1.349	0.0269	0.3103	0.3916	......	....	Willoughby, Ohio
....	53	M	" "	0.0279	0.7394	0.0042	0.0071	0.1937	1.312	0.0254	0.3126	0.3984	......	....	Willoughby, Ohio
....	10	F-P	" "	0.0413	0.7635	0.0065	0.0305	0.2574	2.250	0.0277	0.4821	0.4999	......	....	Cleveland, Ohio
7 } 11 } 12 }	3	F	Mouse, Mountain Meadow.......... *Microtus alticola alticola*	....	....	0.0018	0.0066	......	......	......	0.233	......	......	....	Agassiz Peak, Ariz.
13	1	M	" " "	....	....	0.0032	0.0126	......	......	......	0.476	......	......	....	Agassiz Peak, Ariz.
....	14	M	Mouse, Guatemala*..... *Peromyscus*	0.0122	0.407	0.0014	0.0037	0.0983	0.65	0.0235	0.1477	0.22	......	....	Totonicapan, Guatemala

....	2	F	" "	0.0184	0.4511	0.0021	0.0049	0.1132	1.243	0.033	0.2157	0.303	......	....	Totonicapan, Guatemala
....	8	F-P	" "	0.0200	0.443	0.0024	0.0064	0.1499	1.186	0.0291	0.2255	0.334	......	....	Totonicapan, Guatemala
9	1	M	Muskrat............... *Ondatra zibethica alba*	0.900	5.33	0.0133	0.143	3.23	21.95	1.88	7.45	4.35	......	176	Churchill, Canada
21A	1	F	Porcupine............. *Erithizon dorsatum*	2.800	30.77	0.72	0.62	19.75	112	2.88	26.97	29.88	......	....	Maji Moto, Africa
234 } 289 }	2	F	" "	2.725	21.71	0.361	0.337	14.4	......	......	....	......	......	....	Animal dealer, New York
324	1	M	" "	3.410	19.15	0.341	0.355	15.5	108	......	38	27.1	......	....	Animal dealer, New York
81	1	F	Prairie Dog............ *Cynomys gunnissoni zuniensis* (Hollister)	....	....	0.034	0.019	......	....	......	2.72	......	......	....	Seligman, Ariz. (in hibernation)
84	1	M	" "	....	5.60	0.025	0.028	......	....	......	2.564	......	......	....	Seligman, Ariz.
93 } 94 }	2	F	Rabbits, Cottontail..... *Silvilagus auduboni*	....	....	0.047	0.115	......	....	......	6.123	......	......	....	Florence, Ariz.
97 } 105 }	2	M	" "	....	7.25	0.031	0.094	......	....	......	5.14	......	......	....	Catalina Mountains, Ariz.
323 } 603 }	2	M	Rabbits, Flemish giant... *Lepus*	3.680	10.59	0.685	0.503	10.57	97.9	......	22.35	......	......	....	Cleveland, Ohio
....	22	F	" " "	2.587	10.14	0.403	0.662	9.23	82.63	......	18.3	13.72	......	....	Cleveland, Ohio
80	1	F	Rabbit, Jack........... *Lepus californicus*	....	12.00	0.147	0.256	......	....	......	19.34	......	......	....	Seligman, Ariz.
....	2	....	Rabbits, Wild.......... *Silvilagus gabbi messorius* (Goldman)	0.439	4.50	....	0.750	2.00	19.50	......	3.50	4.50	0.75	....	Adult, Panama
16 } 45 }	2	M	Rat, Mexican pack...... *Neotoma*	....	2.20	0.009	0.078	......	....	......	2.56	......	......	....	San Francisco Crater, Ariz.
62 } 73 } 74 } 47 }	4	F	"	....	1.87	0.014	0.056	......	....	......	2.19	......	......	....	San Francisco Crater, Ariz.
235	1	F	Rat, Norway........... *Mus norvegicus*	0.197	1.61	0.008	0.062	0.730	....	......	....	1.41	......	....	Cleveland, Ohio

* Preserved weights.

RODENTS.—(*Continued*)

Catalogue number	Number of animals	Sex	Common and scientific name	Body weight, kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and intestines	Remarks
701, 704	2	M	Rat, Norway *Mus norvegicus*	0.278	2.30	0.032	0.149	1.61	9.31	0.296	3.03	2.29	0.82	7.02	Cleveland, Ohio
51C, 51D, 51F, 51G, 51I	5	M	Shik-shik *Citellus paryii paryii* (Richardson)	0.878	5.63	0.105	0.228	5.85	36.27	1.77	7.16	9.87	2.12	......	Churchill, Canada
51B, 51E, 51H	3	F	" "	0.958	5.74	0.116	0.208	5.92	44.83	1.73	7.12	10.57	1.14	......	Churchill, Canada
64, 63, 22, 18	4	M	Squirrels, Abert *Sciurus aberti*	......	6.50	0.030	0.204	......	......	......	3.12	......	......	......	San Francisco Crater, Ariz.
......	1	......	Squirrel *Sciurus gerrardi morulus* (Bangs)	0.287	......	......	0.300	2.00	11.00	......	3.00	3.80	0.60	......	Adult, Panama
48	1	M	Squirrel, Ground *Callospermophilus*	......	3.00	0.010	0.035	......	......	......	1.415	......	......	......	Schultz Pass, Ariz.
78	1	M	Squirrel, Ground *Citellus tridecemlineatus*	......	2.00	0.004	0.019	......	......	......	1.09	......	......	......	Seligman, Ariz.
23C, 23F, 23G, 23H	4	F	Squirrel, Red *Sciurus hudsonicus*	0.248	5.02	0.029	0.075	1.82	6.64	0.534	1.32	3.17	......	......	Churchill, Canada
23A, 23B, 23D, 23E	4	M	" "	0.183	4.71	0.023	0.049	1.57	3.99	0.497	1.14	2.66	......	......	Churchill, Canada

633E	1	M	“ “	0.169	4.45	0.068	0.142	2.132	10.79	0.806	1.930	4.016	0.511	9.79	Little Mountain, Ohio
633B, 633D	2	F	“ “ *Sciurus hudsonicus loquax*	0.169	4.21	0.031	0.098	1.23	5.88	0.661	1.51	1.34	......	....	Cleveland, Ohio
633A	1	M	“ “ “	0.183	3.97	0.006	0.082	1.511	4.18	0.390	1.425	3.25	......	....	Cleveland, Ohio
633C	1	M	“ “ “	0.063	4.09	0.0056	0.025	0.545	1.74	0.436	0.615	1.54	......	....	Juvenile, Cleveland, Ohio
17, 19, 23, 26, 31, 32, 60	7	F	Squirrel, Red.......... *Sciurus fremonti mogollonensis*	....	4.30	0.009	0.079	......	......	......	1.74	......	......	....	San Francisco Crater and Schultz Pass, Ariz.
20, 21, 25, 27, 28, 29, 61	7	M	“ “	....	4.40	0.013	0.095	......	......	......	1.74	......	......	....	San Francisco Crater and Schultz Pass, Ariz.

UNGULATES

677	1	M	Bison, American........ *Bison bison*	54.88	334	5.47	6.64	361	695	42.68	256	1,190	146	....	Calf, Zoo, Cleveland, Ohio
79A, 80A	2	M	Buffalo............... *Syncerus caffer caffer*	750 est.	640 est.	34.96	31.05	......	......	......	......	......	......	....	Maji Moto, Africa
45A	1	F-P	“ “ “	572	642	37.30	43.27	3,050	7,175	69.94	1,625	5,150	2,340	146,000	Maji Moto, Africa
71A	1	M	“ “ “	759	560	38.05	50.4	3,628	7,712	55.00	1,825	8,110	......	150,000	Maji Moto, Africa
614	1	F	Bushbuck............. *Tragelaphus scriptus massaicus*	35.38	140	6.76	4.43	325	625	40.53	131	915	92.75	....	Maji Moto, Africa
94A	1	M	“ “	53.07	190	5.08	5.09	350	1,100	......	225	540	......	6,700	Lake Manyara, Africa
1481	1	M	Camel................ *Camelus bactrianus*	453.59	569.5	165.5	25.5	......	......	99.0	......	......	387	....	Zoo, Cleveland, Ohio (goiter)
652	1	F	Caribou, Barren ground.. *Rangifer arcticus arcticus*	71.87	278	3.99	2.29	710	466	33.35	82.77	1,275	131	....	Churchill, Canada

UNGULATES.—(*Continued*)

Catalogue number	Number of animals	Sex	Common and scientific name	Body weight, kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and intestine	Remarks
44 } 653 }	2	M	Caribou *Rangifer arcticus arcticus*	128.47	306	8.37	5.99	1,086	2,445	41.66	151	2,450	310	25,400	Tavane and Churchill, Canada
42	1	M	" " "	62.14	285	5.98	4.16	650	......	......	......	......	....	....	Chesterfield Inlet, Canada
1428	1	F	Cow	408.23	363.8	18.8	25.0	......	3,959	52.8	834.0	......	......	....	2 years old, Lexington, Ky.
1432	1	F	"	378.75	491.5	39.0	13.0	2,018	3,637	75.5	726.0	5,784	......	....	2 years old, Lexington, Ky.
....	1†	F	Aberdeen angus	719	....	57.5	57.50	1,950	6,690	......	1,746	2,654	839	21,682	....
....	44†	F	Ayrshires	491	417.3	33.4	31.2	1,882	6,010	......	1,148	3,311	817	25,156	....
....	5	F	Cows	......	....	11.82	18.07	......	......	......	......	......	......	....	Florida
....	6	F	"	......	....	21.03	24.01	......	......	......	......	......	......	....	Cleveland, Ohio
....	62†	F	Guernseys	450	403.1	31.6	27.7	1,737	6,087	......	978	3,143	832	23,523	....
....	7†	F	Herefords	371	357	15.24	18.46	1,143	3,819	......	672	2,272	561	20,734	....
....	200†	F	Holsteins	574	414	38.1	37.7	2,245	7,248	......	1,445	4,336	946	29,184	....
....	6†	M	Holstein bulls	90	299	14.25	6.37	422	......	......	......	......	......	....	Under 6 months old
....	3†	M	" "	241	386	30.2	10.13	998	......	......	......	......	......	....	6–12 months old
....	5†	M	" "	552	407.7	41.4	19.76	1,905	......	......	......	......	......	....	1–3 years old
....	2†	M	" "	861	471	45.5	22.5	3,243	......	......	......	......	......	....	3–5 years old
....	5†	M	" "	888	462	95.34	41.6	3,357	......	......	......	......	......	....	Over 5 years old
....	218†	F	Jerseys	413	408	27.9	27.4	1,605	5,747	......	983	3,057	801	22,230	....
....	3†	M	Jersey bulls	51.9	304	6.4	5.35	304	......	......	......	......	......	....	Under 6 months old
....	5†	M	" "	214	356	19.38	9.78	744	......	......	......	......	......	....	6–12 months old
....	2†	M	" "	367	384	29.05	14.5	1,270	......	......	......	......	......	....	1–3 years old
....	2†	M	" "	591	444	47.00	18.3	1,987	......	......	......	......	......	....	3–5 years old
....	10†	M	" "	597	447	82.20	27.45	2,186	......	......	......	......	......	....	Over 5 years old

......	213†	M	" "	412	408	27.90	27.40	1,606	......	......	......	......	......	......	Average 8 years 2 month old
......	71†	F	Miscellaneous cows......	506	420	35.2	303.3	1,888	6,786	......	1,207	3,978	812	......	......
......	6	M	Steers......	......	......	18.8	20.68	......	......	......	......	......	......	......	Cleveland, Ohio
......	15	M	"	174	......	13.9	16.57	......	......	......	......	......	......	......	Florida
......	18†	M	"	369	384	20.87	13.16	1,533	......	......	423	......	......	11.1	U. S. D. A.
1390	1	M	Calf......	......	203.6	4.7	5.2	234.5	505.2	32.6	49.6	294.2	52.9	......	Full-term foetus, Lexington, Ky.
1429	1	M	"	10.89	143.1	8.3	5.4	......	433	22.5	72.9	302	......	......	Lexington, Ky. (newborn)
1388	1	......	"	19.5	193.9	8.0	29.4	232	220.5	29.4	106.0	473.2	80.5	......	Three days old, Lexington, Ky.
1430	1	F	"	98.43	387.5	12.1	9.4	810.7	2,938	49.6	476.8	1,411	......	......	Lexington, Ky.
1386	1	......	"	23.36	187.9	6.9	4.8	174.2	535.8	25.9	117.4	509.6	69.5	......	Crossbred, Lexington, Ky.
1389	1	......	"	22.0	215.2	19	32.5	265.3	1,008.8	28.7	167.2	737.1	69.1	......	6 days old, Lexington, Ky.
1387	1	......	"	......	234.6	12.6	3.0	315.3	792.3	14.3	156.4	581.1	103.5	......	Lexington, Ky. (goiter)
1391	1	F	Cow......	489.9	473.5	46.1	17.4	2,601	6,265	69.6	1,105.8	6,359	729.9	......	Lexington, Ky. (goiter)
......	2	......	Deer...... *Odocoileus chiriquensis* (Allen)	2.376	54.1	0.2	0.62	5.16	72	......	16.5	44.3	5.0	......	Juvenile, Panama
......	1	F	" "	13.93	......	......	3.0	15.9	516	......	55	520	35	......	Adult, Panama
124	1	M	Deer, Indian Axis...... *Cervus axis*	......	......	20	8.6	......	......	......	280	......	......	......	Zoo, Cleveland, Ohio (goiter)
644	1	M	" "	88.45	219	17.5	6.45	749	1,730	34.4	247	1,726	223	......	Zoo, Cleveland, Ohio (goiter)
277	1	M	Deer, Malay Samba...... *Cervus unicolor*	148	......	25	30.6	......	......	......	317	......	......	......	Zoo, Cleveland, Ohio (goiter)
184, 181, 182	3	M	Deer, White-tailed...... *Odocoileus virginianus*	......	......	2.33	2.83	......	......	......	......	......	......	......	Cumberland Island, Ga.
172, 177	2	F	" "	......	......	2.12	2.30	......	......	......	......	......	......	......	Cumberland Island, Ga.
272	1	M	" "	65.22	210	5.1	12.25	632	1,025	......	......	1,318	......	......	Zoo, Detroit, Mich.

† Data from Journal of Agricultural Research Vol. 55, No. 4, Aug. 15, 1937. W. W. Swett and associates.

UNGULATES.—(*Continued*)

Catalogue number	Number of animals	Sex	Common and scientific name	Body weight, kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and intestines	Remarks
112, 114	2	M	Deer, White-tailed *Odocoileus couesi*	......	172	2.50	3.25	......	......	......	115	......	......	......	Kaibab Forest, Ariz. (goiter)
101	1	F	" "	......	122	1.65	2.40	......	......	......	85	......	......	......	Kaibab Forest, Ariz.
85, 86, 88	3	M	Deer, Mule *Hemionus odocoileus*	......	182	2.86	5.48	......	......	......	207	......	......	......	Kaibab Forest, Ariz.
87	1	F	" "	......	......	2.30	5.25	......	......	......	250	......	......	......	Kaibab Forest, Ariz.
27A	1	M	Dik-dik *Rhynchotragus kirki*	4.57	37	0.73	0.56	36.8	93.2	......	21.4	44.4	......	......	Maji Moto, Africa
568	1	M	Elk *Cervus canadensis*	13.61	194.2	6.14	2.38	131.1	374	......	73.4	319	......	......	Zoo, Cleveland, Ohio
136	1	F	" "	......	......	9.5	8.85	......	......	......	365	......	......	......	Zoo, Cleveland, Ohio
24, 54	2	M	Gazelle, Thomson *Gazella thomsoni*	24.37	91.8	1.83	2.0	245	525	26.6	105	280	......	......	Maji Moto, Africa
89	1	F	" "	2.430	54.61	0.46	1.04	31.7	60.61	12.35	16.5	74.4	......	380	Infant, Maji Moto, Africa
68A	1	M	Giraffe *Giraffa camelopardalis tippelskirchi*	1,220	700	64.70	78.12	4,990	19,050	127	2,268	12,060	2,266	130,000	Maji Moto, Africa
1259	1	M	Goat *Capra hircus*	27.66	115	......	......	......	525	29.55	......	......	......	1,466	Cleveland, Ohio
53	1	M	Hartebeest, Coke's (Kongoni) *Bublis cokei cokei*	134	275	1.83	9.61	875	1,525	56.36	387	1,850	625	14,540	Moto Umbo, Africa
142A	1	F	Hippopotamus *Hippopotamus amphibius*	543	540	32	53.35	1,610	14,060	35.02	1,175	4,910	......	83,000	Juvenile, Maji Moto, Africa

143	1	F	" "	1,351	723	119	61.10	4,536	23,580	42.70	3,160	11,340	3,175	374,000	Adult, Maji Moto Africa
....	53*	M	Hogs.................. *Sus scrofax*	102.06	....	6.88	4.99	303.5	1,488.3	......	237.83	......	117.74	1,817	Average age, 236 days. Standard-bred castrates
....	36*	F	" "	102.06	....	7.52	4.99	324.39	1,547.3	......	264.09	......	138.64	1,988.07	Age 241 days. Standard-bred young sows
....	30*	....	" "	102.06	....	6.46	5.44	297.5	1,389.5	......	246.45	......	121.71	1,667.7	F² crossbred. Average age, 252 days
176, 178	2	F	Hogs, wild............ *Sus scrofax*	....	....	8.42	2.71	......	......	......	......	......	......	....	Cumberland Island, Florida
179, 180	2	M	" "	....	5.78	....	2.69	......	......	......	......	......	......	....	Cumberland Island, Florida
192, 193, 194, 195, 196	5	....	Hogs, domestic........ *Sus scrofax*	....	105	14.25	4.16	......	......	......	229	......	......	....	Cleveland, Ohio
129, 130	2	F	" "	....	....	16.7	3.05	......	......	......	232	......	......	....	Cleveland, Ohio
1377, 1378, 1379, 1380, 1381	5	M and F	Pigs, full-term foetuses	1.419	30.3	0.45	0.27	14.25	43.0	3.29	10.47	25.66	1.96	....	Lexington, Ky.
1383	1	M	Pig, shoat............. *Sus Scrofax*	4.76	51.2	0.74	0.37	52.1	184.6	4.05	32.8	98.7	12.5	....	Lexington, Ky.
1382	1	F	" "	13.15	86.2	....	3.5	124.5	392.5	5.1	67.4	411.7	29.0	....	Lexington, Ky.
1384	1	M	" "	....	104.5	5.6	9.3	147.3	903.8	6.2	130.8	1358	34.9	....	Lexington, Ky.
1419	1	M	" "	7.60	54	1.6	2.0	469	284	7.0	54.0	128	14.0	....	Lexington, Ky.
1385	1	F	Pig....................	113.2	123.9	10.8	15.6	452	2,334	7.3	395.0	609.7	173.3	....	Lexington, Ky.
3, 161	2	M	Impala............... *Aepyceros melanus*	37.86	149	5.67	3.82	270.05	605	44	162.5	510	210	5,800	Maji Moto, Africa
13, 2	2	M	" "	57.61	175	5.04	5.36	378	855	47.12	225	730	......	....	Maji Moto, Africa

* Data furnished by the Bureau Animal Industry, U. S. Department of Agriculture.

UNGULATES.—(*Continued*)

Catalogue number	Number of animals	Sex	Common and scientific name	Body weight, kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and intestines	Remarks
198	1	F-P	Impala	....	....	5.67	4.62	......	......	......	......	......	......	....	Maji Moto, Africa
699	1	M	Peccary, Collared *Pecari angulatus bangsi* (Goldman)	29	123.5	125	2.95	174	772	10.2	153	279	65.5	....	Zoo (goiter)
....	2	....	" "	13.83	....	....	4.5	70.5	371	......	51.5	120	91	....	Adult, Panama
....	1	....	" "	2.25	....	....	2.0	20	60	......	22	72	10	....	Infant, Panama
109	1	M	Peccary *Pecari angulatus sonoriensis*	....	82	1.2	1.8	......	......	......	60	......	......	....	Catalina Mountains, Ariz. (goiter)
116	1	F	" " "	....	....	20	2.6	......	......	......	60	......	......	....	Catalina Mountains, Ariz. (goiter)
32, 33	2	M	Reed Buck (Bohor) *Redunca redunca tohi*	31.7	109	1.34	2.11	242	523	33.4	102	462	......	....	Lake Manyara, Africa
....	9	M	Sheep (Lambs) *Ovis aries*	40.23	108.8	10.11	2.22	168	......	......	97.06	......	......	2,500	Bureau of Animal Industry
187, 188, 189, 190, 191	5	F	" "	....	88.8	13.3	2.02	......	......	......	93.1	......	......	....	Adult, Cleveland, Ohio (goiter)
1397, 1398	2	....	Sheep *Ovis aries*	2.720	53.8	5.2	3.85	28.30	78.0	13.50	25.8	51.10	10.0	....	Foetus, 2–4 weeks old, premature. Lexington, Ky.
1395, 1399, 1401, 1403, 1404, 1405, 1407, 1420	8		Lambs	6.90	73.6	5.19	6.78	82.13	224.5	18.30	55.8	191.5	17.41	....	About 1 month old. Lexington, Ky.

1394, 1396, 1408, 1421, 1424	5	F	"	8.55	71.5	4.29	6.03	85.0	287.2	13.7	69.5	180.5	27.0	....	About 1 month old. Lexington, Ky.
1409, 1422, 1423, 1427	4	M	"	15.76	88.6	2.0	3.0	158.7	531.8	17.6	108.3	543.5	36.2	....	Lexington, Ky.
1392, 1393, 1400, 1402, 1406, 1425, 1426	7	F		52.1	106.5	10.2	8.3	276.7	957	30.49	159.8	704.8	119.6	....	Lexington, Ky.
25, 141	2	M	Steinbok.............. *Raphicerus campestris neumanni*	8.62	49.5	1.22	1.35	72.2	175	14.87	38.51	150	......	550	Maji Moto, Africa
58	1	M	Warthog.............. *Phacochoerus aethiopicus*	65.32	125	3.6	8.24	325	1,500	17.91	300	550	......	9,550	Maji Moto, Africa
34	1	M	Wildebeest.......... *Gnu taurinus albojubatus*	215.49	451	14.51	7.45	1,325	2,000	......	425	3,200	......	....	Maji Moto, Africa
181	1	M	" " "	208.65	450	7.36	9.4	1,300	2,540	......	570	2,500	......	37,194	Maji Moto, Africa

UNGULATES—ODD-TOED

786, 789, 790	3	F	Thoroughbred foetus.... *Equus caballus*	13.00	150	4.18	2.21	111.3	702	......	99	444.3	82.5	....	Average, 91 days, premature. Kentucky
....	5	F	" "	26.47	254.4	13.23	14.89	331.5	902.2	37.14	245.0	895.7	139.9	....	Average, 46.4 days, premature. Kentucky
....	5	M	" "	27.30	273.9	12.28	4.66	275.9	699.5	51.48	257.4	1,374	162.5	....	Average, 54.4 days, premature. Kentucky
....	11	F	" "	47.68	333.9	17.54	8.10	472.	1,634	42.82	321.3	1,526	335.1	....	Average, 14.6 days premature. Kentucky

UNGULATES—ODD-TOED.—(*Continued*)

Catalogue number	Number of animals	Sex	Common and scientific name	Body weight, kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and intestines	Remarks
....	15	M	Thoroughbred foetus.... *Equus caballus*	38.91	317.3	14.80	6.26	458.2	1,266	45.95	275.6	1,179	235.8	....	Average, 16 days, mature. Kentucky
....	19	F	Thoroughbred foals.....	54.32	366.5	16.80	10.38	606.4	1,651	54.80	405.7	1,414	306.6	....	Average, 5.6 days old. Kentucky
....	18	M	" " "	52.45	370.1	17.57	9.34	565	1,592	48.5	323.5	1,366	319	....	Average, 3.1 days old. Kentucky
1415, 1234, 1241	3	M	" " "	93.89	425.3	15.23	14.43	970	3,386	56.8	859.3	1,427	610.3	....	Average, 33.5 days old. Kentucky
815, 1236, 1244, 1246	4	F	" " "	116.77	470.2	22.6	15.20	1,125	3,704	67.5	812.2	2,393	838.5	....	Average, 83 days old. Kentucky
....	8	M	" " colts.....	285.13	582.8	26.55	18.77	1,999	8,193	71.09	767.7	299.6	1,700	....	Average, 9 months old. Kentucky
1466, 1471, 1472	3	M	" " "	298.0	595.0	21.51	21.85	2,483	4,560	83.2	1,363	2,741	......	....	Yearlings. Lexington, Ky.
1469	1	F	" " colt......	222.0	535.0	36.5	20.7	1,790	3,790	......	855	2,070	......	....	Weanling. Lexington, Ky.
1470.	1	F	" " "	354.0	570.0	28.9	21.9	3,010	....	93.3	1,520	3,280	......	....	Yearling. Lexington, Ky.
1231, 1349	2	F	" " fillies.....	380.11	616	36.9	32.3	2,653	3,452	81.5	1,168	2,969.5	3,379	....	Average, 12 months old. Kentucky
....	5	M	" " colts.....	306.35	602.4	26.81	22.2	2,708	4,821	79.05	970.2	3,110	5,494	....	Yearling colts. Kentucky
1467	1	....	" " gelding...	299.0	530.0	23.5	....	2,330	4,995	77.0	910	6,160	......	....	Yearling. Lexington, Ky.

....	11	M	" " geldings..	445.76	639	29.91	34.30	3,444	5,354	97.20	1,404	3,963	4,239	....	Average, 4⅓ years old, Kentucky
1224, 666, 1351	3	M	" " colts.....	433.92	621.4	26.50	27.71	3,488	3,931	89.90	1,297	3,659	4,190	....	Average, 2–3 years old. Kentucky
....	7	F	" " fillies.....	408.5	632	30.56	38.41	3,237	5,350	98.82	1,653	4,588	3,438	....	Average, 2–3 years old. Kentucky
1473	1	M	Thoroughbred stallion...	431.0	....	47.5	76.7	5,270.0	....	72.4	3,580	6,170	......	....	Lexington, Ky.
685	1	M	Thoroughbred stallion "Pennant"	442.1	735	36.35	25.02	5,250	7,050	91.75	1,892	4,995	5,350	....	Whitney Stables, Lexington, Ky.
676	1	M	Thoroughbred stallion "Equipoise"	521.52	808.5	33.40	46.62	4,455	....	......	1,549	....	3,968	....	Whitney Stables, Lexington, Ky.
686	1	M	Thoroughbred colt by "Equipoise"	262.1	611	20.04	13.20	2,038	4,518	71.31	809	2,240	1,850	....	Whitney Stables, Lexington, Ky.
661	1	F	Thoroughbred mare "Brown Eyes"	548.87	650	26.45	60.78	4,435	6,904	117.13	2,220	4,085	5,045	....	Goodloe Stables, Lexington, Ky.
636	1	F	Hunter "Roxanne".....	402.65	690.11	24.45	47.32	3,648	5,220	112.60	1,200	10,120	1,760	28,110	Little Mountain, Ohio
....	5	M	Thoroughbred stallions..	485.31	706.7	32.15	33.03	4,688	5,685	106.34	1,971.7	7,154	3,474	....	Average, 17.2 years old. Kentucky
1468	1	M	Thoroughbred stallion...	531.0	620.0	24.0	44.0	4,800.0	6,670	106.3	1,930	4,800	......	....	13 years old. Lexington, Ky.
....	10	F	" " mares	443.36	637.7	29.76	43.5	3,663	6,176	105.0	1,667	4,758	3,856	....	Average, 19.1 years old. Kentucky
684	1	M	Arabian stallion "Nureddin"..........	461.76	618	46.80	26.80	3,909	6,375	112.24	1,512	5,080	3,000	....	27 years old. Portsmouth, Ohio
1287	1	M	Arabian stallion "Mirage"	362.80	573	34.95	42.17	3,275	4,670	108.08	1,108	6,475	1,900	....	30 yrs. old. Portsmouth, Ohio
1221	1	F	Arabian mare "Guemura"	....	711.4	80.00	....	3,230	....	107.8	....	....	......	....	Franklin, Tenn.
1308	1	M	Burro gelding..........	199.58	392	14.43	24.2	1,184	3,770	......	844	1,462	507	....	25 years old. Kentucky
707, 711	2	M	"Charcoal" horses......	122.98	478	4.80	16.64	850	1,953	84.31	813	1,320	280	....	Average, 4 years old. Guatemala City, C.A.
708	1	F	Burro.................	150.73	410	10.32	16.34	825	1,266	69.30	1,575	1,260	590	....	Guatemala City, C.A.
1242	1	M	Grade Draft...........	70.76	248	11.2	7.9	546	1,197	40.0	230	916	524	....	Foal. Kentucky
659, 660	2	F	Grade Pony............	184.16	525	10.49	12.98	1,165	2,100	67.47	420	1,348	458	....	1 year old. Kentucky

UNGULATES—ODD-TOED.—(*Continued*)

Catalogue number	Number of animals	Sex	Common and scientific name	Body weight, kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and intestines	Remarks
664	1	F	Draft Horse	521.64	655	24.30	52.51	3,260	6,920	105.92	1,510	4,125	1,807	....	12 years old. Kentucky
1317	1	M	Hackney Pony	362.87	504	29.6	21.2	1,427	....	......	....	....	....	....	Urbana, Ill.
....	10	M	Horses, Panama	279	452	10.77	25.75	....	....	......	....	....	....	....	Average 12 years old. Panama gelding workhorses
....	31	F	" "	262	468	12.77	25.62	....	....	......	....	....	....	....	Average 14 years old. Panama mares
....	21	M and F	" "	230.9	520	....	35.45	1,843	4,277	......	942	3,627	940	13,542	Panama
....	3	M	Mules, Panama *Equus asinus*	211	371	8.66	24.6	....	....	......	....	....	....	....	Average 13.3 years old. Panama
....	4	F	" "	291	478	9.75	35.5	....	....	......	....	....	....	....	Average, 20 years old. Panama
....	1	M	" "	42.64	227	....	....	397	1,191	......	227	628	283	1,219	Panama colt
....	4	M and F	" "	279.2	....	....	42.53	2,048	3,594	......	513	4,026	766	13,396	Panama
792	1	F	Mule	249.47	543	11.3	47	2,144	6,301	......	1,049	....	802	....	1 year old. Kentucky
1297	1	F	"	444.52	543	18.98	45.1	3,604	5,342	124.0	964	5,678	1,802	....	25 years old. Kentucky
690	1	M	Percheron Stallion	635.04	662	40.84	39.22	5,600	8,520	136.7	1,700	5,710	3,430	....	14 years old. Ohio
691	1	F	Percheron Mare	771.40	650	56.55	37.40	4,700	6,725	137.4	1,750	5,400	1,550	....	23 years old. Ohio
635	1	F	Polo Pony	380.75	692	52.10	24.23	3,570	4,835	115.92	950	8,616	1,250	24,490	25 years old. Cleveland, Ohio
1307	1	F	Pony	376.48	604	20.02	28.00	2,607	5,012	96.5	1,894	2,558	3,846	....	18 years old. Kentucky
791	1	F	Saddle-bred foetus	19.50	226	7.2	2.6	181.5	913	......	....	1,038	141	....	71 days premature. Kentucky

1245	1	F	Saddle-bred foal........	118.8	475	12.8	10.2	894	2,796	56.0	735	......	536	....	3 months old. Kentucky
1296	1	F	" weanling....	181.4	492	......	......	1,418	......	64.0	......	2,981	......	....	6–7 months old. Kentucky
800 } 1293 }	2	M	Saddle-bred colts........	300.5	588	18.43	17.33	1,658	4,397	87.55	1,033	3,457	1,079	....	1 year old. Kentucky
1239 } 1305 }	2	M	" geldings.....	335.68	569	16.95	20.70	2,199	4,616	84.48	929	3,189	2,010	....	1 year old. Kentucky
1458	1	....	Saddle horse gelding.....	449.0	540.0	14.57	40.5	3,495.0	7,220	110.0	1,520	3,550	3,475	....	Portsmouth, Ohio
1348	1	M	Shetland Pony gelding...	242.67	560	15.25	23.5	2,195	3,975	104.0	870	3,740	1,380	....	29 years old. Kentucky
1449	1	F	Shetland pony..........	272.19	553.2	87.6	23.2	2,508.0	4,543	93.0	1,307	1,871	......	....	Cleveland, Ohio
273	1	M	" stallion........	150.35	496.11	14.70	16.29	1,375	1,805	......	......	4,111	......	....	Little Mountain, Ohio
803	1	F	Standard-bred foetus....	31.75	242	11.9	6.7	402	1,052	......	196	921	84	....	About 60 days premature. Kentucky
1240	1	M	Standard-bred foal......	92.98	400	14.6	10.1	971	2,400	69.0	624	1,489	330	....	3 months old. Kentucky
636	1	F	Hunter (Thoroughbred).	402.65	690	24.45	47.32	3,648	5,220	112.6	1,200	10,120	1,760	28,110	15 years old. Ohio
693	1	M	Western gelding.........	426.38	562	25.59	35.37	3,487	5,338	107.0	1,196	4,005	5,750	....	23 years old. Ohio
8A	1	M	Rhinoceros.............	764	655	53.05	168.66	4,800	14,310	22.56	3,000	7,350	2,720	129,270	Maji Moto Africa,
			Rhinocerur bicornis												
1464	1	F	Tapir..................	58.06	159.4	7.44	11.02	540.0	815	14.88	482	2,068	......	....	Panama Canal Zone
			Tapirella bairdii												
....	1	....	Tapir..................	8.60	....	......	2.0	74	220	......	92	162	84	....	Juvenile, Panama
			Tapirella bairdii (Gill)												
....	1	....	" "	14.26	85	......	3.0	121	483	......	167	318	172	....	Adult, Panama
686	1	M	Zebra..................	29.48	....	14.77	6.24	330	937	39.5	90.54	655	135.8	....	Foetus, Zoo, Cleveland, Ohio
			Equus quagga granti												
35A	1	M	" " "	7.900	125	3.04	1.43	75	275	......	53.56	300	......	....	Embryo, Maji Moto, Africa
634	1	F	" " "	43.09	413	29.2	9.6	581	1,275	......	166.4	740	156.1	....	Infant, Zoo, Cleveland, Ohio (goiter)
179A	1	F	" " "	56.59	410	10	4.95	515	950	......	262	1,025	605	9,520	6 weeks old, Maji Moto, Africa (goiter)

UNGULATES—ODD-TOED.—(*Continued*)

Catalogue number	Number of animals	Sex	Common and scientific name	Body weight, kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and intestines	Remarks
626	1	M	Zebra.................. *Equus quagga granti*	78.02	494.4	48.6	11.5	660	....	......	357.3	....	......	....	Zoo, Cleveland, Ohio (goiter)
20A } 160A }	2	M	" " "	254.99	541	20.08	23.08	1,925	4,037	94	850	2,025	1,170	....	Maji Moto, Africa
162A	1	F-P	" " "	297.1	555	17.34	27.8	1,970	4,400	89	900	2,790	......	....	Maji Moto, Africa
698	1	M	" " "	317.5	642	36.0	44.1	2,231	6,336	103	1,239	....	1,121	....	Jungle bred, 6 years old, Zoo, Cleveland, Ohio
			PROBOSCIDEA AND HYRACOIDEA												
148A	1	M	Elephant.............. *Loxodonta africana knochenhaueri*	6,654	5,712	860	940	26,080	107,670	116.15	18,180	138,790	......	924,000	Maji Moto, Africa
142	1	F	Elephant, Pygmy....... *Loxodonta cyclotis*	....	....	....	84	....	....	......	5,200	....	......	....	Zoo, New York City
149A	1	M	Hyrax................. *Heterohyrax brucei*	0.750	12.27	0.081	0.161	3.63	31.53	......	6.45	5.532	......	255	Lake Manyara, Africa
			SIRENIA												
1475	1	M	Manatee *Trichecnus mantus*	424.0	351.0	57.51	....	1,250.0	5,500	8.0	....	3,050	......	....	Miami, Fla.

Addendum

During the summer of 1941, after the manuscript of this book had been sent to the printer, an expedition was made to Fields Landing, California, and the energy-controlling organs of five whales were collected—three humpback whales, one sperm whale, and one finback whale.

In the literature, the weight of whales is based on the estimate of 1 ton per linear foot, but we could find no account of the detailed weight of the various organs, and glands, skeleton, flesh, and blubber.

Through the cooperation of the whaling-station staff at Fields Landing and the use of their power machinery, we dissected and weighed in sections a female finback whale 71 feet long, allowing 20 per cent for body fluids and blood.

We were fortunate, while there, to have a sperm or toothed whale to study. The feeding habits of the sperm whale seldom take it out of the temperate or warm seas, where it lives on large fish and deep-sea cephalopods, such as the giant squid.

The food of the whalebone whales consists largely of krill, plankton, and small sardines found in the cold fringes of the Arctic and Antarctic Oceans and in the neighborhood of drift ice.

On page 297, under Cetacea, a striking difference is seen in the weight of the thyroid gland and heart of the sperm whale, whose habitat is the more equitable temperature of the warmer seas, compared with the weights of the thyroid glands and hearts of the whalebone whales that are subjected to the cold of the polar seas.

If the brain of the sperm whale follows the pattern of the heart and the thyroid gland, as we fully expect it will, then the energy systems of these mammoth creatures—the largest now living or that have ever lived—will conform with the formula of a large brain, a large heart and blood volume, and a large thyroid gland, which we have found for man and animals in the north, as compared with a smaller brain, a smaller heart and blood volume, and a smaller thyroid gland, which we have found for man and animals in the tropics.

A detailed comparative study of these various species will be published later.

FINBACK WHALE, FEMALE (length 71 feet)
Balaenoptera physalus
Taken at Whaling Station, Fields Landing, California

Data	Pounds	Kilograms
Body weight	130,946	59,394
Brain	18.353	8.325
Pituitary gland	.062	0.028
Thyroid gland	8.752	3.970
Adrenal glands	1.614	0.732
Heart	842	382
Liver	1,783	809
Eyes	3.792	1.720
Kidneys	461	209
Lungs	868	394
Spleen	15	6.80
Stomach	685	310.71
Intestines (length 585 ft.)	2,255	1,009
Diaphragm	552	250
Muscle	21,780	9,863
Tongue (length 18 ft.; width 7½ ft.)	2,705	1,227
Fat plus muscle*	27,319	12,391
Blubber	25,581	11,603
Skeleton	19,651	8,913
Uterus with oviducts	214.65	103
Ovaries	11.35	5.150

* Body fat, independent of muscle.

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