THE HUMAN SPECIES

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CONSIDERED FROM THE STANDPOINTS OF
COMPARATIVE ANATOMY, PHYSIOLOGY, PATHOLOGY
AND BACTERIOLOGY

BY

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AUTHOR'S PREFACE.

Whenever the question as to the essential nature of Man is raised the uninitiated seem to think that there is nothing easier to answer. To them not only all that concerns the body, but also man's soul, is something so long since settled, so self-evident, as to require no further discussion. On the other hand, however, ever since the establishment of anthropology as an independent science, with untiring diligence experts have been busy investigating the nature of Man as compared with that of the lower animals, and now not a year passes without these investigations resulting in distinct modifications of the accepted points of view, in one or other direction.

The aim of this book is the comparison of the essential characteristics of Man with those of the lower animals in the light of the results of recent research. Many a character hitherto regarded as distinctively human will be found to be shared by the lower animals, many another be proved man's indisputable possession, though here and there he may not be particularly edified thereby. To arrive at a clear understanding of the nature of Man the parallels drawn between him and the animal world must not be confined to anatomy and physiology only, but extended, in a rigidly critical spirit, to psychology and pathology, for psychology is but the physiology of the soul, and pathology the doctrine of life under changed circumstances.

THE AUTHOR.

STUTTGART, *July*, 1907.

PREFACE.

In his work on the "Human Species," Hopf compares the structure, functions and diseases of man with those of animals. It must not be taken, however, that the volume is simply a collection of facts and details. A glance at the headlines of the pages will reveal the wide extent of the ground covered. After discussing the distribution of mankind, the ancestors of man, the structure and functions of the various tissues, Hopf deals with such interesting questions as psychology, the origin of the mind, emotions and their expression, social customs, marriage, communism, modesty, shame, religion and art. He then proceeds to consider the diseases of man and animals, the parasites common or peculiar to each, and concludes with a fascinating chapter on self-help in animals and primitive man. Realising that such aspects of the subject will appeal to the general reader. the text has been shorn of scientific terminology as much as possible.

In preparing an English translation the Editor has tried to follow out the general idea of the author, and therefore no apology is needed for the terminology employed. Difficulties have arisen in adapting the German classification to the English reader, and in some instances it has been necessary to retain terms and distinctions not usually current in English books. A few alterations and additions have been made, but these in no way affect the deductions, theories or views of the German author. Wherever possible, German quotations from English works have been verified, and the original English wording cited. There is little doubt but that those who study this work will find in it a fund of information presented in an interesting, though concise, manner.

W. H.

1909.

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PART I.

Introduction and General Considerations.

WHEN we bear in mind the age of mankind as estimated by the geologist, the recognition of man's true place in Nature must seem a comparatively young, even modern, achievement. This fact is certainly very striking, but is easily explained by the circumstance that the question as to man's place in Nature is indissolubly bound up with the question of man's origin.

Ever since there have existed on our planet thinking beings who have speculated as to the origin of the visible world, two conflicting dogmas have found currency. "The world was created," cried some; "The world has grown," replied the others. Thus it is but natural that the same difference of opinion has prevailed from the earliest times on the subject of the origin of man. The belief in a Creator of the world, and of man, is found in its lowest form among certain savages, who hold the curious doctrine that not the Creator himself but certain animals, acting for him, created the world and man. According to the faith of the Savo Islanders (Solomon Isles) it is to the shark that we are indebted for the creation of the island, and of the men and the mound-birds who inhabit it. Among the tribes of America the idea of animal demiurges is strongly developed. They regard animals as symbols of the divine force in Nature, and as existing before the creation, and taking part in the production of the world and of man. The principal part, however, is played by a fabulous bird which is either a god itself or a revelation (abode) of the same.

Certain western tribes of North America imagine the earth to have been created by a crow; the people of Delaware and Florida venerate the stag as a powerful spirit and creator of the world and of man. Others, again, attribute the act to the hare, the beaver, the otter, or the bear, but wherever the coyote appears it is to him that chief honour is paid, on account of his sagacity, and he is regarded as the creator; indeed, in the Oregon region, where the language contains no special word for "deity," the "little wolf"—half animal, half higher being—is the chief object of veneration.

On a considerably higher plane stand those tribes who attribute the creation of the world and of man to a mediator between God and man, in other words to a demiurge possessing human attributes. All the nomadic tribes of the Polar regions, for instance, believe in a powerful benevolent deity who, however, is too sublime to conduct the work of creation personally, and has consequently entrusted it to his only son. The same fundamental idea is to be traced in the Javanese tradition, according to which there dwelt in the centre of the universe, long before the creation of heaven and earth, a deity named Sang-yang-Wisesa who gained permission from the supreme god to create heaven and earth, sun and moon, and finally man himself. This demiurge, Sang-yang-Wisesa, is identical with the Unkulunkulu of the Zulus of South-West Africa, with the Numank Machana of the Peruvian Indians, and with the demiurgic architect of the Aztecs, who first improved the form of the created world on its emerging from the deep, whereupon man, in his original state a formless mass of flesh and blood, was brought to perfection by Quetzalcoatl.

Although among many American tribes the deity from whom man has descended is of an undeniably anthropomorphous nature, being himself the "*First Man*," among many others the idea of a *demiurge in human form* is clearly traceable. For instance, the Leni Lenape represent the first man, Naḥabasch, as mediator between god and man; the Caribbeans maintain that the first man, Loguo, descended from heaven and returned thither after creating the world and man; finally, the Algonquins' principal god, Menabogho, is sometimes represented as mediator between the supreme spirit and mankind, sometimes as the progenitor of the human race and creator of the second world, the first having been destroyed by evil spirits.

We sometimes even find the first man regarded as the son of the supreme spirit; for instance, among the Californians, whose great god Cumango sent his son, the first man, Guaayayp, down to earth to perfect the state of imperfectly created man. Etalapass, the god of other western tribes of America, did, it is true, create men, but they were imperfect and incapable of movement till another god, Ecannin, had compassion on their helplessness and opened their mouth and eyes, bestowed the power of movement on hands and feet and taught them to make boats and nets. In the mythology of the maritime tribes of North America sagas tell of semi-human beings whose definite separation into man and beast only took place later through the intervention of the son of god during his wanderings on earth.[1]

Son of god and creator of the world is also Adam Kadmon of the cabalistic book of Jezirah; he proceeds from Ensoph, the highest of beings, as the first source of light; thereupon ten Sephiroth, or spiritual powers, radiate from him and serve, in conjunction with the twenty-two numerically conceived consonants of the Hebrew alphabet, as the instruments of the creation of the world and man. The Gnostics again, whether they incline to the Greek or the Oriental version, are unanimous in attributing the material world, including man, not to the highest divine being, the Pleroma, but to an inferior creator, a demiurge, who is connected with the material world, and subordinate to the Pleroma. "Pleroma" signifies "fulness of Divine life".

Whether this idea of a demiurgic son of god be primary or, as Waitz and other anthropologists assume, secondary, of later date, it must certainly be deemed inferior to the conception of a single omnipotent creator. This type of creator is to be found, under the most varied forms, among the savage peoples of all parts of the world. Space does not permit us to attempt a complete enumeration of the names under which the creator appears, and the traditions of the creation of man therewith connected. But we must not overlook the remarkable sagas, current among certain tribes, which treat of the creation of woman as a distinct act of creative power. The Munda Kolhs, for instance, maintain that their god Singbonga only then pro-

[1] A full account of North American mythology will be found in the *Bureau of American Ethnology Bull.* 30.

ceeded to create a girl when the first boy had been killed by a horse. In the tradition of the Andaman Islanders the first man created by Paluga was tall and blackbearded, and did not receive a wife until he had proved that he was capable of supporting himself; the Arawaks, a branch of the Caribbeans, are so lacking in chivalry as to assert that man was created by a good spirit, and woman by an evil one. The Eastern Eskimos also ascribe the creation of the world and man to two distinct deities: one good, bearing the masculine name of Tongarsak, the other malevolent and nameless, but it has not been proved that they impute the creation of woman to this latter.

The contrast between a good and an evil creator is still more striking in the Zend-Avesta, the sacred writings of Zoroaster, the philosopher of ancient Persia. Ormuzd, wishing to raise a bulwark against his enemy, Ahriman, created the material world with its living beings in 365 days, taking 75 days for the creation of man alone. This primitive being was bisexual, and from him descended the first pair, Meschia and Meschiana, the progenitors of the peoples of the earth. Ormuzd was, however, powerless to prevent man's ultimately falling a victim to the sinister god Ahriman (Death).

Zoroaster's teaching represents man as created for his own sake, whereas, in the Indian doctrine of the revelation of Ekhumescha, according to the Sastra of Brahma, living organisms, including man, were created merely in order to serve as a purifying, intermediate stage for the fallen devetas (angels), the cow forming the last stage but one, and man the final.

In all these legends man is simply a dynamic creation. The supreme being willed that he should be, and he was. In contrast to this purely dynamic process of creation we have the conceptions of those nations who endeavour to explain the process on material mechanical grounds.

Here too we find the most diverse ideas prevalent, for is it not inevitable that all speculation as to the creation of the world in which we live should be powerfully influenced by our surroundings, organic and inorganic? Hence it need not astonish us to learn that man is sometimes supposed to have originated in plants. For instance, the Leni Lenape think that the supreme spirit formed the first man and woman out of a treestump. According to the belief of the Sioux Indians, the first created men stood for several generations like tree-trunks, with their feet rooted in the ground, until a great snake gnawed through the roots and thus endowed man with the power of movement. The Caribbeans believe that their creator, Aluberi, seated himself on a tree and broke off twigs which he changed into animals; but one he turned into a man, and the man fell asleep, and on awaking found a woman at his side. The Bagoba tribe, inhabiting South Mindanao, believe that the first plants were a bamboo and a betelnut palm, and that at the bidding of their god, Todlai, from the cleft bamboo there sprung a boy and from the palm a girl; when they were grown up they married and became the parents of the human race.

In other parts of the world the creator is supposed to have made man out of animals; the Dieyeries, an Australian tribe, believe man originated from black lizards. The benevolent deity, Moora Moora, changed their feet to fingers and toes, added a nose to the face and, in order to preserve their equilibrium when standing erect, removed the tail, whereby they became lords over all other creatures.

Nevertheless, traditions of man originating in plants or animals are rare in comparison with the overwhelming majority of those wherein he has been created out of clay, earth, or stone. Traditions of this type are current among the Gallas of East Africa, the Javanese, the North American Indians, and, in very pronounced form, among the semitic tribes of Further Asia, the Babylonians and the Hebrews, their followers in civilisation, and, in yet another more modified form, among the Mohammedans.

The so-called Mosaic tradition of the creation handed down from the Babylonians, forms one of the most remarkable phenomena in the history of civilisation, for it not only constitutes a strict article of the Jewish faith but, from the founding of Christendom, has continued for over nineteen centuries to be the official explanation of the origin of man in all Christian churches and schools. The philosophic-theological speculation of scholasticism could do it no harm, for even after the early dialectical stage of scholasticism had given way to pure philosophy, the quintessence of the philosophy was, after all, only a confirmation of the belief in revelation. Thomas Aquinas, the celebrated disciple of Albertus Magnus, remarks drily on this subject: "The beginning of the world (and of man) is not a matter of knowledge but of revelation".

Even the naturalists and mystics of more modern times, such as Valentin Weigel, Theophrastus, Paracelsus, Cardanus and Telesius, do not go very deeply into the question as to how and whence man came into the world, but occupy themselves instead in attempting to establish the true relation between divinely created man (microcosm) and the universe (macrocosm). Cartesius, even while admitting that God created man, cannot explain the actual process of creation, and when Leibnitz advances his theory of a world constructed of animate monads proceeding, according to predestined plan, from the first monad, God, by means of ceaseless radiations from the Godhead, he still does not show us how the special creation of man from these monads is to be explained.

If we examine the views of the natural philosophers of the more positive school down to the most recent times we find the same result. Even assuming an omnipotent and omniscient God as Creator of the world and man, thought is still baffled as to the manner of their creation.

The Almighty had but to will, and all organisms, up to man himself, God's own image, stood complete before him.

This was the view held by all those philosophers who found satisfaction in an analytical exposition of detail, while their faith in the Scriptures remained unshaken. Linnæus, to whom we owe the establishment of the theory of species, cannot rid his mind of the conviction that every form of life had its original corresponding species, and that of every living creature, including man, God first created a pair. Cuvier, the great authority on comparative anatomy, firmly supported the theory that all created species are original and immutable, and explained the occurrence of new species in consecutive geological strata as resulting from vast upheavals in certain parts of the world, whither, later on, living beings from other parts found their way.

Agassiz likewise accepted the theory of these devastating revolutions, but is more consistent in that he supposes an intervention of the Creator after each upheaval, and, feeling the incessant re-creation of complete organisms to be somewhat too improbable an hypothesis, he takes refuge in the theory that all living beings, man included, originated in eggs created by the Supreme Power.

The Koran requires no such sworn evidence. In the fifteenth Sura it is written: "God said to the angels: 'I will make man out of dry earth and black clay, and after that I have made his form perfect and breathed my spirit into him then shall ye fall down and worship him'".

The first Arabian philosophers, Alkendi, Alfarabi and Ibn Sina, in spite of their acquaintance with the Aristotelian philosophy, were orthodox dogmaticians, and even among the later sects none would have ventured to question the teaching of the Koran; indeed, the orthodox members of the Hanifilic sect even maintain that all strife and contention over the articles of faith laid down by the Koran is expressly forbidden by Mahomet. The truth of this assertion is supported by the fact that among Mohammedans the creation of man is sometimes discussed, but never his origin.

The conception of a simple, natural origin of man can as well arise in the mind of the untaught savage as in the highly cultivated brain of a philosopher. Hence we find among savages traditions that in their essence bear a strong analogy to the teachings of the natural philosophers of all times.

Certain tribes of Eastern Asia settle the matter with admirable simplicity by saying that the first man came into existence of his own free will. The majority of primitive peoples, however, who believe in a simple origin of man, endeavour nevertheless to give some satisfactory interpretation thereof, choosing one or other substratum whence man is supposed to have arisen. In the Mautewa Islands of East Africa a demon fished a case, containing human forms, out of the sea, and they grew into men, and the amiable demon turned into a leguan in order to protect them from vermin. On the banks of the Bramapootra the story goes that out of a swelling on the hand of Kalia Adeo issued the twelve families of the Gonds, who, however, in consequence of an evil smell attaching to them were shut up in a cave by the god Mahadeo, only four brothers escaping. A similar idea prevails in Madagascar, only in this case the first human being, a man, is already created and becomes afflicted with an abscess on the left leg, to which strange source the natives discourteously trace the origin of woman. According to a Slavonian tradition the first man was created out of already-existing organic matter, but here the organic matter is of divine origin, for during his first wandering God grew weary and a drop of sweat fell from him to the earth, where it straightway turned into a man. In America there is a widespread belief that man originally issued from the earth, from caves, or from stones. The Greenlander believes the first man to have been made of clay and the first woman, the mother of all succeeding generations, to have sprung from his thumb. The Iroquois believe themselves to have come from the heart of a mountain, and the Oneidas call themselves "sons of stone" because they believe, like the people of Rotuma in Polynesia, that the first man was made out of a stone. The belief in man having originated in caves is found in Central America, among the Indians of the Antilles, the Carribeans, the Solostos and other Brazilian and Peruvian tribes, the latter even venerating under the name of "paracina" those places where the first human beings are supposed to have emerged from the earth. Under these circumstances, therefore, we need feel no surprise at finding a widespread belief in man's origin in plants.

The Salivas, on the Orinoco, believe the first human beings to have been like reeds, others like the fruit on the trees, and a third variety of a nobler type, to have come down from the sun. The national hero of the Goldens in Northern Asia in the course of a pilgrimage through the land came upon a mighty tree whose branches bore round shining discs. With an unerring bowshot he brought one to earth, but no sooner had it touched the ground than it turned into a human being, a woman, whom the hero married, they thus becoming the progenitors of the tribe. Similar legends of the origin of man are found among the Hereros of South-West Africa, in the Island of Nive in Polynesia, and in Samoa, where a creeping plant grew on a rock, and on dying bred worms and afterwards man. Here the animal origin of man is only indirectly implied, but in all parts of the world legends are to be found treating of man's immediate descent from animals.

Among the Fiji Islanders the first boy and girl were produced from a hawk's egg, while the Santals—a Bramapootra tribe allied to the Kolhs—prefer to believe that the progenitors of the human race proceeded from the eggs of a pair of ducks. In New Zealand man originated in an egg laid by a monstrous bird on the water. A Peruvian legend tells how three eggs fell from heaven—gold, silver and copper—containing respectively the princes, the nobility, and the common people. Other tribes of Peru, before the time of the Incas, traced their genealogy from the puma, jaguar, eagle, vulture, etc., just as the North American tribes believe their ancestors to have been the dog, wolf, bear, hare, bog boar, beaver, wild turkey, turtle dove, tortoise, crocodile, snake or salmon. The tribes of North-West America carry their belief in an animal origin so far as to think that their chief ancestors descended from heaven in the form of birds. The result of this belief is the well-known Totemism, in which Virchow tries to find a dim feeling after Darwinism, or relationship with the animal world.

We need not dwell upon the belief of the Aleutians in their descent from a dog, and that of the Ainos that their forefathers were bears, but the widespread belief in man's descent from the apes is deserving of more attention, being of great anthropological interest. Savage tribes of the Malay Peninsula, who are regarded by the more civilised Malays as no better than animals, trace their descent from a pair of "unka putch" (the white mountain ape), who sent their young down to the plains, where they reached such a state of perfection that they and their descendants became men. Similar to this is the Buddhistic legend of the origin of the platyrrhine races of Thibet; they are supposed to have descended from two very perfect apes and to have been changed into men to people the snowy regions. Another instance we have in the Djatwas of Rajputana who claim to descend from the ape-god Hanuman, and in support of the legend maintain that their princes bear the sign of their origin in a prolongation of the spine.

A close examination of these traditions reveals the fact that in every case a process of generation is pre-supposed, a fact occupying a still more prominent position in those doctrines of creation held by all polytheistic races, whether civilised or uncivilised. As a rule all phenomena of the universe, man not excepted, are attributed to the union of two primitive beings, a male and a female. Signs of this belief are found even among those races who believe man to have simply arisen from the earth.

The Indians of New Holland in North America believe that they were literally born from the earth as from a human mother; they believe that before the beginning of things there existed a creative force, in female form, which first bore a stag, a bear and a wolf, and uniting in turn with each produced the most diverse offspring, till lastly man was born. Naturally, where a female creative force was imagined the idea of a male being was necessarily associated therewith. This belief is held by the Comanches of North America, by the natives of Sumatra, the New Zealanders and the inhabitants of the Marien Islands, and it is invariably through the union of a god, or hero, with a female deity (the Earth) that man has originated.

To regard the creation of the world and man as resulting from a process of generation is so entirely natural and consistent a point of view for the untaught mind, which necessarily judges everything by its own surroundings, that it is not surprising that the priests and philosophers of the older civilisations presented the doctrine of creation in anthropomorphous form, in order to bring it nearer to the general mind (or perhaps with precisely the opposite aim ?). According to the Egyptian, Babylonian and Phœnician cosmogony, the creation of the world and man results from the union of two primitive beings, the male fair, the female dark. Among all branches of the Aryan race we likewise find the idea of all living beings having descended from two parents; thus the Indians have Brahm and Brahwani, the Greeks Zeus *πατήρ* and *Δημήτηρ*, the Romanic nations Jupiter and Rhea. As early as in the Rig-Veda we find the legend of the great parents Dyäuspitar and Prthivi mâtar, and Tacitus mentions the ancient Teutonic legend of the god Tuisco being the son of Heaven and Earth. Among nations of the Mongolian stock, particularly the Chinese and Japanese, it is but natural to meet with the same fundamental idea when we consider their special veneration of ancestors. And what are the gods and goddesses wherewith the polytheistic imagination peoples heaven and earth but personified natural forces called into action at the creation of the universe and afterwards worshipped under the names of heaven, earth, light, etc.? Nor need we despise this theogony since it is, in reality, the dawn of approaching natural science. One step further and a veil is lifted, revealing the venerable fathers of natural philosophy in earnest meditation over the material causes of the world and of man.

First comes Anaxagoras who taught that the earth had brought forth man and beast from the germs scattered over its surface, until they were able to propagate their race alone; the world, however, was not formed out of the pre-existent matter until that matter was associated with the force-giving spirit. Thus Anaxagoras cannot escape Dualism any more than can Archelaos of Miletus, or Empedocles whose derivation of the organic world from the four elements is extremely interesting: first came plants, then animals and men, whose different parts at first grew separately out of the ground and were afterwards set together by Eros (love, or elective affinity), the most fantastic forms being thus accidentally evoked, destined to ultimate destruction. The human being, moreover, was at first a formless mass of earth and water, cast up by subterranean fires and attaining its perfect form only by slow degrees. Diametrically opposed to the above were the views held by the old Ionian naturalists who, according to the express testimony of Aristotle, admitted none of the various motive forces of matter. Thales and Pherekydes assume water to be the first element from which all else has proceeded; Anaximander, infinite substance; Anaximenes and Diogenes of Apollonia, air; Heraclitus, fire (heat). Diogenes and Anaximander alone state their convictions as to the origin of organisms, the former assuming that the influence of the sun's heat caused the earth to produce vegetable and animal organisms; the latter, however, expressly states that all animals, man included, originated in fish-like form in the primeval ooze and only on the drying up of the earth attained their present form. Neither the Atomists nor the pantheistic Eleatic philosophers seem to have shared this view.

Xenophanes argued from the occurrence of fossilised marine animals in high mountains that the earth had passed from a semi-fluid to a solid state. Parmenides, like Democritos, thought the development of man due to the influence of the sun's heat on the earth. In the works of Plato and Aristotle, his disciple, nothing is to be found on the origin of living organisms. Aristotle, the naturalist so far in advance of his contemporaries, limits himself to a classification of plants, animals and man, in a regular system, and a description of the same on general lines, but as regards their origin he preserves a complete silence.

It is owing to the predominant influence of Aristotle on the philosophy of the Middle Ages that the scholastics and their followers so seldom ventured to formulate independent theories on the origin of the world and of man. Strange to say, Ebn Tophail, the Arabian philosopher who died towards the end of the twelfth century, mentions in his celebrated book an earthborn autochthon. "In the temperate zones," he says, "autochthones may actually have existed in former times, the earth producing out of itself, *per generationem æquivocam*, human forms capable of absorbing the rational spirit, eternally radiating from the Godhead." Even the anti-scholastic Andreas Cæsalpinus in the seventeenth century, held it to be possible that animals originated in their perfect form from the effect of the sun's heat on the earth, since they could not have been produced by generation. Other independent thinkers of the sixteenth and seventeenth centuries, while adopting a monistic standpoint, leave us nevertheless in doubt as to their conception of the actual origin of organisms out of "divine substance, itself one with God".

We pass on to the latter half of the eighteenth century when cosmology seemed to enter upon a new era with Kant's theory of the formation of the world. After stating that our solar system with its moons and planets has been evolved from nebulæ, and showing that our earth must have required an enormously long period of cooling and consolidation before water could be formed on its surface, it might have been expected that he would extend the theory to organisms, but in his later works, for instance, in the *Criticism of the Teleo-*

logical Faculty of Judgment, he firmly supports the dualistic view and ascribes the creation of organisms to God, according to his special aim and intention.

Fortunately, about the same time the doctrine of the origin and evolution of organisms found champions in those thinkers who, as forerunners of the great naturalist and philosopher, Charles Darwin, merit our respect. In France it was Lamarck, the celebrated author of the *Histoire naturelle des animaux sans vertèbres*, who in his *Philosophie Zoologique* (published 1809) set forth the view that the entire animal world as at present existing must be considered as descended in changed form from earlier organisms, a theory which was republished in elaborated form in 1815.

Lamarck explained the gradual transformation of animals as the result of use and habit, whereas his friend, Geoffroy St. Hilaire sought the cause in the modifications of the qualificative and quantitative state of our atmosphere. Both were defeated in the contest with Cuvier, which Goethe followed with so deep an interest, but the struggle was taken up by other men, each of whom brought to it his own conception of the story of creation.

Both Lamarck and St. Hilaire held the theory that the higher organisms have been developed, through progressive modification, from a few original types of the simplest organisation.

Oken, the German naturalist philosopher, could not conceive of living creatures having arisen by other means than that of original generation; hence his view that germs of life, called by him Infusoria, originated in the bed of the ocean, and through the absorption and discharge of gases, in other words through breathing, developed into living organisms. In his opinion all higher organisms, man necessarily included, are constructed from an infinite number of Infusoria, and after death are again resolved into the separate elements of the organic substance whence they sprang. Apart from the fact that what Oken described as Infusoria were discovered later on by the microscopist Schwann to be cells, he has still given us no satisfactory explanation of the actual construction of organisms out of his so-called Infusoria, and the progressive development of the lower into the higher forms.

The first man in Germany to attack boldly this question was no other than the great poet and thinker, Goethe, whose genius gave him a deep insight into the secrets of the organic world, and made him pre-eminent, even in technical matters, over his contemporaries. His *Metamorphosis of Plants*, written in 1790, was followed by *Comparative Craniology*, and in 1818 by *Metamorphosis of Animals*, in which work Goethe assumes as the leading factors in metamorphosis an internal creative force, the type, and an external creative force, or power of adaptation.

Then followed a long series of works by the German naturalists C. Ernst v. Baer, Schleiden, Unger, Viktor Carus, Schaaffhausen and Ludwig Büchner, and by the English naturalists, Erasmus Darwin, William Herbert, Herbert Spencer and Huxley. The way was thus well prepared for Charles Darwin's epoch-making work on the *Origin of Species by means of Natural Selection* (1859). Darwin adopts the theories of Lamarck and St. Hilaire on the metamorphosis of organisms, but his penetrating mind seeks to prove them on entirely new lines, in that he assumes, as the main agents of metamorphosis, inheritance, individual variation, inherited variation, the struggle for existence and natural selection. His first work treats solely of animal and vegetable organisms, but in his later work, *On the Descent of Man*, he applies the same laws to the gradual evolution of man from lower forms of life. In the introduction [1] he vigorously protests against the attacks of ignorance on science. "It is those who know little, and not those who know much, who so positively assert that this or that problem will never be solved by science." Darwin considers that there is ample justification for the conclusion that man, in common with all other species, is evolved from some lower and extinct form.

It was inevitable that a member of the ape family should be selected as the immediate forerunner of man, but that Darwin represents one of the surviving forms of ape as the progenitor of the human race is merely a false assertion on the part of his antagonists. Unlike Lamarck, who pleads the

[1] *Complete Works of Charles Darwin*, from the English, by Viktor Carus, Stuttgart, 1875, vol. v., p. 3.

cause of original generation, Darwin does not occupy himself with the question of the origin of life itself. He simply assumes that in all probability every organic being that has ever existed on the earth has descended from some prototype, into which life was breathed by the Creator. Haeckel,[1] however, Darwin's zealous follower in Germany, goes further. To him the question of man's origin is not only the question of questions, surpassing all other problems of the theory of evolution, but it brings him back to the question of original generation. He distinguishes two varieties: autogony, or origin of organic matter from an inorganic, non-albuminous fluid, and plasmogony, or origin of organisms in a fluid containing carbon in some form. Here natural science coincides with certain of the ancient theories of cosmogony. In many of the old traditions of creation, life was held to have originated in the darkness of the deep, and in the latter half of the last century scientific research actually revealed the fact that in the lowest depths of the ocean, where an even temperature of 4° Celsius is perennially maintained, protoplasm existed in the form of the Gymnocytoda, to which is allied the Bathybius, a low form of life, discovered by Huxley, consisting of a conglomeration of jelly-like particles. To these succeed in a progressive scale of development the Lapocytoda, furnished with an integumentary membrane, formed by the congealment of the outer surface, then the first cellules with a nucleus, and lastly the testaceous cytoda with nucleus.

Like the belief in the central position of the earth, the conviction of man's central place in Nature dominated thought throughout the Middle Ages. Hence it is oddly inconsistent that the encyclopædias of the early Middle Ages (Isidor von Sevilla, sixth to seventh century; the Venerable Bede, seventh to eighth century; Rhabanus Maurus, eighth to ninth century) and more especially the voluminous works of the scholastic naturalists of the following centuries, place the anatomy and physiology of man side by side with that of plants and animals. Indeed, in the works of Albertus Magnus on natural science (1193-1280), the description of man receives but scant attention.

[1] E. Haeckel, *Our Present-day Ideas upon the Origin of Man.* Bonn, Strauss, 1899.

A fuller account is given by the English writer Bartholomæus, surnamed Anglicus, in the fifth volume of his Encyclopædia, *De genuinis rerum coelestium, terrestrium et internarum proprietatibus et de variarum rerum accidentibus* (1258-1260). Encyclopædias comprising human anatomy and physiology were also compiled by the French author Vincentius Bellovacensis (died 1264), the Englishman, Alexander Neckam, and his friend, Alfred de Seresbel, and by the Dutchman, Thomas Cantimpratensis, whose bulky comprehensive work, *De naturis rerum*, was later issued in a smaller edition, in the German language, revised by the Canon of Regensburg, Konrad v. Megenberg; the work in this form became the first German Natural History and was very frequently published. The first part of this *Book of Nature*[1] deals with "Man in his common nature".

We may pass over the specialists in human anatomy of the latter part of the Middle Ages and the subsequent scientific regeneration of Europe, since they occupied themselves mainly with a close study of the human body itself rather than with theories of man's place in Nature. The founders of modern Zoology, on the contrary (Gessner, Aldrovandi, Swamerdamm, Ray, etc.), were content to compile zoological works, or to publish studies of minutiæ without establishing any relation between man and the lower animals. This state of things was completely changed when the great reformer Linnæus subjected the whole world of organisms to observation and examination. He it was, too, who in his zoological system placed at the head of the mammalia the order of anthropomorphous animals (later styled Primates or "chief of animals") wherein man was classified with the Simiæ and Prosimiæ. This system was revised and man's place more clearly defined by Blumenbach and Cuvier. They subordinated the order of Quadramana (four-handed animals), comprising Simiæ and Prosimiæ, to the order of Bimana headed by Man, since in man's case alone did they admit the possession of two hands. In Huxley's opinion this view is false, as the apes also have but two hands.

The majority of authors towards the end of the last century subdivided the Primates into three classes: (*a*) Prosimiæ, (*b*) Simiæ, (*c*) Man.

[1] Edited by Dr. Franz Pfeiffer. Stuttgart, 1861.

Apes were again subdivided as follows :—

(*a*) The American (New World) *Platyrrhines*, with broad nasal septum and short bony auditory passage.

(*b*) The Old World *Catarrhines*, with narrow nasal septum. The catarrhines, especially the higher varieties, the anthropoids, are in their physical structure most closely related to man.

Robert Hartmann divides the whole order of Primates into three families :—

(*a*) Primarii : Man and the anthropoid apes.

(*b*) Simiæ : Apes, both Platyrrhines (broad-nosed) and Catarrhines (narrow-nosed).

(*c*) Prosimiæ : semi-apes (Lemuridæ).

Huxley also places man together with the anthropoid apes in a separate class, stating his reasons for so doing as follows : "The anatomical differences separating man from the gorilla and chimpanzee are not so great as those distinguishing these latter from the lower apes". This opinion has become a general axiom of modern natural science and is approved by Haeckel. In his lecture on the "Origin of Man" he says: "Comparative anatomy applied to the Catarrhine group, proves conclusively that the morphological differences existing between man and the anthropoid apes are not so great as those between the anthropoids and the lowest members of the same group".

Man's place in this order is most clearly defined by Haeckel's classification :—

(1) All the Primates, including man, descend from a common prototype.

(2) The progenitors of man formed a group of Catarrhines, now extinct. The very earliest ancestors of this group belonged to the lower caudate apes, possessing three or four sacral vertebræ. The later ancestors of the group belonged to the tailless apes with five sacral vertebræ.

(3) The Catarrhines form a natural group which may be traced back, directly or indirectly, to a branch of the Prosimiæ.

(4) The true apes (Simiæ) have been developed from the half-apes (Prosimiæ).

But this classification of man in the order of the Primates did not satisfy the supporters of the doctrine of evolution, among whom may be numbered almost all naturalists[1]; they demanded a still closer investigation in order to ascertain the relation of man to the other mammals and lower vertebrates. C. Gegenbauer, in his *Manual of Human Anatomy*,[2] finds nothing in the physical structure of man constituting a fundamental difference. "In the construction of the human body we find not only resemblances to the organisation of animals but a widely comprehensive correspondence wherever there is a similarity of function, a correspondence complete down to the finest structural details; an absolute uniformity is not to be expected since it is not found even among closely related animals." In spite of the manifold resemblances between man and the lower animals, Gegenbauer feels bound to point out that man in the structure of his bodily organs has not yet reached the highest stage of creation, in that rudimentary organs still persist in his structure; these, however, are not to be regarded simply as imperfections, but rather as a form of compensation, preparing the way for the organism to attain ultimate perfection.

One of the most important points of resemblance between man and the other mammals is the maxillary joint, which distinguishes them sharply from certain birds, reptiles and amphibia furnished with a quadrate joint. Further, all mammals have a diaphragm, forming the partition between thorax and abdomen. Their red blood cells are small, circular, and biconcave. The skin is covered with hair. All new-born mammals are fed on the milk of the mother. The sucking action has developed the palate and the epiglottis, and is not found in any other class of animals.

Man's correspondence to the whole class of vertebrates rests chiefly on their possessing in common a firm inner framework of bone and cartilage consisting of vertebræ and skull, and enclosing the organs of psychical activity, the brain and spinal cord. Common also to all is the ventral heart, as opposed to the dorsal heart of the Articulata and Mollusca; the early appearance of a respiratory tube distinct from the intestinal

[1] The most obstinate resistance was offered by Virchow. Even as late as 1895, in his speech at the opening of the Anthropological Congress at Vienna, he asserted that man could equally well have descended from the sheep, or elephant, as from the ape.

[2] Fourth edition. Leipzig, Engelmann, 1890, vol. i., p. 33.

tube; the highly developed muscular system, and the perfection of the urinary and genital organs. In all these respects man corresponds, broadly speaking, not only to all the other mammals, but to birds, reptiles, amphibia and fishes; hence all mammals, birds, reptiles, amphibia and fishes must be descended from a common prototype.[1] Now as the fishes occupy the lowest position among the vertebrates, Darwin is justified in concluding that all vertebrates are descended from a fish-like prototype. As lowest of the fishes once ranked the Amphioxus lanceolatus with its small, symmetrical, lancet-shaped body, without brain or heart, and, strictly speaking, without a head; since it possesses in place of a vertebral column merely a Chorda dorsalis, such as is found in the Ascidians, Darwin[2] concludes that here we have most probably the parent form of the vertebrates. Haeckel[3] carries his investigations of man's ancestry still farther back, extending them to still lower invertebrate animals. Thus he takes the Gastræa as ancestor of all the Metazoa, because it represents the gastrular stage of all Metazoa, the members of the Volvox genus as representing the blastula stage in the development of the Metazoa, and lastly the Protozoa corresponding to the single-celled egg. As connecting link between the lowest Metazoa and the Ascidians on the one hand, and the Amphioxus on the other, Haeckel selects the Frontonia, a class of the humblest chordate animals, from which are descended both molluscs and mammals. The Frontonia form a branch of the invertebrates, which in their turn are probably descended from the Rotatoria, or wheel animalcules.

Distribution of Mankind.

For many centuries we have unhesitatingly accepted the Mosaic classification of man as descendants of Shem, Ham and Japhet, the three sons of Noah. The tribes described by Pliny in his *Natural History* and mentioned by Sebastian Munster in his *Cosmography* (sixteenth century), were regarded as particularly abnormal: the Cynocephali, the Cyclops, the Megapods and sundry other monsters haunted the mind of

[1] Darwin, vol. v., p. 206. [2] Darwin, vol. v., p. 208.
[3] Haeckel, *Lecture*, etc., p. 27.

the credulous reader, in spite of the voyages of discovery made in the fifteenth century. Natural science had but just shaken off the fetters of scholasticism, and the men had not yet arisen who should bring a clear, unbiassed judgment to bear on the reports of the explorers. The first attempt at a strictly scientific classification of the human race was made by Linnæus; he divides mankind into four races:—

(1) *The American*, physically characterised by reddish colour of the skin, slender stature, straight, thick hair, and almost beardless chin. His temper is choleric. Linnæus sums him up thus laconically: "He is stubborn, contented, fond of liberty, paints his body in Dædalian style and is ruled by habit".

(2) *The European*, with white skin, fleshy body, fair, curly hair, blue or grey eyes; of sanguine temper. "He is active, shrewd, inventive, likes closely-fitting garments and respects the authority of law."

(3) *The Asiatic*, with yellow skin, of compact build, has dark hair and brown eyes and is melancholy in temper. "In character he is cruel, avaricious, fond of show; he likes to dress in flowing garments and is ruled by prevailing opinion."

(4) *The African*, with black skin, loose build, very black curly hair, velvet-smooth skin, broad, flattened nose, protruding lips; of phlegmatic temper. "He is cunning, indolent, indifferent, anoints his body with grease and is governed through despotism."

In the Linnæan system together with much able, pertinent criticism, there are many erroneous statements; *e.g.*, the classification of all the diverse tribes of Asia in one group, and the fact of furnishing all Europeans with fair, curly hair and blue or grey eyes. Moreover, it is obvious that Linnæus is not entirely free from the fantastic notions prevalent among the mediæval writers of Natural History. Besides the *Homo diurnus* as highest representative of the *Homo sapiens* he gives further a four-footed, hairy, speechless *Homo ferus* on the strength of alleged cases where children grew up among animals without human care. Linnæus enumerates as *Homini monstrosi*:—

(1) The inhabitants of the Alps, small, active and timid.

(2) Human beings furnished with a single testicle: the Hottentots.

(3) The beardless: many American tribes.

(4) The megacephalous, with conical heads: the Chinese.

(5) The oblique-headed, with skulls flattened in front: the Canadians.

Blumenbach's system, which has obtained for so long in the scientific world, though possessing valuable advantages over that of Linnæus is still not entirely adequate. He gives *five* races or varieties.

(1) The *Caucasians*, white skinned, with red cheeks, brown, or brownish hair, round skull, oval face, smooth forehead, narrow, slightly aquiline nose, small mouth, perpendicular front teeth, face symmetrical and agreeable. In Europe all nations with the exception of the Laplanders and Finns. In Asia the inhabitants of all parts as far as the Caspian Sea, the Obi, and the Ganges. In Africa, the North Africans.

(2) *The Mongols*, with yellowish sallow skin, straight, thin hair on the head, almost square skull, broad face, shallow and flattened, the nose small and turned up, narrow eyes and projecting cheek-bones. In Asia all nations except the Caucasians and Malays. In Europe the Finns, Lapps and Eskimos.

(3) *The Ethiopians*, with dark brown skin, black, curly hair, laterally compressed skull, bulging forehead, projecting cheek-bones, blunt nose, blending into the prominent upper jaw, upper teeth sloping, protruding lips, retreating chin, femoral bone curved inwards. In Africa, all tribes except those of North Africa.

(4) *The Americans*, with copper-coloured skin, thin, straight, black hair, low forehead, deep-set eyes, rather large nose slightly turned up, broad but not flattened face. Forehead and skull frequently artificially deformed. In America, all aborigines except the Eskimos.

(5) *The Malays*, with chestnut-brown skin, black hair, rather soft, thick and curly, skull rather narrow, forehead rounded, broad nose with thickened tip, large mouth with upper jaw slightly projecting. In Asia, the inhabitants of the Malay Peninsula, the Marian, Philippine, Molucca and Sunda Isles. In Australasia, the islanders of the Pacific Ocean.

The advantage of Blumenbach's system consists in the greater prominence given to the relative values of the skull, both the occipital and sincipital, and in the greater exactitude of the geographical distribution, those characters acquired by physical conditions and culture being made subordinate and regarded as secondary race distinctions.

Cuvier, the illustrious anatomist, has treated the subject more simply; following the plan of the Mosaic distribution he recognises only *three* races: the white, the yellow, and the black, without further particularising their distinguishing characters. The latter task was undertaken by the later French naturalists who took into account, as additional race characters, skull, nose and hair. Thus Topinard subdivides each of Cuvier's three races into six sub-races.

Darwin, in the *Descent of Man*, in order to show the inherent difficulty of classifying mankind according to race has compared the views of different authors on the point. Vivey gives two races, Jacquinot three, Kant four, Blumenbach five, Buffon six, Hunter seven, Agassiz eight, Pickering eleven, Bory St. Vincent fifteen, Desmoulins sixteen, Morton twenty-two, Crawford sixty, and Burke sixty-three. Of the more recent classifications Huxley's celebrated system has won pre-eminence by its simplicity. He admits only four principal types, these being variously modified by means of intercrossing.

1. *The Xanthochroic Type*, half white, fair, with blue or grey eyes, bearded, with abundant growth of hair on the body, dolichocephalous, mesocephalous or brachycephalous skull. Inhabitants of the greater part of Central Europe. In the South and West they are replaced by the Melanochroi (Brunettes), a result of intercrossing between Xanthochroi and one of the dark types. In the East is found an admixture of the Mongolian type.

2. *The Mongolian Type*, in stature short and thick-set, with golden-brown skin, sleek, coarse, black hair, scanty beard, pronounced brachycephalous skull, flat, small nose and oblique-looking eyes. They inhabit the entire region east of a line from Lapland to Siam. Differing from the type in their skull formation are, first, the dolichocephalous Chinese and Japanese, secondly, the Polynesians, approaching the Australian type and

probably a mixture of Malay with Negrito, and, thirdly, the Eskimos, Greenlanders, and all aborigines of North and South America with their pronounced dolichocephalous skulls.

3. *The Negroid Type.*—In all individuals of this type the skin and eyes are brown or black, hair of the same colour, short, woolly and not abundant. The skull is dolichocephalous, the forehead rounded and childish, the nasal bone flattened, and the teeth sloping. This type inhabits Madagascar and the region between the Sahara and the Cape of Good Hope. Modifications of the type are the Bushmen and Hottentots, the latter having perhaps originated in an intercrossing of Bushmen and Negro. The Negritos, representing a further modification, resemble the Australian type.

4. *The Australian Type.*—The representatives of this type are characterised by a dolichocephalous skull, extremely prominent eyebrows, unusually large teeth (especially the canines), and the sloping position of the upper front ones. In stature they are tall and long-limbed, with skin of a chocolate brown and black hair, long and woolly. This type is found on the mainland of Australia and in the heart of the Deccan and Hindustan. According to Huxley, representatives are also to be found in Egypt, but it is not clear to what tribe he refers.

Amongst the systematists the philologist Friedrich Müller occupies a special position. Had he attempted to base his distribution of mankind solely on linguistic differences he would necessarily have failed, since it is well known that the most diverse peoples speak the same language. This it was which led him to adopt, in addition to language, the hair as distinguishing character. Hence he gives *two* principal types:—

1. *The Woolly-haired Type*, namely, the bushy-haired Hottentots and Papuans and the fleecy-haired African Negroes and Kaffirs.

2. *The Sleek-haired Type*, namely, the straight-haired Australians, Eskimos, American Indians, Malays and Mongols, and the curly-haired Dravidians, Nubians and inhabitants of the Mediterranean coasts. Müller's classification gives us twelve races subdivided into tribes according to language and race, but race and language seldom coincide. In spite of the

complexity of this system, on the whole there is real merit in Müller's classification of the Middle European races, under which head he includes:—

1. The Basques.
2. The Caucasian tribes.
3. The Hamito-Semitic peoples.
4. The Indo-Germanic race.

Does Mankind Consist of One or of Several Species?

As we have already seen in the mythologies of all nations man has sprung from a single pair of beings, but, be it observed, by the term "man" was understood only the particular nation concerned. On a closer examination, however, we are faced, not only in the legends of wild tribes but also in the Mosaic story of the creation, by the contradictory statement that the descendants of the first human parents have dealings with other beings who must have been created either before or together with themselves. Even Linnæus professed himself a staunch adherent of the Biblical faith, but since those days scientific research has raised many a weighty argument against that faith. Karl Vogt,[1] for instance, considers it beyond question that the human race has descended from several species originally distinct from each other as are the rest of the mammals; further, that during the countless ages of man's existence, those manifold bastard forms have arisen which we now call intermediate types, varieties or races.

Haeckel gives the *Veddahs* as the lowest of the sleek-haired races, and the *Akkas* as lowest of the curly-haired, and considers it probable that still lower down at the common (Pliocene?) root the two chief branches of the human family blend into one. These two pigmy forms Haeckel regards as true species of the *genus Homo*, and vigorously protests against the assumption of a single human species. In this view he is supported by Dames, who asserts that were any animal but Man under discussion the widely differing characters would lead every zoologist to subdivide them into several genera and numerous species. The illustrious Quenstedt expresses himself

[1] Karl Vogt, *Zoolog. Briefe.* Frankfurt, 1851, vol. ii., p. 553.

similarly: "If Negro and Caucasian were snails, the zoologists would unanimously declare them to be two perfectly distinct species that could never have arisen by gradual divergence from a common parent form". In opposition to this view, the majority of naturalists (Kollmann, Virchow, K. E. v. Baer, Ranke, etc.) agree in classifying man as a single species, their opinion being that the existing differences are not sufficiently distinctive to constitute different species, and hence that it is not a question of species, but rather of varieties or sub-species. With his customary critical thoroughness Darwin has stated his opinion on the subject so long discussed by the polygenists and monogenists. The former argue that the various so-called races are found, on careful comparison, to differ importantly from one another, not only on anatomic-physiological lines (texture of the hair, relative proportions of the body, capacity of the lungs, form and cubic content of the skull, convolutions of the brain, etc.) but also on psychological and pathological lines. Now as these characters have persisted for thousands of years, and the different races have adjusted themselves to different climatic conditions, and have even different parasites (Pediculi), we may, without hesitation, infer that man consists of several species, more especially when we remember that certain races are completely sterile when crossed. On the other hand the monogenists, whose theory was supported by Darwin, hold the view that the most distinct races possess a greater resemblance to one another in respect to form than is usually admitted. Further, that the chief distinctive race characters (formation of the skull, features of the face, colour of the skin, and distribution of hair on the body) are extremely variable, and, most important of all, the races graduate into each other. Now it is usual to unite all the forms that graduate into each other under a single species; hence applying the same principle, there can be but a single human species. This view is supported by the fact that for many centuries the most complex intercrossing of the different races has gone on, and that all races bear a striking resemblance to one another in tastes, manners and customs, expression of the emotions, and the use of weapons and ornament.

The question as to whether the separate races (sub-species) each originated from a single pair of progenitors has given rise to a great deal of discussion. With domestic animals this is quite possible, provided that the varying descendants are most carefully selected for pairing. According to Darwin, the origin of most of our races is to be attributed not to a single pair of methodically selected progenitors, but rather to many individuals, which varied, though perhaps in ever so slight a degree, and these variations were either natural or artificial; hence, we may assume that in all probability the races of man have arisen in a similar way, whether through the modifying influences of different physical conditions, or through the indirect effect of natural selection, more particularly of sexual selection.[1]

In comparison with sexual selection the influences due to climate, environment, continued use of parts and the law of correlation are of secondary importance. The fundamental precept, however, upon which all recent research as to man's origin must rest, is the conclusion with which Darwin closes his work on the *Origin of Man*, namely, that we are bound to acknowledge that man is descended from some lowly organised form.

The Ancestors of Man.

In his work, *On the human teeth found in the pisolitic iron ore of the Swabian Alps*,[2] Branco assumes that the favourable moment for man's development from his animal prototype was during the Tertiary Period. It was not the severity of the struggle for existence that caused man to rise from the animal world; indeed it was precisely this struggle that prevented the anthropomorphous animals from attaining to human state. "The struggle for existence had to be lightened for the development of man from an anthropomorphous ancestor to become possible." As superior equipment for the struggle Branco suggests the erect position, and the higher development of the hand and brain. Only on assuming an erect attitude could the hands become free; Dames even goes so far as to say that man only became human when he learnt to stand firmly on his feet. At first the hands still required a support (such as trees, etc.), but gradually early man learnt to walk independently and left

[1] Darwin, vol. v., pp. 218-37.

[2] Würtheim, *Jahreshefte f. vaterl. Naturkunde*, 1898, p. 70.

the woods. As to the causes to which the erect position may be due, two points come under special consideration: first, the great weight of the body (Ch. Morris) which may well have led to the abandonment of an arboreal existence, and, secondly, the shortness of the legs. According to Morris, man's half-human progenitors must have had short arms, similar to those of existing man, ill adapted for quadrupedal progression, and consequently the feet must have been already perfected for locomotion. The free use of the arms resulted in a higher development of the brain. No such intermediate form, as described by Morris, has ever been discovered, but, as Branco points out, fossil anthropoid remains of any sort are very rare, the Pithecanthropus being the only specimen pronounced by naturalists to be an "ape-man". It will be quite clear, therefore, that Branco belongs to those zoologists who derive man from some extinct anthropoid, and not from any still existing species. Haeckel has been most consistent in developing the theories of Darwin, and has drawn up a genealogical table, which, having the Prosimiæ (semi-apes), and Lemuridæ, at its base, leads us up to the Simiæ (apes), *viz.*, the Catarrhines of the Old World, and the Platyrrhines of the New World, and finally to the anthropoids, *viz.*, the Chimpanzee and Gorilla of Africa, and the Orang and Gibbon of Asia. The group of Tertiary anthropoids gives rise to the "speechless ape-men," and these again to the *Homo sapiens*.

E. Dubois's arrangement of the genealogical tree differs slightly from that of Haeckel in that he starts from the Protohylobates (primitive Gibbon). As its descendant we have the Palæopithecus of the Sivalik stratum, next the Pithecanthropus erectus, and finally Man. From a lateral branch of the Protohylobates Dubois derives the Pliohylobates and the Gibbon; and similarly from the Palæopithecus, the Orang, Chimpanzee and Gorilla.

Each of the above authors bases man's genealogy on the anthropoids, but a different view is held by Schlosser, who maintains that the New World Platyrrhines are far more closely related to the Old World anthropoids, and to man, than is usually admitted. That the Platyrrhines possess thirty-six teeth Schlosser regards as of secondary importance, but of great significance is the high finely arched skull, especially in the

Cebus genus. In his opinion the Cebidæ are descended from Prosimiæ, or Lemuridæ which migrated from North to South America. Briefly put, Schlosser's theory is as follows: The anthropoids and man are the advanced descendants of Platyrrhines which underwent transformation during the Tertiary Period.

One grave objection to the theory is that up to the present no anthropomorphous fossils have been discovered in South America!

Quite recently Rhumbler, in tracing man's descent from earlier anthropoids,[1] followed closely Darwin and Haeckel, and laid stress on the number of morphological characters possessed by man in common with the anthropoids which are absent in other mammalia. In his opinion it is impossible that the human foot, one of the most eminently distinctive characters of man, can have been evolved from the prehensile foot through climbing large trees, as suggested by Klaatsch. Rhumbler considers it far more probable that during the transition to the erect attitude the opposable first toe of the prehensile foot was the chief part to come into contact with the ground, and that in this way according to the law of adaptation it acquired its present importance as one of the three points of support for the human body.

It has been remarked already that Charles Morris is of the opinion that the shortness of the human arm has been inherited and not acquired. According to E. D. Cope[2] man also inherited a foot adapted for locomotion. Both these views are fundamentally opposed to the anthropoid origin of man. According to Cope's theory, man's early progenitors never led an arboreal life, whereas the foot of the ape has become prehensile through adaptation. Cope assumes the common parent form of man and the apes to have been the Phenacodus, an order belonging to the early Tertiary Period, which must have possessed a prehensile hand and a foot constructed for support and locomotion. From the Phenacodus, remains of which are found in the oldest eocene strata of

[1] *Corr.-Blatt d. deutsch. Gesellsch. f. Anthropologie*, etc., 1904, No. 8, pp. 62-64.

[2] *The Geological Magazine*, London, 1886, p. 238.

North America, and occasionally in Europe, the apes and man are descended on the one side, and on the other the ungulata (hoofed animals) and the carnivora. This view is shared by Topinard.

Klaatsch also denies any special importance to the anthropoids among man's progenitors, but seeks his origin in still earlier forms of the mammalia. He assigns great importance to the teeth. Taking the highest figures that have been obtained from the observation of anomalous cases of every kind of human being, and arranging them synthetically, he arrives at a set of teeth corresponding not to that of the apes, but to that of much earlier eocene mammals. Similarly, the protuberances of the molar teeth in man correspond to the same in groups of eocene mammals. Klaatsch further points out that the opposable thumb is not peculiar to man and the apes but was present in the parent form of all mammals; nor did the special development of the great toe originate with the apes, it being found in the prehensile foot of certain half-apes. In the opinion of Klaatsch the great toe acquired its present importance through man's ancestors having climbed very thick-stemmed trees requiring a firm side pressure of the prehensile foot against the trunk. The theory that several lower animal forms have served as the fundamental form of man is unconditionally rejected by Klaatsch, for, he argues, only to adduce two proofs, it is inconceivable that the redness of the lips and the presence of hair in the armpits, both distinctive characters of man, should have been repeatedly developed from different animal ancestors.

Fossil Apes.

Up to the present the fossil remains of apes that have been discovered are not abundant, although of extreme interest, especially to those naturalists who base the origin of man on the anthropoids of the Tertiary Period. Fossil remains of apes have been discovered from the year 1836, and have been described by the most experienced palæontologists; they were formerly not recognised as such and were not admitted by Cuvier to the end of his life. Fossil apes and semi-apes have been found more abundantly during the last decades of the nineteenth century, among others a gigantic semi-ape, discovered by Forsyth Major in Madagascar. These discoveries led the indefatigable Haeckel to draw up a complete scale from the earliest fossil semi-apes to the anthropoids and man.[1] At the base stand the early eocene Pachylemurs with forty-four teeth; then follow the eocene Nekrolemurs (Adapidæ) with forty teeth, and the Autolemurs (Stenopidæ) with thirty-six teeth, like the New World Platyrrhines. Remains of the teeth of a macacus, named by the discoverer *Inuus suevicus*, have been found at Heppenloch near Kirchheim-unter-Teck (Jura Alps, Swabia), and ascribed to the pliocene age. Of still greater interest to us are the fossil remains of anthropoid apes (see Fig. 1, a). The most ancient relic found in Asia is the remnant of an upper jaw, discovered in the Sivalik strata of India. Standing alone and probably belonging to the pliocene period is the anthropoid ape called by palæontologists *Palæopithecus sivalensis;* it is distinguished by a comparatively narrow palate, and molars resembling those of the gibbon and chimpanzee, but still more closely those of man. The discovery of fossil anthropoids in Europe dates from 1836.

The remains found were most frequently those of the Pliopithecus antiquus, and were chiefly jaw-bones, upper and lower, furnished with teeth; this anthropoid is held by Schlosser and Zittel to be identical with the gibbon, but is regarded by Dubois as representing a separate order of long-armed apes, now extinct. Judging from the distribution of the fossils, the *Pliopithecus antiquus* inhabited a region extending from the north, south-east, west and south-west of France over Switzerland to Steiermark.

Another extinct gibbon of the early pliocene period is the Pliohylobates, surnamed Eppelsheimensis, from Eppelsheim, the place of its discovery. The fossil femur closely resembles the corresponding bone in man; indeed, Pohlig, from the presence of a linea aspera, declares this gibbon to resemble man far more closely than any other, extinct or living.

Still greater interest was aroused by the discovery of the *Dryopithecus Fontani* in the south-west of France, in the middle of the nineteenth century. At St. Gaudens, Haute Garonne, the first relics brought to light were two halves

[1] Haeckel, *Lectures*, p. 22.

of an under-jaw and a humerus, apparently that of a young animal, and later on another jaw was discovered near St. Gaudens, and judged by Owen to be indisputably that of a gibbon. The humerus, as well as the teeth, is strikingly human, according to the testimony of most naturalists; indeed, both in the first place were attributed to man. This *Dryopithecus* underwent, on the whole, many vicissitudes. At first it was considered the most human of fossil apes, only to be later declared by Gaudry and Zittel as the least human, a conclusion again disputed by Pohlig and Schlosser.

Here, as usual, the truth is to be found midway between the extremes. Judging from the formation of the teeth and the very slight prognathism, there can be no doubt, says Branco,

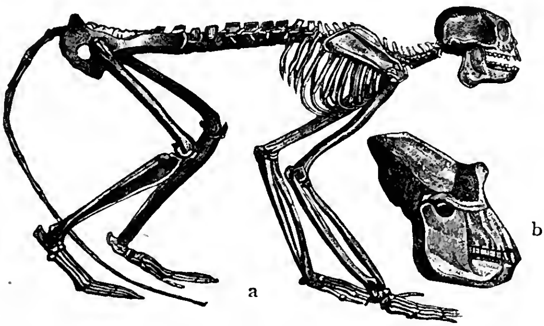


Fig. 1. a, Mesopithecus Pentelloi. b, Skull of a gorilla. (Hörnes, *Urg. d. M.*)

that the Dryopithecus in these respects is most closely related to man, but there are other points to take into consideration. In the first place, it has been pointed out that the tongue of the Dryopithecus occupies a much smaller space than is the case with any other anthropoid, but truth compels us to admit that in this respect an approach to the anthropoid type is found among many wild tribes, *e.g.*, the Sambaquis, the Cayapo Indians and the Nago negroes. Gaudry has drawn attention to still another characteristic of the Dryopithecus lower jaw, which detracts from its claim to human resemblance, *viz.*, the retreating chin sloping backwards from above; Gaudry's investigations have shown also that the wisdom teeth were not, as at first supposed, erupted at a later date than the others, nor are the eye-teeth specially small. Nevertheless, the Dryopithecus has so much in common with man that it must rank as one of the most remarkable phenomena in the whole pedigree of man.

To the Dryopithecus belong probably also the teeth of anthropoid apes, found since 1850 in the pisolitic iron ore of the Swabian Alps, consisting of one lower pre-molar (milk-tooth), two upper molars, and seven lower molars. The two upper molars were at first declared by Owen to be human teeth, and Quenstedt was the first to assign them to an anthropoid, though he admits that their resemblance to human teeth is so close as to be misleading. Branco gives an exact description of each tooth, and arrives at the conclusion that they bear the closest resemblance to those of a gibbon, in fact a Dryopithecus. Whether this particular Dryopithecus was a Dryopithecus Fontani, or the member of another species, he leaves undecided. Doubt and uncertainty surround the most recent important discovery of anthropological palæontology, namely, the fossil remains found in Java (1891) in the Upper Tertiary strata and described by the discoverer, E. Dubois,[1] as Pithecanthropus erectus, an intermediate form between the anthropoid apes and man (see Fig. 2). The remains found include a third right molar tooth, a left femur and a second left molar. As Dubois points out, the extraordinary resemblance to man is less in the teeth, though they too are sufficiently characteristic, than in the cranium and femur. The most striking points about the skull are the absence of the special structure peculiar to all other anthropoids, and its great capacity, reckoned at 990-1000, or two-thirds of the capacity of the human skull.

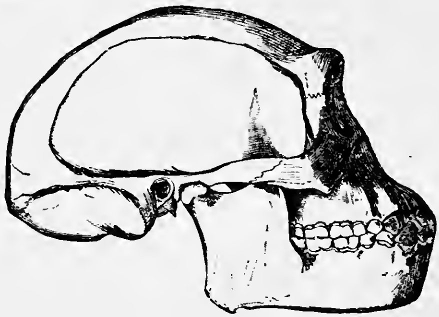


Fig. 2. Restored skull of the Pithecanthropus erectus. (Dubois.)

[1] E. Dubois, *Pithecanthropus erectus, eine menschenähnliche Uebergangsform aus Java.* Batavia, 1894.

The line of the profile resembles that of the most pithecoid races of man: the Veddahs of Ceylon and the Akkas of Central Africa. The femur, with a slight forward curve, is of a length and thickness proportionate to the frame of a man of medium height and of normal weight. Dubois is of the opinion that these remains belonged to a creature representing the intermediate stage between anthropoids and man, so long the object of Haeckel's search, a descendant of the anthropoid species *Anthropopithecus sivalensis*. Remains of *Anthropopithecus sivalensis* have been found in the Upper Tertiary stratum of India, namely, an upper jaw with the teeth; it is of a short, broad, horse-shoe shape, like the human jaw, so that the beginning of the possibility of speech already existed. Besides Dubois and Haeckel, the naturalists Dames, Manouvrier, Marsh, Nehring, Petit and Vernau believe the Pithecanthropus to be neither man nor ape, but an intermediate form between the two. The skull has been almost as often declared by naturalists to be that of an ape as that of a man, and most authorities are agreed that the femur closely resembles the human bone or even actually belonged to a man. According to Branco, the Pithecanthropus was undoubtedly an ape, but an ape well able to stand erect owing to the occipital cavity being situated nearer to the middle of the base of the skull and the occipital bone being sharply curved forward. Finally, when we take into consideration the large, well-arched skull with its spacious brain-cavity, we may infer that the Pithecanthropus erectus was distinguished from all other anthropoids by special powers of intelligence.

Tertiary Man (Pliocene and Pleistocene).

The discovery of the Pithecanthropus erectus has made the question of Tertiary man's existence one of burning interest, though it had long played an important part in all anthropological journals and at anthropological congresses, and was well worthy of the attention bestowed upon it. Since the remains of Quaternary man have been found in Europe, Asia, North and South America, we necessarily infer a Tertiary man as ancestor of the Quaternary man, as the latter could not have arisen suddenly, through a trap-door, as it were.

Schlosser has expressed his opinion on this subject with unmistakable clearness in the "Literaturbericht für Zoologie," 1883 (*Archiv für Anthropologie*, pp. 160, 289). Since not only most of the mammals, but also most of the anthropoids, existed in the Pliocene Period, it would be remarkable, says Schlosser, if man had not also existed at that time, but he considers it probable that Tertiary man differed widely, both physically and mentally, from the species Homo of the present day. It must be admitted that clear proof of the existence of Tertiary man is as yet very scanty, being limited to discoveries in two different places. In a hard conglomerate, undoubtedly Tertiary, in Burma, remains of hewn flint stones were found, one in the form of a stone knife, together with the tooth of a hipparion. Still more interesting are the discoveries in the loess of the Pampas of South America. Here in the lowest stratum, unquestionably belonging to the Tertiary Period, numerous traces of man's existence were brought to light, such as weapons, carved bones, marks of former fireplaces, and human skeletons (small and dolichocephalous). It is characteristic of these places of discovery that the glyptodon is generally found together with the traces of man's existence. In one cavity a skeleton was found under the carapace of a glyptodon, no other remains of the glyptodon being present. Other glyptodon carapace having been found in a perpendicular position—serving perhaps as screens—we can but conclude that Tertiary man slew the giant armadillo in the chase and robbed it of its carapace for his own purposes.

It is no matter for astonishment that so few fossil remains of Pliocene man have been found when we compare the scanty discoveries of Pliocene anthropoids and bear in mind that, in all probability, the entire number of human beings in the Pliocene Period did not exceed a few thousands.

Certain French and German naturalists believe that they have discovered traces of the presence and activity of Tertiary man, though not in the form of skeletons or bones. Mortillet attributes the fragments of flints found near Thenay, in France, to a hypothetical anthropomorphous being, and the palæontologist Gaudry was inclined to assign to the Dryopithecus similar fragments collected from the Tertiary limestone of Beauce, near Paris, by Abbé Bourgeois. Since Mortillet took up the subject, the Pleistocene flint tools, the so-called "eoliths," have never ceased to be brought forward as proof of man's existence towards the end of the Tertiary or beginning of the Quaternary period, Rutot, in France, and Klaatsch, in Germany, vigorously defending the theory. In judging doubtful flint implements of the Upper Tertiary strata Mortillet attached the greatest importance to the *bulbe de percussion*, Rutot to the *retouche*. Rutot does not admit the possibility of their having been formed by natural agencies (change of temperature, strong water-currents, sea-waves, movements of strata), and his investigation of various strata led him to classify the consecutive zones as Reutelia, Mesvinia and Mesvino-Chelléa.

Besides hewn stones, specimens of which are said to have been found also in Portugal by Ribeiro, carvings on bones were regarded as proofs of the existence of Tertiary man, and are thought to have been produced by means of a flint instrument. Capellini found crescent-shaped carvings on the bones of a Balænotus, Desnoyers has drawn attention to carvings on bones of the Tertiary Period from the sand-quarries of St. Prest, and von Dücker believed he had found traces of man's work on the bones of a hipparion from Pikermi (Greece).

Virchow and Ranke hesitated to pronounce the Tertiary flints the work of man. Virchow, while admitting the possibility of other explanations, inclined to the belief that they had been cleft by fire. Zittel,[1] the geologist and palæontologist, expresses himself more positively. In the flint fragments in question, he sees merely the work of natural agencies, fragments that have been split asunder by meteorological processes and resembling those, for instance, that are scattered for miles over the surface of the Libyan desert. Hörnes[2] shares this view in every particular, and regards the so-called flint implements of the Upper Tertiary strata, brought forward by Rutot, and defended by Klaatsch, as merely illusory natural phenomena. There would be no difficulty in collecting from the thousands of

[1] Zittel, *Handbuch der Paläontologie*. München, 1893, vol. iv., p. 710.
[2] Hörnes, *Der diluviale Mensch in Europa*. Braunschweig, 1903, p. 22.

flintstones in West Flanders a whole series having the appearance of being hewn. Hörnes and Szombathy have pointed out that both the *bulbe de percussion* and the *retouche* could have arisen in a perfectly natural way. The only absolutely reliable proofs of an apparently hewn stone having been artificially produced lie in the character of the outline and the regularity of the *retouche;* Rutot's flintstones fail in both these requirements. This is severe criticism, but any one who, like the writer, has had frequent opportunity of examining whole series of alleged Tertiary stone implements will not think it unjust, for the bone carvings are extraordinarily vague and deceptive. In Ranke's opinion the incisions may equally well have been caused by natural agencies, such as sharp-edged stones, the teeth of rodents (porcupine, beaver), the swordfish, etc. Moreover, Hörnes is entirely justified in emphasising the fact that up to the present no traces of encampments or dwelling places from the Tertiary Period have been found in Europe.

To sum up: Tertiary man probably existed in Europe but we have as yet no definite proof thereof.

The stature of the Tertiary man must remain a matter of conjecture, since we do not know whether it is possible to assign the proportions of the South American Tertiary man to the alleged European. The effect of civilisation on the human body being partly injurious, weakening and stunting, partly beneficial and favourable to growth, man's ancestors, as Branco[1] remarks, may have been taller, or shorter, than the average man of the present day. If we accept as a fact that giants lived in Europe in the Tertiary Period, it must be remembered that no traces of any giant descendants of theirs have ever been found in any part of the world. Kollmann assumes that Tertiary man was a pigmy, and regards as his descendants the neolithic pigmies of South-East France and Switzerland, and the still existing pigmy tribes of Africa, Asia, Europe and America. This, however, is but another hypothesis, and one which can only find support in the low stature of the Pampas skeletons of Tertiary man in South America.

Admitting the existence of Tertiary man, where shall we seek his birthplace and primitive home? The recent discovery

[1] Branco, *loc. cit.*, p. 113.

of the Pithecanthropus in Java has again brought this question into prominence, for, needless to say, the generally accepted legend to the effect that the Mesopotamian Paradise was man's first home can be regarded by scientific anthropology as nothing more than legend. Darwin acted as pioneer in this question. Arguing from the theory that man is a lateral descendant of the Catarrhine stock, and that these exist, and have existed only, in the old world, he reasons that Australia and the islands of the Pacific are necessarily excluded from being man's original home. As, also, the early progenitors of man must have been inhabiting a hot country at the time of losing their hairy covering, and as in each great region of the world the living mammals are closely related to the extinct species of the same region, Darwin [1] concludes that Africa was probably man's birthplace, especially as it is probable that Africa was formerly inhabited by extinct apes closely allied to the gorilla and chimpanzee.

In recent times the old theory has been revived of Australia being the birthplace of man, and Schötensack [2] of Heidelberg has spoken, and written much, in its defence. In his opinion it is not to be supposed that the development of man from a lower form has been the result of so severe a competition for life as that experienced by the anthropoids and other mammals, for man being unequipped by nature, and still incapable of making weapons for himself, could not have competed in a struggle against powerful beasts of prey. No part of the world could have been more favourable to man's development than Australia, for the struggle for existence must have been milder there than elsewhere, the hunting of the marsupial fauna offering no particular danger. Schötensack nevertheless assumes South-East Asia to have been the first home of man, the Pithecanthropus having been found in Java. From this point the descendants of the Pithecanthropus spread to Australia by way of the Celebes and New Guinea, which in the Pliocene Period were still connected with the mainland. In support of this theory Schötensack says: The Australians of the present day may

[1] Darwin, *loc. cit.*, vol. v., p. 203.

[2] Dr. Schötensack, *Die Bedeutung Australiens für die Heranbildung des Menschen aus einer niederen Form. Verhandlung des natur-med. Vereins.* Heidelberg, 1901.

be described as the remnant of a very ancient race both in physical and cultural respects. At the time of their discovery they were ignorant of the art of pottery and of the use of bow and arrow; their only instruments were the boomerang and the throw-stick, both of which have been found amongst palæolithic remains in other parts of the world (also in Europe). Schötensack further assumes that when early man migrated from Australia back to Asia over the isthmus he took these weapons with him and thus spread their use. The arts of pottery and stone-grinding, and the use of bow and arrow, he learned later on in other lands. Those who had remained in Australia could have no share in these inventions, for the Pliocene isthmus became later submerged. Schötensack also points out that the Australian, in order to obtain the wild honey that was to be had in abundance, must have climbed high trees, whereby the great toe developed gradually its present position and significance as a distinctive character of man.

The Australian had discovered the art of making fire, and subsequently that of cooking, the frequent thunderbolts and prairie-fires having taught him the meaning of fire and its effect on the flesh of animals. In conclusion we must make mention of the dingo (the wild dog of Australia), an animal introduced into Australia by man and representing in that land the only non-marsupial mammal. The dingo was domesticated by man, and this probably led to the domestication of the wild dog by those who had migrated from Australia to other parts of the world. Schötensack's view is shared almost entirely by Klaatsch, the latter merely suggesting that man migrated to Australia before the Pliocene Period, even returning to Asia over the Pliocene isthmus, since it has been all but proved by the discovery of eoliths that Tertiary man existed also in Europe. We have seen above how far this statement may be regarded as conclusive, but on other grounds the Schötensack theory has no lack of antagonists. Rhumbler[1] does not deny that the Australian corresponds in many ways to Palæolithic man, but he considers it far more probable that the great continent of Europe-Asia, connected with America by the Behring Straits, was the first to be inhabited by man, and that at an extremely remote period a

[1] *Corr.-Blatt f. Anthropologie*, etc., 1904, p. 64.

part of the human race migrated to Australia and were eventually cut off from their fellow-beings. In support of this theory there is the fact that all the more highly developed forms of the mammalia have occurred without exception on the great continent. The greater the continent the more numerous will be the individuals inhabiting it, hence the greater probability of some among those individuals surpassing the rest by reason of their superior organisation. This proposition may equally well be applied to man. Klaatsch, for instance, has pointed out that both the skull and the extremities of primitive, diluvial man bear a greater resemblance to those of the Mongolian race than to those of the Australian. In any case he attributes, as does also Const. Könen, the Neanderthal man (see below) to an extremely remote geological age, at the latest the Upper Pliocene Period.

Quaternary Man.

While the evidences of Tertiary man are somewhat limited, diluvial (Quaternary) man has bequeathed us not only his bones and teeth, but human portraits—the work of his hands—giving the rough outlines of his stature. Even when both skeleton remains and portraits are absent from his former dwelling-places, there exist the traces of his activity in the form of weapons and tools of stone, bone and horn, besides the tubular bones of the animals he slew in hunting, and hearths where he cooked their flesh.

From the differences existing between the various stone implements and animal bones examined by him, Mortillet concluded that Diluvial man passed through four stages of culture. It should be borne in mind that although this may be applied to France it does not hold good for the rest of Europe (and at present we are considering Europe alone); for the climate of France, especially in the south, admitted of uninterrupted habitation and the unbroken development of its human inhabitants, whereas in all other parts of Middle Europe habitation was interrupted by the intervening Glacial Period.

Mortillet's four periods are as follows:—

(1) *The Chelles period* (from Chelles in the Seine et Oise Departement) with a warm, damp climate and a warmth-loving

fauna. The man of this period was of a low order, and employed both as weapon and tool a thick, heavy, rough-hewn flint like a cudgel (*coup de poing*).

(2) *The Moustier period* (from Moustier in Dordogne). Representatives of this period are to be found also in those parts of Italy, Germany, Austria and Poland, that escaped the influence of the Glacial Period. It was marked by a cold, damp climate, and its fauna was suited to these conditions. Man had progressed, and no longer used the heavy cudgel, but had hand-picks, hewn only from one side, and *racloirs*.

(3) *The Solutré period* (from the place of the same name in the Saône et Loire Departement) with a dry, temperate climate. Man shared this period with the reindeer, wild horse, and mammoth; he shaped his flint like a laurel leaf and sometimes even furnished it with a handle.

(4) *The Madeleine period* (from La Madeleine in Dordogne) was again cold and dry, so that the mammoth died out, but the reindeer was still to be found in abundance. The man of this period preferred light, narrow stone-knives, made tools out of bone and horn, and possessed marked ability for drawing and carving on bone and horn.

Hörnes[1] combines the Chelles with the Moustier period, thus reducing the four to three. The earliest period he subdivides into two stages, the first of which, following on a Pliocene Ice Age, comprises the discoveries at Tilloux, Mosbach and Südenborn (near Weimar), the *Elephas meridionalis*, *antiquus* and *primigenius*, and man; the second contains the discoveries made at Tanbach, *Elephas antiquus*, *rhinocerus megarhinus*, *Cervus giganteus*, the reindeer and man.

The human remains from the Diluvial Period, when man dwelt partly in caves, and partly in colonies in the open country, may be arranged in three categories according to their antiquity.

To the oldest and at the same time lowest race of man (corresponding to the Chelles-Moustier period) belongs the *Homo antiquus*. Remains of the same have been found in France at Tilloux, Villefranche and Moustier; in Belgium in Spy Grotto; in Germany at Tanbach, in the Neanderthal caves at Düsseldorf and in the Rübeland caves; in Austria at Krapina

[1] Hörnes, *loc. cit.*, p. 6.

(Croatia), and in the Stramberg cave; in Russian Poland in the lower cave of Wierschowic. The low stage reached by *Homo antiquus* is most strikingly shown by Neanderthal man with his massive skull, strongly projecting brows, retreating forehead and chin, and the curved bones of his extremities. Virchow, who was inclined to look at the pathological side of everything, declared the remains to be those of an old man whose bones had been rendered crooked in childhood by rickets, and his joints attacked in old age by deformative rheumatism. This then was the verdict for the Neanderthal race, and yet Virchow asserts that among the Frisians, individuals with the same dolichocephalous skulls, and the same projecting superciliary ridge, are to be commonly found. Even in the fragments of a lower jaw found in the Sipka cave Virchow endeavoured to discover some pathological character; the two teeth next to the right eyetooth, *viz.*, the two right pre-molars, are deeply imbedded in the jaw, and Virchow, considering their great size, thinks this to be an example of retention of temporary teeth in an adult. Walkhoff, however, has pointed out that this is no sign of retention, nor does it point to a race of giants, as Wankel suggests; it is the normal jaw of a prehistoric child of about ten years of age with, it is true, somewhat extraordinarily large teeth. Another striking peculiarity of this lower jaw is the rudimentary state of the muscular attachment of the *digastricus* and *genioglossus*, which in conjunction with the absence of chin points to a very low stage of culture and but rudimentary powers of speech.

The fossil remains found at Krapina (Croatia) may be referred to a similar period, and consist of teeth and fragments of bone belonging to at least ten individuals of various ages. The brows are still more prominent than in the Spy and Neanderthal skulls, the jaw being enormously developed, with a still more retreating chin than that of the Sipka jaw, and the remaining molar teeth are marked by corrugations of the enamel of a pithecoid nature. Equally striking is the rudimentary state of the muscular process for the genioglossus muscle.

Viewed in the light of Walkhoff's explanation of the Sipka jaw, the discoveries at Krapina, together with all the above-mentioned remains of bone and teeth, may be referred to an early Palæolithic race; Schwalbe and Klaatsch in the meantime had subjected the Neanderthal man to renewed investigation, and indisputably established his low type of development. According to Klaatsch the *Homo recens*, the Neanderthal man, and the *Pithecanthropus erectus* are descended from a common parent belonging to an extremely remote period. Schwalbe believes the Neanderthal type to be quite extinct, and maintains that not a drop of its blood flows in the veins of the human race of to-day. Walkhoff, on the other hand, regards the Neanderthal man as the fundamental form of the *Homo recens* and the isolated cases of resemblance to the Neanderthal type found among the lower races of man as cases of reversion.

The men of the earliest Diluvial Period may have been physically of a very low type, and in mental respects may never have advanced beyond the rudiments of speech, but they were nevertheless men, essentially distinguished from the anthropoids by their superior skull and brain capacity.

Hörnes and Vernau agree that between the *Homo antiquus* of the Neanderthal type and the *Homo antiquus* of the later Diluvial Period a race of African origin should be inserted. This race chiefly inhabited the West and South-west of Europe, but was also to be found in the East, and dwelt in caves, or in the open country, possibly protected by screens of brushwood or skins. Remains of their dwellings have been found in France in the caves of Brassempouy, Solutré and Laugerie Haute; in Belgium in the caves of Pont à Lesse; in North Italy in the caves of Mentone; in Moravia at Brünn and Predmost, and in Ukraine in the caves in the neighbourhood of Kiev. That men of an African type actually lived in Europe during the Solutré period is indirectly proved by the ivory figures of steatopygous females such as could only have been made by an African who had had opportunity of observing his fellow-countrymen.

In the so-called "Capuchin head" we find the African platyrrhinism, prognathism and retreating chin reproduced with unmistakable clearness. But there are also positive proofs. Both the skeletons from the eighth igneous stratum found in the Grotto of Mentone are almost of pigmy proportions with elliptic skull, platyrrhine nose, pronounced prognathism and retreating chin. Gaudry (*Contribution à l'histoire des hommes fossiles*) considers that the Mentone skull resembles the Australian type, especially in the formation of the lower half of the face; namely, the narrow, elliptical curve of the jaw, the marked prognathism, the narrowness of the lower jaw, and the size and corrugation of the teeth. These characters, however, are also common to the lower African types of man.

The human remains from the Austrian loess-deposit point to a low type, though perhaps not quite so low as the Neanderthal type. The femur from the Willendorf loess-deposit is sharply curved and furnished with a very prominent crest, and belonged to an adult of middle height and compact build. The dolichocephalous skull found under the Franz-Joseph Street in Brünn shows a low, coarse brow formation with strongly projecting supra-orbital ridge and retreating forehead; the parietal bones have a very slight curve and there is a large gap at the lambdoidal suture. The upper and lower jaw from Predmost have been examined by Walkhoff, who considers that the chin is an improvement on those of the Sipka and Krapina jaws but still in a very backward state of development; the most striking anthropoid character is the increased tendency towards the formation of enamel on the crowns of the molars. In any case these beings from the loess-deposit, in spite of their low type, must be definitely regarded as human.

Vernau sees in the man of the second stage the parent form of the third, and holds the opinion that improved conditions of life led to the gradual change, but so long as proofs are not forthcoming this opinion must remain a mere hypothesis.

The third race, belonging to the Madeleine period, shows a decided advance in physical structure, but since we are ignorant as to whether the region was uninterruptedly inhabited, we cannot state with certainty whether these men of improved physical structure descended from those of the second period, or whether they belonged to a distinct type originating elsewhere. The Madeleine race (called the Cro-Magnon race, from the place of their discovery) must have been superior to the earlier inhabitants of Middle Europe, not only physically but also intellectually, since the skulls found are of large capacity (*e.g.*, skulls from Cro-Magnon have a capacity of from 1,590 to 1,640 ccm.).

The men of this period usually dwelt in caves, but sometimes made their homes under projecting rocks or in other protected places. In France we have the Madeleine Stations, Laugerie basse, Les Eyzies, Bruniquet, Mas d'Azil, etc.: in Switzerland, Kesslerloch; in Belgium, the Trou de Chateaux: in Germany, Schussenried, Andernach, and various caves in the Jura Alps, Swabia (see Fig. 3); in Austria, the Gudenus cave and Kulna near Sloup; in Russian Poland, the Maszyck caves. Human remains have been found in Cro-Magnon,

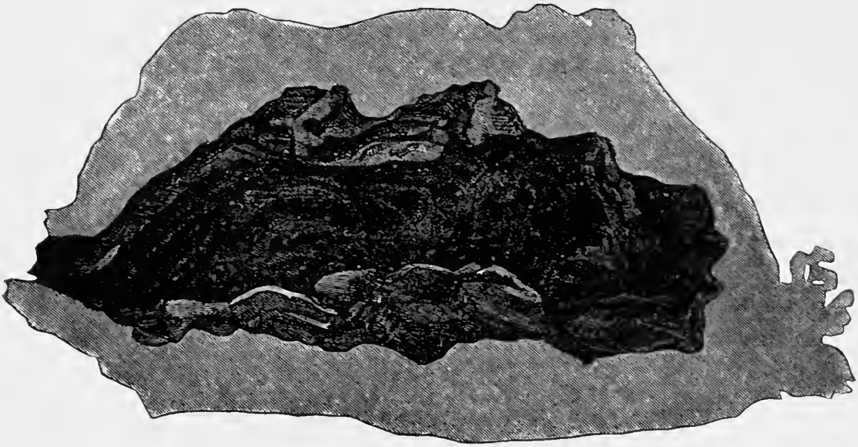


FIG. 3. Transverse section of the Hohlefels in Aachtal (Swabia). (Hörnes.)

Laugerie basse, La Chancelade, in the Duruthy cave near Sorde, in the seventh igneous stratum in the Kieder grotto at Mentone, and in the Fürst-Johanns cave at Cautsch in Moravia. It is probable that the various human remains discovered belong to several different races rather than to any single one; the French naturalists, Hamy, Dupont, Hervé and P. Girod, who agree in regarding the Hyperboreans of the present day, the Tschaktschens, and the Eskimos, as the nearest relatives of the Madeleine cave-dwellers of Western Europe, must be referring solely to those below medium height, to which race the tall, well-grown people of Cro-Magnon surely did not belong. To the pigmy race of the Madeleine period are to be attributed most probably the small tools of flint, bone and horn, clearly intended for small hands. It was they too who produced the surprisingly faithful drawings of animals on horn and bone so that we involuntarily compare these reindeer hunters with the equally gifted, artistically endowed Eskimos of the present day.

In caves of Bohemia (*e.g.*, the Zuzlawitz caves) small, dolichocephalous skulls have been found with very slightly arched parietal bone, and powerful teeth.

Now it would be of incalculable value to anthropology if the problem of the physical structure and general appearance of Palæolithic man could be solved by the portraits of him which he has bequeathed us. But the hope of solution from this quarter cannot be other than illusory. As trustworthy evidence we might perhaps take the circular, ivory female figures of Brassempouy,[1] for they represent with unmistakable realism steatopygous females of an inferior African race. On the other hand, the ivory human figure found in the loess-deposit at Brünn would lead us to hazardous conclusions, were we to regard it, with its low forehead, projecting brows, broad nose and long chin, as the deliberately designed representative of the race to which the skull belongs found in the same place. The same may be said of the steatopygous figure and the head from the crystalline limestone of Mentone. Moreover, as is seen from Piette's recent investigations in this direction, the possibility of false imitations must be taken into account. One fact, however, is clearly established by the palæolithic sketches of the human body, namely, that at that time man went unclothed. (La femme au renne, hunter with bison.)

To draw conclusions from the details of the sketches would be as much out of place as to regard our children's attempts at drawing as faithful portraits. How far a naturalist may be led astray by his imagination is shown in the interpretation Piette gives to his latest discoveries in the Mas d'Azil cave. Scratched on the shoulder-blade of an animal is an indistinct drawing, *en face*, on one side, and on the other a clear sketch, *en profil*, of a man with strongly marked phallic characters; breast, back, abdomen and nape of the neck are covered with hair, both

[1] M. Hörnes, *Urgesch. d. bild. Kunst in Europa*. Wien, 1898 p. 47 and plate ii.

arms stretched forward, the right hand apparently holding a wooden club. Now, because the calves and seat are very little developed, and the latter, moreover, is somewhat long, and the face characterised by a very prominent nose, retreating brow and chin, Piette concludes the sketch to represent the *Pithecanthropus erectus*, whereas it is obviously only another example of a childishly executed human portrait.

As to the descent of Palæolithic man we are still by no means well informed. We can, certainly, as Hörnes[1] remarks, prove that he existed in various places, but whence he came and his previous manner of existence we know not nor can we ascertain it without a "history of his antecedents' antecedents". Broadly speaking, the discoveries of Western Europe permit us to conclude that during the diluvial period several different races existed. Some of the inhabitants of the middle period probably came from Africa originally. But we can form no opinion as to the probable birthplace of Neanderthal man, nor can we state with certainty[2] whether the people of the third period, the reindeer hunters of Cro-Magnon and Laugerie, were of Northern or of Southern origin; or whether they had developed in Middle Europe from earlier existing forms. As France and Spain were connected with North Africa by an isthmus, during the diluvial period, Hörnes considers this to have been the source whence Middle Europe received its palæolithic inhabitants, and he assigns the same part to this "Diluvial Orient" as that played by West Asia in more recent times in connection with Europe. A closer acquaintance with the details of this question is, in the opinion of Hörnes, only to be obtained by the co-operation of palæolithic geology and archæology.

European Diluvial Man. Transition from the Palæolithic to the Neolithic Period.

The same doubt and uncertainty that envelops the origin of diluvial man has long surrounded his later fate. Did he simply disappear in order to make room for the newly arrived neolithic man, or was some remnant left that under new influences de-

[1] Hörnes, *Der diluv. Mensch*, etc., p. 2.
[2] Hörnes, *loc. cit.*, p. 184.

veloped and attained to a higher state of culture? When we consider that in many parts of Europe (Belgium, Switzerland and Austria) a completely new neolithic stratum occurs immediately above the palæolithic, that in others again between the two strata an entirely neutral one occurs, varying in depth, we are justified in rejecting the theory of a gradual transition. Many parts of France, too, by the occurrence of a perfectly neutral stratum between palæolithic and neolithic go to prove the migration of the reindeer hunters and a subsequent period of abandonment before the advent of a new race. On the other hand, discoveries have been made in parts of North and South France and North Italy whereby a gradual transition from the one period to the other may be traced.

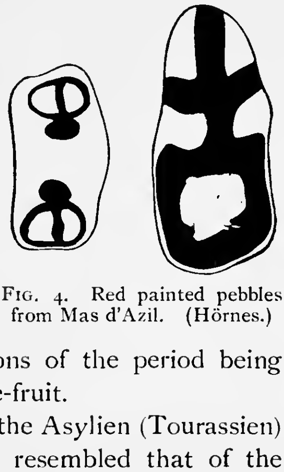


Fig. 4. Red painted pebbles from Mas d'Azil. (Hörnes.)

In the cave at Mas d'Azil, Piette found the small stone implements of the palæolithic age, but no sign of the art productions of that time. Instead there were flat pebbles (see Fig. 4), bearing peculiar signs painted in red, resembling the hieroglyphics of the oldest civilisations. There were no signs of pottery, ground stones, or domestic animals (the usual neolithic characters), the only suggestions of the period being the grains of corn and the rind of stone-fruit.

At that time, called by the French the Asylien (Tourassien) Period, the climate must have closely resembled that of the present day, the fauna also being the same. The reindeer had disappeared and the stag had taken its place, and from its antlers the hunters carved harpoons. It is possible that some of the palæolithic reindeer hunters had remained and now hunted the stag instead. It is not to be assumed, however, that palæolithic man himself laid the foundations of the later culture of which we find traces in his dwelling-places; indeed, we are compelled to believe that this culture was due to the influence of strangers who gradually supplanted the old-established population.

Our acquaintance with the physical structure of the man of this transitionary period is very slight, being obtained from the scanty remains discovered in the South of France and the North of Italy. In the Mas d'Azil cave, Piette found two skeletons, the flesh of which had been removed with stone implements, and the bones coloured red with oxide of iron. In the "Barma grande," the fifth Grotto of Mentone, lay three skeletons, also coloured red (a full-grown man, a young woman, and a youth); the skull formation is dolichocephalous, and similar to that of the Cro-Magnon race. We still need a detailed anatomical description of these skeletons which, judging from the system of burial, all belong to the same race.

We have now only to consider the later transitionary period between palæolithic and neolithic, traces of which have been found chiefly in Italy, France and Denmark; they occur also in Portugal, Belgium, England, Poland, Finland, in the Ural Mountains, and even in Palestine. This stratum (in France, Campignien; in Denmark, Kjökkenmöddingen) has been named *Mesolithic* from the simultaneous occurrence of palæolithic and neolithic characters therein. The chief mesolithic characters are: fossil remains of animals, wild and domestic; barbed arrow-heads of flint with handles; polished stone axes, and potsherds. The occurrence of palæolithic together with neolithic characters is most strikingly illustrated in the North-east and South-east of Italy, where the discoveries show a mingling of the two such as can only have been caused by the irresistible advance of a new culture. "Perhaps," says Hörnes,[1] "the native element, pushed ever backward as the superior culture advanced, retreated from the West to the East of Europe, and is responsible for the contents of the 'kitchen middens,' being acquainted with the art of pottery but ignorant of agriculture and cattle-rearing." Probably the dog was their sole domestic animal.

Karl Penka is quite clear as to what race mesolithic men belonged. He believes them to be the descendants of the dolichocephalous, palæolithic race who on the approach of the Cro-Magnon race followed in the track of the retreating reindeer and became the progenitors of the fair-haired, blue-eyed Aryans, a theory supported by no proof whatever, there being even no remains of the supposed reindeer forthcoming.

[1] Hörnes, *Der diluv. Mensch*, etc., p. 92.

In France a human skeleton was discovered in a refuse heap, and numerous skeletons, male and female, differing in age, were brought to light in the mesolithic formation in Portugal (see Fig. 5). Quatrefages, who examined them, is of the opinion that they represent two races, a dolichocephalous, and a brachycephalous, and assumes that the Atlantic coast was first inhabited by the barbarous, dolichocephalous race, and that the brachycephalous tribes who arrived at a later date were more highly cultivated, possessed stone knives, and gradually mingled with the native race.

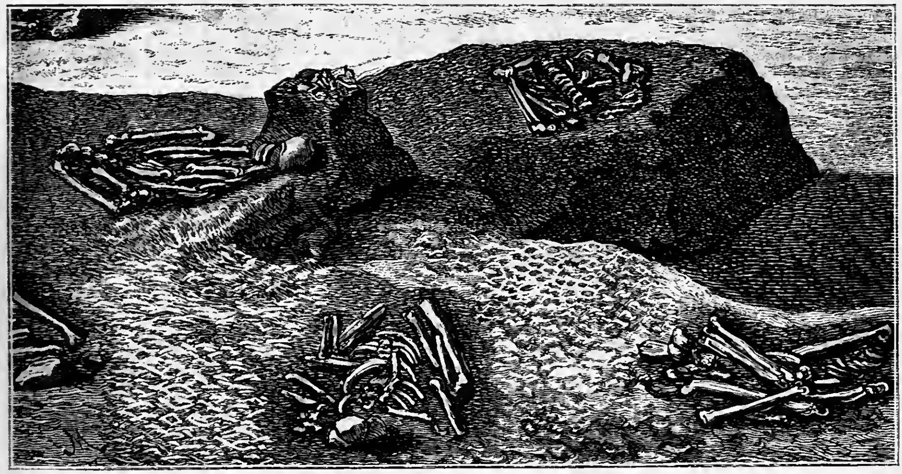


FIG. 5. Shell-heap at Magern (Portugal) showing the exhumed skeletons. (Hörnes.)

Neolithic Man.

Neolithic man, as compared with palæolithic, had made enormous progress in civilisation. He was no longer dependent on rough-hewn flint tools, though they were still in use. He had acquired the art of grinding and polishing many other kinds of stones which he found in the river-beds; he fitted them into handles of wood or horn, and could even drill holes in them for the purpose.

His well-ground stone axe served him not only as a weapon in hunting, and in war, but was also used for felling trees from which he fashioned his log-canoe, and obtained the beams for his hut and material for various wooden utensils. Sometimes he still dwelt in caves, sometimes in the open country in huts of wicker work, pit-houses, or terramaras, or in pile dwellings on the lakes (see Fig. 6). Fish, birds, and the varied produce of the chase—especially venison—formed his food. He had also learnt to domesticate such animals as dogs, oxen, goats, sheep and pigs; he cleared the forest and tilled the ground and sowed corn (millet, barley and wheat), and was able to appreciate the value of various wild fruits as articles of food. But neolithic

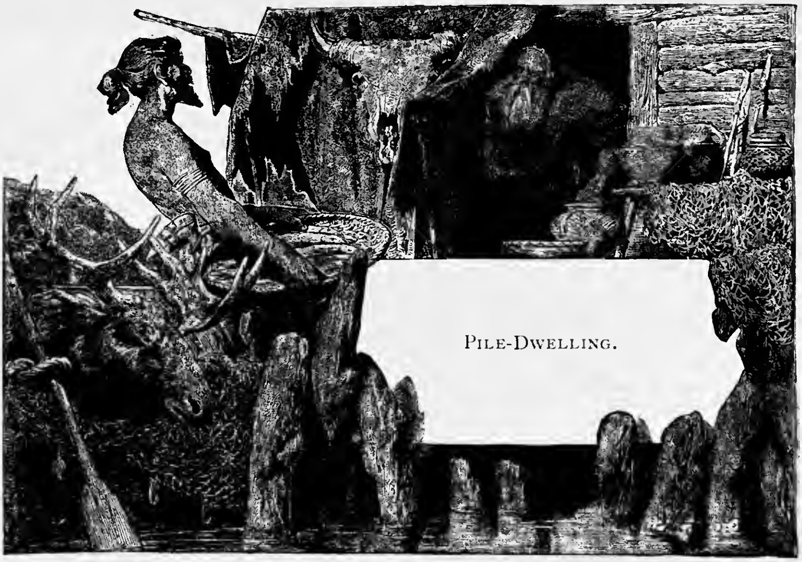


FIG. 6. A pile-dwelling. (After Prof. Häberlin.)

man possessed yet other advantages over his predecessor. He had acquired two new arts: pottery and plaiting and weaving, both essentially adapted to help forward the work of civilisation.

We may safely conclude that these arts were introduced into Europe from elsewhere, discoveries in Egypt having proved that in other continents the dawn of a new day had broken long before the people of Europe had left the Palæolithic Age behind them. The art of plaiting and weaving flax, and the employment of flax in spinning, must also have been brought from other lands, for in none of the earlier palæolithic deposits was any trace of flax seed or thread ever found. Lastly, the neolithic system of burial also shows a considerable advance; the dead were no longer buried separately in caves, or in the open fields, but many together in a small room skilfully constructed of stone, or, as in the Rhine districts, in graveyards arranged in rows, and apart from the country settlements. Specimens of these settlements have also been excavated and they may be described as villages. In the graves the skeletons are found sometimes lying at full length, sometimes in a sitting posture or half-sitting with the knees drawn up to the chin, sometimes lying on the side.

The discoveries of neolithic graves prove beyond a doubt that Europe in the neolithic period was not peopled by one uniform race alone, but that the process of division into dolichocephalous and brachycephalous races (the latter of small stature) which began in the palæolithic period was continued into the next. Remains of a tall, dolichocephalous race have been found in the stone coffins and burial vaults of Sweden, in the cave graves of Aurignac and Duruthy, in the neolithic graveyards on the Rhine, and in the narrow "sitting-graves" of Lengyel (Hungary). A few isolated graves in Sweden contain brachycephalous skeletons of short stature, as do the Aggteleker caves in Hungary and the grottoes of the French Maritime Alps; the skull of a lake dweller preserved in the Museum at Berne also belongs to a member of the same race. In the dolmens (cromlechs) of France remains of dolichocephalous and brachycephalous individuals were found together—a triumphant proof that the two races were contemporary.

The frequent discoveries of mesocephalous skulls proves that a mingling of the races most certainly took place. In course of time, the dolichocephalous type died out in Europe (with the exception of Scandinavia), being gradually supplanted by the mesocephalous race, till they in their turn were forced into the background by the brachycephalous, which eventually became the predominant European type.

PART II.

A. Comparative Anatomy and Histology.

I. The Bones.

In common with the radiata, mollusca and arthropoda man possesses a skeleton as framework for the muscular tissue, and in common with the vertebrata, an inner skeleton, which in the lower fishes and in the early stages of development of the other vertebrates is cartilaginous in nature, in the later stages osseous.

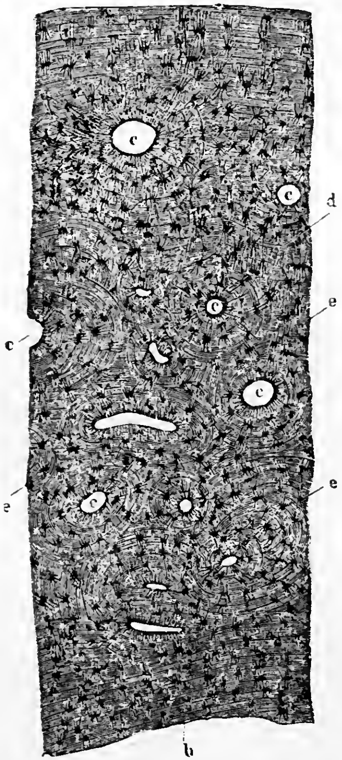


Fig. 7. Transverse section of the metacarpal bone: a,. outer surface; b, inner surface; c, medullary canals; d, lamellæ; e, bone cavities with their ramifications. Highly magnified. (From Thomé, *Zoologie*.)

The bones may be classified as solid, porous and cellular. They contain as inorganic constituents basic phosphate of lime together with fluorine, calcium, carbonate of lime, phosphate of magnesia and soluble salt; as organic, bone, cartilage and fat (see Fig. 7).

The number of bones in the human body (see Fig. 8), when the hyoid bone, the sternum and the coccyx are each reckoned as one only, is 223. The human skeleton is so constructed that wherever it corresponds to the animal skeleton it still possesses certain essential differences which render the smallest human bone immediately distinguishable from the corresponding animal bone. It is the aim of the present work to specify these distinctions and to define the characteristic attributes of man. In view of the paramount importance of the skeleton of animals and man it is clear that even the most concise treatise on comparative anatomy demands a relatively large amount of space.

The Skull.

A skull in the form of a hard capsule made up of several bones, containing the brain, and connected with the facial bones, is possessed solely by the vertebrates. C. Gegenbauer[1] has stated with admirable clearness the relation of the human to the animal skull. He says: "The peculiarities of the organisation of the human body are nowhere so significant as in the skull". When we bear in mind that the formation of the skull in all vertebrates is determined by its relation to the brain, to the organs of sense and to the upper extremity of the intestinal system, the conditions may be formulated as follows:—

In all animals, the apes included, the ultimate capacity of the brain is attained much earlier than in man, so that the human skull has a considerably longer period in which to develop for the benefit of the growth of the brain. Gratiolet points out as cause of this fact that in the anthropoid skull the closing of the sutures begins in the frontal region, whereas among the higher races of man it takes place first at the sutura parieto-occipitalis. The lower races of man in this respect resemble the anthropoids. As regards the cavities in the skull for the reception of the higher organs of sense man is by no means superior to the animals, indeed in the development of certain senses he is their inferior.

While the cranium of lower animals ceases early to grow, the facial bones continue to develop until adult age; this accounts for the preponderant development of the face in all animals up to the anthropoids, as well as for the still greater development of the teeth, and the masticatory muscles, these latter giving rise, in the male, to a bony vertical ridge (see

[1] C. Gegenbauer, *Lehrbuch der Anatomie*, 2nd edition, p. 253.

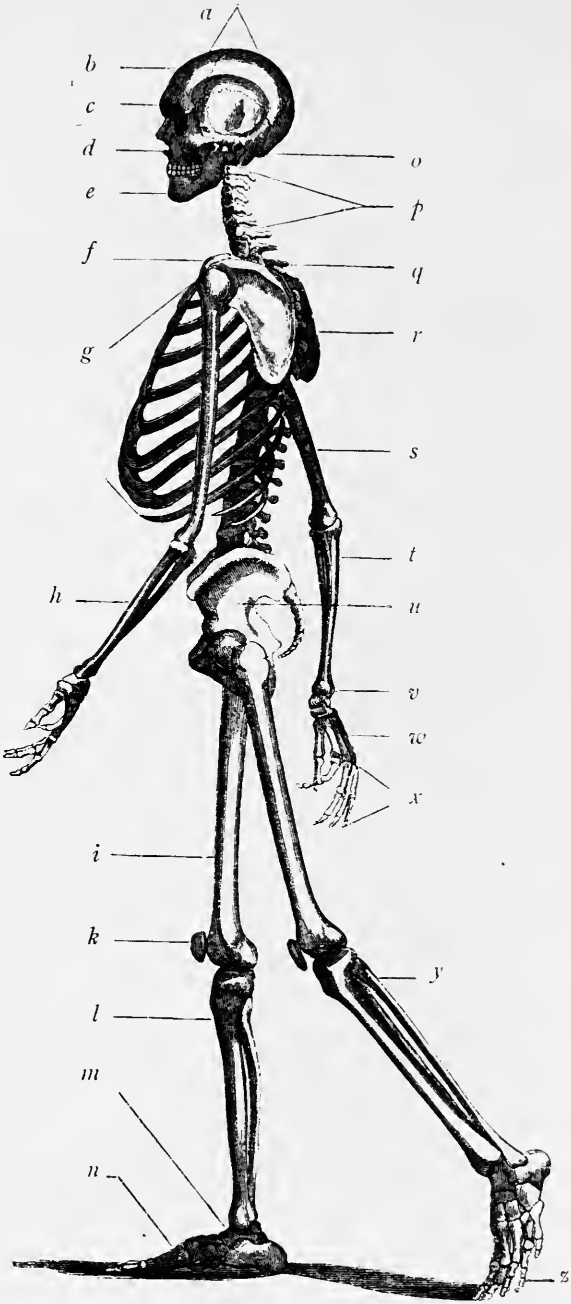


FIG. 8. Human skeleton: *a*, parietal; *b*, frontal bone; *c*, temporal bone; *d*, upper jaw; *e*, lower jaw; *f*, clavicle; *g*, ribs; *h*, radius; *i*, femur; *k*, patella; *l*, tibia; *m*, tarsal bones; *n*, metatarsal bones; *o*, occipital bone; *p*, seven cervical vertebræ; *q*, vertebral column; *r*, scapula; *s*, humerus; *t*, ulna; *u*, pelvis; *v*, carpal bones; *w*, metacarpal bones; *x*, fingers; *y*, fibula; *z*, toes.

Figs. 9 and 10). According to Topinard the average capacity of the skull of a

Male European	=	1400 ccm.	
Male Gorilla	=	498	"
Female Gorilla	=	458	"
Male Chimpanzee	=	409	"
Female Chimpanzee	=	392	"
Male Orang	=	426	"
Female Orang	=	406	"

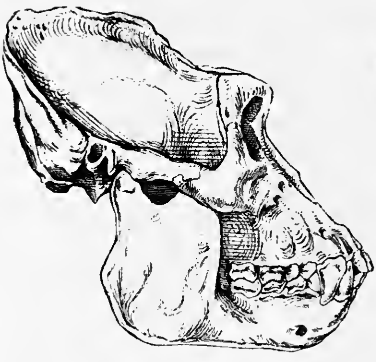


FIG. 9. Gorilla.

FIG. 10. Orang-Utan.

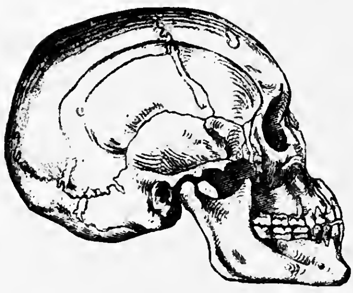


FIG. 11. Female Australian.

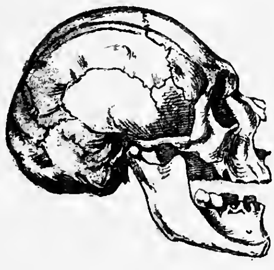


FIG. 12. Microcephalous skull.

Skulls of anthropoids and of the lower races of man. (*From the Corresp.-Blatt f. Anthrop., Ethnol. und Urgesch.* 1877.)

Ranke,[1] taking the capacity of the skulls of a male and female European (Bavarian) respectively at 1503 and 1325, states it to be an established fact that the absolute cubic content of the female skull is less than that of the male. In all the higher races of man, the inferior height and arch of the female skull,

[1] Ranke, *Der Mensch*, 1st edition, i., 293.

and the more perpendicular position of the forehead are considered as secondary sexual characters, whereas among the lower races the distinction between male and female is much slighter.

The human skull, in addition to its relatively superior size, has other distinctive characters:—

On the inner surface of the skull we are struck by the great size of the basal angle and the downward direction of the occipital foramen which in the other vertebrates tends rather backwards. This situation of the occipital foramen enables the human head to be freely balanced on the vertebral column; it is caused by the skull and brain being pressed in this direction during an early phase of embryonic development. In all other animals, up to the anthropoids, the frontal half of the skull is

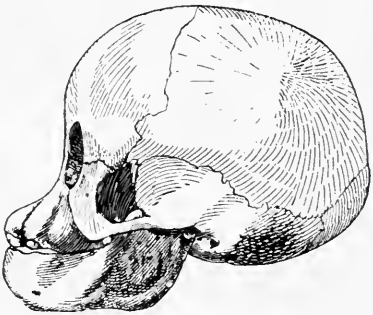


FIG. 13. Skull of a newly-born Orang. (From Selenka.)

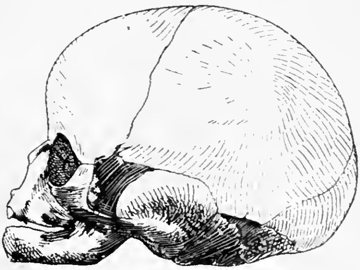


FIG. 14. Skull of a human embyro of ten months. (From Selenka).

preponderant, and this has led to a proportionately greater development of the cervical muscles (see Figs. 13 and 14). In man the inwardly visible basal angle corresponds with the outwardly visible inclination of the planum nuchæ; this inclines at a sharper angle in man than in animals, a fact due to the greater development of the brain. Hence the higher development of the frontal lobes in the human brain causes the greater breadth of the interorbital septum and the great size and extent of the ethmoidal cells. In the ape the frontal lobes are smaller and narrower and the interorbital septum is therefore narrow, the ethmoidal cells being either entirely absent, or but very slightly developed.

The sutura transversa occipitalis, which makes its appearance very early in the fœtus, sometimes fails to close completely, thus giving rise to the so-called Os Incæ, and Virchow considered the presence of the Os Incæ as the character of a low race; he also felt compelled to regard as a fixed character of the anthropoids, and the lower races of man, a certain furrow-like depression of the temporal region (sometimes called "temporal strait") combined with extreme narrowness of the sphenoid bone and the formation of a lepidoid process from the temporal bone direct to the frontal bone. Ranke,[1] however, has shown that among civilised races the same phenomenon occurs in a certain percentage of cases. The division of the frontal bone into two parts, which is peculiar to the lower mammals, not only occurs in the embryonic human skull, but is found not seldom in adults, when the two frontal bones are joined by a suture; this was pointed out by Canestrini in the brachycephalous skulls exhumed from the glacial drift.[2]

An important difference exists between the arcus supra-orbitalis of the human being (where it is always more pronounced in the male than in the female) and that of the anthropoids. In the latter, the prominent supraorbital ridge rests on a massive bone foundation and the frontal cavities are but rudimentary, whereas in man the cavities are highly developed, as may be seen from the skulls of Neanderthal, Spy, Krapina, the Australian of the present day, many South Sea Islanders, and, indeed, many an inhabitant of South Germany.

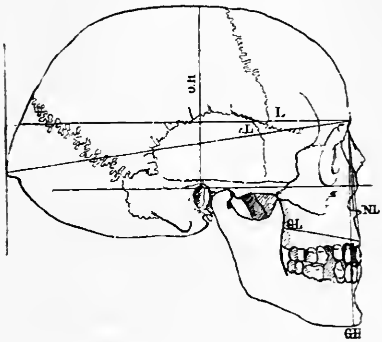


Fig. 15. Dolichocephalous skull viewed from the side. L, diameter; r.L, maximum diameter; GH, height of face; GL, length of profile; NL, height of nose; OH, height of ear. (From the *Corr.-Blatt f. Anthrop.*, etc., 1883.)

It is the cranium which determines the dimensions of the whole head. The Swedish anatomist, Retzius, was the first to classify the primitive races of Europe as (1) long-headed (dolichocephalous), where the diameter from front to back is greater than from side to side, and (2) short-headed (brachycephalous)

[1] Ranke, *loc. cit.*, i., 291. [2] Darwin, *loc. cit.*, vol. v., p. 50.

where the diameters are almost equal. Now, as each naturalist adopted his own method of measurement the results were very conflicting and unreliable, until the agreement[1] on craniometry was drawn up at Frankfort, whereby the German level was adopted as a basis for future measurements. The level is determined by two straight lines passing through the lowest point in the lower rim of the orbit, and through a point in the upper side of the bony auditory orifice perpendicular to the middle of the cavity of the ear (see Fig. 15). Taking this level as a basis, measurements are made of the diameter, the entire height, the maximum breadth, breadth of the brow, angle of inclination of the occipital foramen, angle of the profile, etc.

As we have seen in Part I., two distinct races of man have existed from the most remote times, a dolichocephalous and a brachycephalous, and the intercrossing of these two races in the course of ages has resulted in a third, a mesocephalous. It must not be supposed, however, that this quality is peculiar to man, for the wild horse of the Palæolithic Age was divided into two races; one small, short and broad-headed, the other larger with a long narrow head; the same distinction is found among the half-wild, half-domesticated cattle of the neolithic pile-dwellers.

Proceeding to the face we take first the *orbits* which belong partly thereto. The lower we descend in the scale of the vertebrates, the more laterally placed are the orbits and the less clearly are they distinguished from the temporal cavities. In man and also in the apes and anthropoids the orbits are situated in the front of the face and are completely closed. The laminæ papyraceæ which in man aid in forming the orbit are found otherwise only in the apes and in certain armadillos. In the gorilla and chimpanzee, it is true, the orbits are tubular and prominent, but this need not be regarded as an absolute contrast to the conditions of things in man, for the orang also does not possess this bony orbital tube.

In certain apes, and other mammals, the upper jaw-bone consists of two parts. Now, although in adult man the same bone is generally not so divided as in the two-month-old embryo, the division is found and not seldom remains throughout life,

[1] *Corr.-Blatt. f. Anthrop.*, etc., 1883, vol. i., p. 1.

especially among the low prognathous races, whence Darwin concludes that the division must have been a constant character of the early progenitors of man. Formerly the absence of the intermaxillary bone, bearing the incisors, ranked as one of the leading distinctive characters of the human face. This bone, which is separated from the canine teeth by a suture was first described by Galen; later on Vesal, and after him, Peter Camper, Blumenbach and Sömmering dispossessed man of it, judging it to be the peculiar property of the lower animals, until Meckel, and at the same time Goethe, proved it to be a normal formation in man, transitionary and appearing at a very early stage, but constant. Ranke[1] has definitely cleared up the point (see Fig. 16). The sutura incisiva (the suture dividing the back edge of the palate of the two intermaxillary bones from the palate of the upper jaw-bone) is always present in young mammals and only later becomes indistinct, finally disappearing. In the middle of the sutura incisiva is the foramen incisivum. The sutura incisiva may be observed not only in the skull of the newly born but also in adults; indeed, it has been shown that, as Autenrieth supposed, in the human fœtus, each of the upper incisors is imbedded in a separate intermaxillary bone, giving rise, accordingly, to a sutura interincisiva.

Fig. 16. Human palate with intermaxillary bones. (Ranke.)

Out of 100 skulls from the Munich Collection examined by Ranke, the sutura incisiva was found in 73 per cent., the sutura interincisiva in 10 per cent. Thus we see that the intermaxillary bone is by no means to be considered a peculiarity of the lower animals, nor are we justified in regarding the divided nasal bone as a specific character of man, as asserted by Wiedersheim,[2] for the nasal bone is frequently found divided in other mammals, and though in certain apes it grows together in early youth, the suture re-

[1] *Corr.-Blatt f. Anthrop.*, etc., 1901, p. 96.

[2] Wiedersheim, R., *Der Bau des Menschen als Zeugnis für seine Vergangenheit*, Freiburg, 1887, p. 66.

mains distinctly visible (*e.g.*, in the genus Cebus). Moreover, Hyrtl has pointed out that in the Hottentot skull the two bones are either partially, or completely, grown together, and this affords sufficient proof that its divided state cannot be peculiar to man. Virchow takes the catarrhine construction of the nose to betoken a low race; by catarrhine construction is understood that state wherein the nasal bone is not connected with the frontal bone by a more or less broad, transverse sutura, but tapers to an end, as in the gorilla and orang, in the form of small narrow laminæ generally grown together. This construction of the nasal bone is common among the Malays but is rarely observed among other nations. In man the lower edge of the nasal cavity generally terminates in a sharp point, called the nasal spine, whereas in the anthropoids the lower edges are blunt and the nasal spine is absent. Exceptions are found, however, among the markedly prognathous European and negro races; here the edges of the nasal cavity slope gradually away and on either side two low ridges are seen, between which runs a shallow prenasal fossa.

The malar bone (cheek-bone), which in the lower mammals is simply a narrow ridge and in the carnivora a wide arch, broadens in man and the apes into a solid arched plate with processes to the temporal and frontal bones and the upper jaw bone; in the anthropoids, it has a much broader span than in man owing to the greater development of the masticatory muscles.

The maxillary joint, the quadrate bone of amphibians, reptiles and birds, is in man as in all the other mammals a temporal joint, and the condyloid process possesses the character of a transverse cylinder. In many mammals the two halves of the lower jaw-bone remain divided throughout life, but they unite into one solid bone in man, in the walrus, sloth, camel, pachydermata, ungulates, bats and apes. In the anthropoids the lower jaw is far more strongly developed than in man, proportionately to their greater masticatory muscles.

In all the higher orthognathous races the jaws, upper and lower, form an equilateral triangle, the breadth being to the length as 100 : 100. On the other hand, in all the lower, prognathous races, as well as in the anthropoids, the jaws form instead of an equilateral, an isosceles triangle, the sides being greater than the base. Hence the proboscidate character of such skulls.

The leading peculiarity of the human jaw, distinguishing it from that of the highest anthropoids, and of all other mammals, is the projection in the middle of its exterior surface, the protuberance of the chin. Compared with the most ancient human jaws from the Palæolithic Age (La Naulette, Sipka, Krapina), the lower jaw of the Homo recens, with its more or less strongly defined chin, has undergone marked improvement.

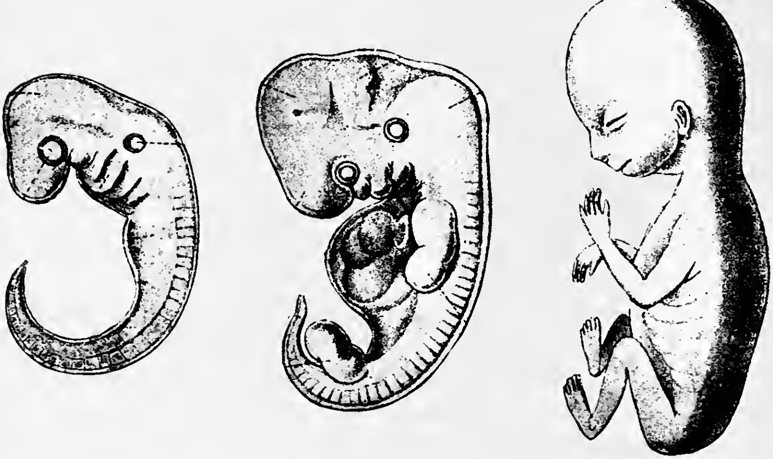
The most varied opinions prevail as to how the formation of the chin and the consequent improvement in the form of the jaw was brought about. Walkhoff assumes that the trajectories of the Musculus digastricus and especially of the M. genioglossus have been the chief factors in determining the growth of the chin. Weidenreich holds the view that the development of the chin is due to a reduction in the size of the teeth, and of the alveolar edge of the lower jaw, but this is probably erroneous, since, at the present day, man, civilised and uncivilised, possesses a chin in spite of his teeth being almost as large as those of palæolithic man.

Toldt believes the true cause to lie in the development of the form of the head, particularly in the broadening of the frontal part of the skull, which has lead to a corresponding increase in the width of the face and of the lower jaw; in order to relieve the consequently great tension of the lower jaw the bones were strengthened at the point of union of the two halves. This first takes place at the time of birth, appearing as the ossicula mentalia in the median symphysis and forming the starting-point for the structure of the chin. It did not originally exist in the earliest races of man, but has developed gradually in the course of time under the influence of the function it was to perform. Hence, according to Toldt,[1] the chin is correlated to the whole structure of the head and is a material advantage possessed by man over all the other animals; it is, by no means, to be regarded as a sign of weakness or degeneration, which it would be were it traceable to a reduction of the teeth.

Another important difference between man and the other

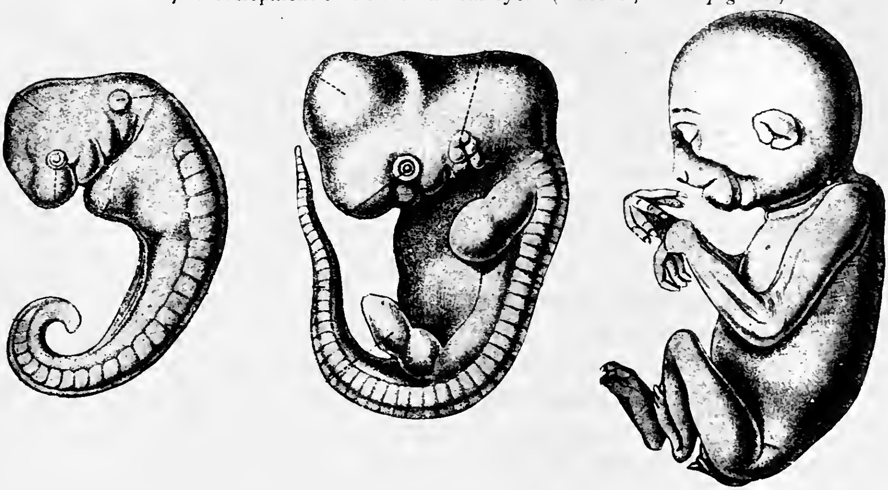
[1] C. Toldt, Vienna, *Corr.-Blatt f. Anthropol.*, etc., 1904, pp. 94-98.

mammals, the anthropoids included, lies in the measurements of the skull in profile. This measurement was formerly based on Camper's facial angle, but since the Frankfort agreement it



I II III

Fig. 17. Development of the Human embryo. (Haeckel, *Anthropogenie*.)



I II III

Fig. 18. Development of the Gibbon embryo. (Haeckel, *Anthropogenie*.)

takes, in common with all other craniometrical measurements, the German level as basis.

Camper described a horizontal line passing along the base of the nose and orifice of the external auditory canal, and classified all skulls according to this line, attaching special importance to the direction of the cheek-bone. He then described at right angles with the horizontal a perpendicular passing down the profile from the highest central point of the brow; he thus obtained a clear impression of the proboscidate character of the animal skull in comparison with that of man. He arrived at the following results:—

In a Macaeus cynomolgus	a facial angle of	42°
,, ,, young orang-utan	,, ,, ,, ,,	58°
,, an adult European	,, ,, ,, ,,	80°

But there are human beings possessing a much smaller facial angle; for instance, the negroes and Kalmucks have a facial angle of 70° owing to the prognathous character of their skulls. Isolated cases of true prognathism in a lesser degree are found in all races, caused by the prominence of the whole upper jaw and the corresponding projection of the lower jaw, but these cases should be carefully distinguished from the very prevalent alveolar prognathism where only the aveolar process projects. E. Fischer (Freiburg) at a meeting of Anthropologists at Dortmund (1902)[1] showed conclusively that in spite of the many differences between the human facial angle and that of the apes, they have still much in common in the early phases of embryonic development. Fischer compared the human embryo with the embryo of Macacus cynomolgus and of Semnopithecus maurus. That there is a close resemblance between the human skull and that of the apes in the early embryonic stages has been long admitted, and this refers not only to the anthropoids but also to the lower apes

FIG. 19. Gorilla fœtus of the size of a human fœtus of one to one and a half months. Nat. size. (Duckworth.)

[1] *Corr.-Blatt für Anthrop.*, etc., 1902, p. 153.

whose skulls are strikingly human in appearance in the arch, the relatively slightly developed organ of smell and its proboscidate character and in the breadth of the septum interorbitale (see Figs. 17 and 19).

The human teeth also possess distinctive characters. In early zoological manuals we find it asserted that man alone possesses an unbroken series of teeth, and that they are all of the same size; only the first part of this assertion is correct, it being a fact that in man neither is a whole series of teeth absent as in certain other mammals, nor does he possess certain spaces into which the upper and lower canine teeth fit, as in the carnivora, or only the lower canines, as in the apes. As regards the uniform size of the teeth, however, man has in reality no advantage over the other mammals, for, apart from individual differences of size in the molars and incisors, we find signs of a transition stage between the anthropoids and man, both in the molars and canines, there being people in whom the points of the canine teeth are considerably higher than the rest.

The milk molars of man and the anthropoids bear a great resemblance to one another, but when we come to the canine teeth the resemblance disappears. Man has shorter and broader permanent molars than have the anthropoids, and the form and height of the molar cusps are constant in man but vary in the different anthropoids. Another human attribute is the lesser divergence of the molar roots (see Fig. 20). In man and in the anthropoids, the upper premolars and molars proper have three roots, the lower two; further, the four cusps of the upper molars are generally the same in man and the anthropoids, but in the Prosimiæ only the first molar has four cusps, the other two having but three each. In man the inner anterior cusp is connected with the outer posterior cusp by means of a ridge and the inner exterior cusp is separated, as it were, from the rest of the tooth by a small furrow.

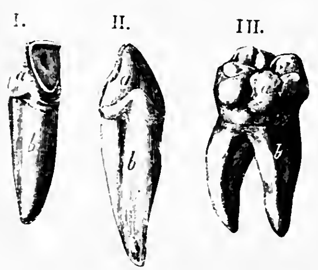


FIG. 20. Human Teeth. I. Incisor; II. Canine; III. Molar; (*a*) crown, (*b*) root.

PLATE I.

Upper molars of Tertiary apes, later anthropoids and Hottentots.

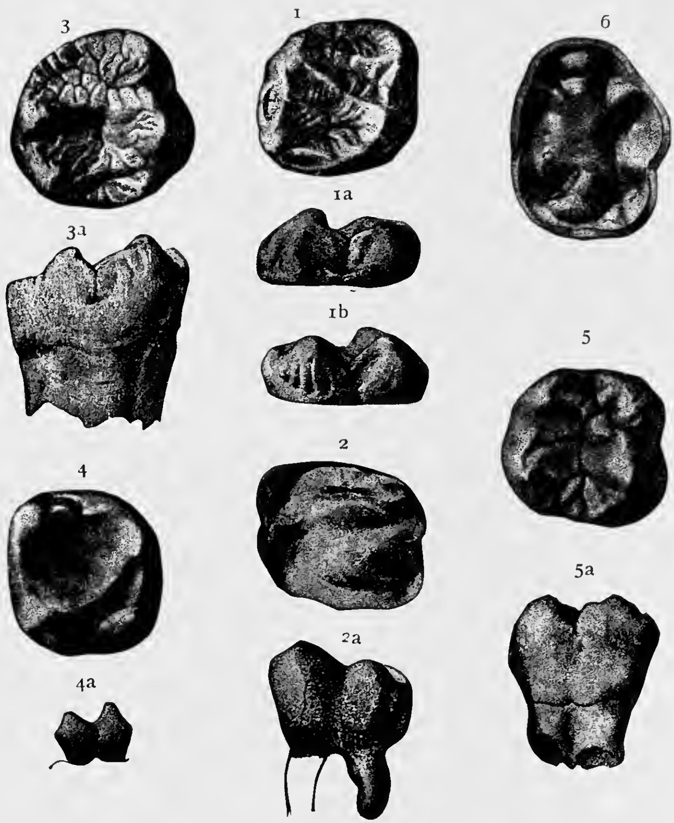


FIG. 1, 1a, 1b, 2, 2a and 6, Upper molars from the pisolitic iron ore.
,, 3 and 3a, Upper molars of the Orang.
,, 4 and 4a, ,, ,, ,, Gibbon.
,, 5 and 5a, ,, ,, ,, a Hottentot.

(Württ. *Jahreshefte des Vereins für vaterl. Naturkunde*, 54 Jahrg., Tafel i.)

PLATE II.

Lower molars of Tertiary apes, later anthropoids and of man.

FIG. 1, 1a, 2, 2a, 4, 4a, 5, 6, 6a, 7, 7a, Lower molars from the pisolitic iron ore.
,, 10, Last lower milk premolar, from the pisolitic iron ore.
,, 3 and 3a, Lower molar of the Gibbon.
,, 8 and 8a, Lower molar of the Orang.
,, 9, Lower molar of man.
(Württ. *Jahreshefte des Vereins für vaterl. Naturkunde*, 54 Jahrg., Tafel ii.)

The above are the usual figures for the upper molars in man, but there are also races, who have not teeth of a uniform size, in whom the second and third upper molars have three cusps: *e.g.*, the Eskimos and not seldom Americans who are descended from European emigrants. The molars of the lowest races of man (Malays, Australians and negroes) have the highest number of cusps (4, 4, 4) and all these races have besides unusually large teeth. The lower molars in man have normally five, but sometimes six cusps and two roots. It not uncommonly happens, however, that there are only four, three, or two cusps, whereas in the anthropoids far less variation is to be observed. The first and third molars have usually five cusps, but this is subject to modification, especially in the third molar which in most, though not in all, anthropoids is very large, larger indeed than the first or second.

Darwin[1] is of the opinion that the wisdom tooth is tending to become rudimentary among the civilised races, and attributes the fact to the preference for soft food, whereby the posterior part of the alveolar arch has become reduced (Schaaffhausen). In the United States it is said to be of quite common occurrence that children have some of their molars extracted, as the lower jaw is too small to allow of the development of the normal number of teeth. Speaking generally, we may say that the teeth of civilised man stand at one end of the scale, those of the anthropoids at the other, and the negro's midway between.

To palæolithic man eating and chewing were evidently of more importance than speaking. The jaws were longer and contained larger teeth. Since then the tendency to a reduction of the upper and lower jaw—a tendency dating still farther back in man's history—together with the transition from prognathism to orthognism has sensibly increased. As a form of compensation, the jaws have become broader, as Toldt (see above) has shown, and in the lower jaw the chin has been developed.[2]

Klaatsch, to whose untiring pen we owe the rehabilitation of the Neanderthal man, and who follows up the very earliest traces of man, regards the human teeth from an original point of view. As in his opinion man by no means stands at the head of all living beings with respect to all parts of his

[1] Darwin, *loc. cit.*, v., 257. [2] R. Wiedersheim, *loc. cit.*, p. 172.

organisation, so also he considers that the human teeth are among the most primitive possessed by any of the existing mammals. Had man not sacrificed twelve teeth in the course of his gradual development, he would now have forty-four, the largest number possessed by any land-dwelling mammal. One of the most important points in classifying man in the order of animals is, in the opinion of Klaatsch, the four-cusped human molar. Now as the arctocyon and the Phenacodus (a member of the Ungulata) of the Eocene Period possessed molar teeth which resemble man's as closely as man's resemble those of the anthropoids, Klaatsch concludes that man, as regards his molar teeth, has not progressed beyond the stage of development reached by the mammals in the Tertiary Period. Further proofs must be produced in connection with other organs of the human body.

Wiedersheim[1] has pointed out that the teeth of the higher vertebrates show interesting signs of reversion. In fishes, amphibians, and certain reptiles the first signs of teeth are epithelial formations which later become absorbed into the mesoderm and form the teeth-ridges, and these develop in due course into the actual teeth. The higher vertebrates have also in the first place similar teeth-ridges but without the preliminary formation of papillæ. Röse, however, has found that in the human embryo a transitionary formation of rudimentary papillæ precedes the formation of the teeth-ridges.

Vertebral Column.

In the fishes, batrachians, and reptiles, the division of the body into distinct regions is rudimentary, first being perfected in the birds; the vertebral column in birds, and in mammals, differs conspicuously as to the number of separate vertebræ.

Man alone (see Fig. 21) possesses a fixed number of vertebræ. Birds have frequently very numerous cervical and lumbar vertebræ, and in mammals the figures are as follows:—

12 to 23	dorsal vertebræ
3 to 7	lumbar vertebræ
2 to 5	forming the sacrum
4 to 46	caudal vertebræ
7	cervical vertebræ

[1] R. Wiedersheim, *loc. cit.*, p. 172.

(except in the dugong). Man, on the other hand, has invariably 7 cervical, 12 dorsal (very rarely 13), 5 lumbar, 5 composing the sacrum, 4 (very rarely 5) united in the coccyx. The human vertebral column resembles most closely that of the anthropoids. In the orang, gorilla, and chimpanzee, the normal number of thoracic-lumbar vertebræ is 16, in the hylobates 18.

In exceptional cases the fifth lumbar vertebra is converted into the first sacral. According to the relative number of his vertebræ, man occupies an intermediate position between the hylobates and the other anthropoids.[1] Peculiar to man is the double S-shaped curve of the spine; according to Cunningham and Huxley there are faint signs of it in the gorilla, but it is entirely absent in all other anthropoids, even in an erect attitude.

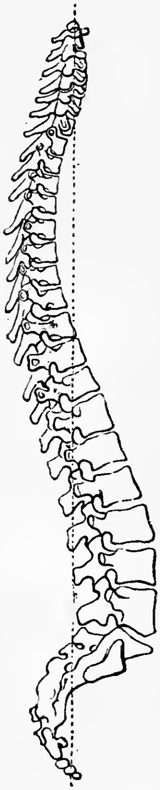


Fig. 21. Human vertebral column in erect position viewed from the right side. (H. Meyer.)

In all mammals the dorsal and lumbar vertebræ are ventrally concave, and in European children and the lower races of man (*e.g.*, the Veddahs), the lumbar vertebræ at least are ventrally concave. In the adult of the higher races it is the S-shaped curve which gives the spine its elasticity and enables it to maintain an erect position.[2]

This divergence from the original type of the Primates is, according to Klaatsch, due to the fact of the lumbar vertebræ being sharply curved against the sacrum, this being caused by the repeated backward pressure of the sacrum in climbing high trees, after the manner of existing wild tribes. Through the peculiar curve of the lumbar spine thus attained, the weight of the head and of the upper part of the trunk was directed so far to the back as to establish the balance necessary for the erect position. On this head the apes may be divided into two groups: the lower apes having the same curve as all other quadrupeds, and the anthropoids in

[1] C. Gegenbauer, *loc. cit.*, i., 175. [2] Ranke, *loc. cit.*, i., 351.

the following order: gorilla, orang, chimpanzee and hylobates bearing an increasing resemblance to the curve of the human spine.

Another peculiarity possessed by man, in contra-distinction to the apes, is that the spinous processes of all human cervical vertebræ branch out into two points; this does not occur in any other Primate, and in the chimpanzee only at the second and third cervical vertebra (see Figs. 22 and 23). Moreover in the chimpanzee, gorilla and orang, the spinal processes are much longer than in man. Of phylogenetic importance is the perforation of the transverse processes of the cervical vertebræ giving them the appearance of two processes joined together, of which the anterior ones (from the point of view of comparative anatomy) must be regarded as rudimentary cervical ribs.

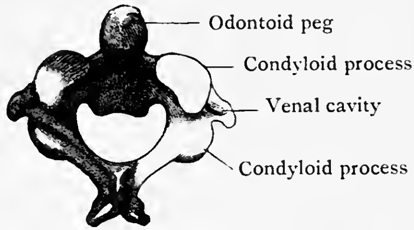


FIG. 22. Episterpheus (front view).

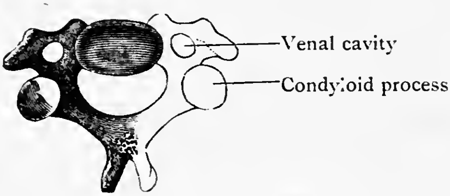


FIG. 23. Fifth cervical vertebra (viewed from underneath).

The neck with its covering of flesh and muscle is a further characteristic attribute of man. It rises freely above the shoulders, is cylindrical in the neighbourhood of the head, becoming broader towards the thorax, and is curved, back and front, where it joins the head. It forms another distinction between man and the anthropoids, for in the latter the neck is by no means free, the head hangs forward on the breast, sunk between the shoulders as in a human being deformed by rickets. The ligamentum nuchæ is considerably less developed in man than in the other mammals. Schwalbe has found that in the cervical ligament of the ruminants the elastic filaments are arranged like cords inside which they are connected with one another by means of well-defined anastomoses.

Thorax.

The barrel-like form of the human thorax is due to the erect position (see Fig. 24). The thorax was originally keel-shaped and is so still in all those mammals who support the weight of the body on all four extremities (pachyderms, beasts of prey, ruminants, equidæ), the barrel-shaped form being a later development in man and in all mammals the weight of whose bodies is supported by water, by air, or by the posterior extremities (marsupials, rodents, insectivora, cetaceans, otters, sea-otters, bats and anthropoids). That the barrel form has been evolved from the keel form can be proved, ontogenetically and phylogenetically. The determining factor in the transformation of the thorax in the Primates was the gradual conversion of the anterior extremities into organs of prehension, with their great muscular development. This form of the thorax causes the centre of gravity to be transferred to the back, thus facilitating the adoption of the erect position.[1]

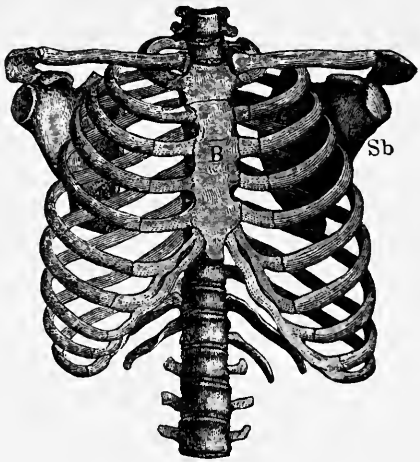


Fig. 24. The Human Thorax.
B, sternum ; Sb, scapula.

Man in common with the orang has normally twelve ribs, the gorilla and chimpanzee have thirteen, the hylobates fourteen. As Wiedersheim[2] states so emphatically, the history of evolution has shown that man's progenitors must have had a greater number of ribs, and it is a fact that a thirteenth rib is present in the human embryo; it disappears later on, though in exceptional cases it continues to develop. Traces of supernumerary ribs have been found in the region of the lumbar

[1] Wiedersheim, *loc. cit.*, pp. 39-41. [2] *Ibid.*, p. 42.

vertebræ, and it is not uncommon to meet with cervical ribs proceeding from the last cervical vertebra.

The sternum, or breast-bone, which, it must be remembered, in our early progenitors consisted of a series of consecutive parts, in all mammals, may be divided into three parts: hilt, blade and ensiform process; but in man, as in the rest of the Primates, it forms a uniformly broad, compact plate. The interarticular cartilages correspond to the lateral parts of the episternum of the other mammals.[1]

The clavicle, or collar-bone, is developed in the same way as in the mammals which employ the upper limbs for grasping, scratching, flying, climbing or striking. The human clavicle corresponds most closely in its development to that of the apes and bats.

A masterly and exhaustive treatise on the scapula has been issued by Ranke.[2] In the quadrupedal mammals the scapula forms the point of support for the upper limbs and consists of a long, almost triangular bony plate with a relatively deep cup-like cavity (the glenoid cavity) at its outer angle.

Into this cavity the head of the humerus fits, producing thereby an almost perpendicular upward pressure. The surface modelling of the shoulder-blade is modified, on the one hand, by the mechanical action of supporting the arm, and, on the other hand, to an important degree by the muscles. The shoulder-blade is further strengthened by the thickening of the edges converging towards the glenoid cavity, and also by the spine of the scapula, which in many mammals (*e.g.*, the carnivora) runs midway between the two edges of the scapula towards the glenoid cavity.

The spine of the scapula indicates the direction of the main pressure, forms the chief support and is situated perpendicularly to the middle of the joint (Figs. 25-31). The closest resemblance to the human shoulder-blade is found in the orang, gorilla, and chimpanzee; that of the hylobates is intermediate between the anthropoids and the cynocephalous apes. The anthropoid scapula differs from the human in the following respects (p. 71). The incisura scapulæ is absent. The posterior border of the human scapula takes a downward perpendicular

[1] Wiedersheim, *loc. cit.*, p. 49. [2] *Corr.-Blatt f. Anthrop.*, 1904, p. 139.

direction; in the anthropoid it describes a curve from the upper exterior edge to the lower interior. The basal line of the spine, described from the posterior edge of the scapula to the lower edge of the glenoid cavity, forms with the posterior border: in man a right angle; in the orang an angle of 120°. The angle of the scapula in the anthropoids corresponds to their semi-erect position. The articular cavity differs also in form and depth in man and the anthropoids. In the orang it is comparatively deeper and narrower. In man, the surface of the cavity is kidney-shaped, in the orang purse-shaped. In man, the humerus possesses a far greater power of rotatory

Collection of scapulæ. (Ranke.)

FIG. 25.

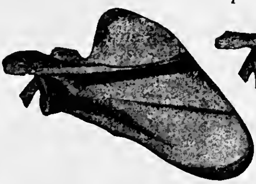


FIG. 26.

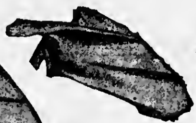


FIG. 27.

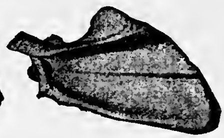


FIG. 28.

FIG. 29.

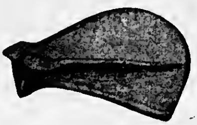


FIG. 30.

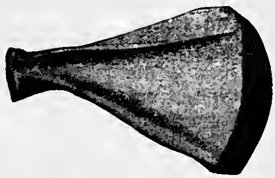


FIG. 31.

25. Man. 26. Gorilla. 27. Chimpanzee. 28. Orang. 29. Hylobates. 30. Dog. 31. Stag. (*Corr.-Blatt f. Anthrop.*, etc., 1904, 141.)

motion. In man, the surface of the cavity is nearly parallel with the outer edge of the scapula; in the anthropoids the angle of inclination is $45° = \frac{1}{2}$ R. The chief difference between the human scapula and that of the gorilla, which resembles man's more closely than does that of the orang, is that the spine cuts the outer edge at a much lower point in the gorilla than in man. The incisura scapulæ is absent in the gorilla as in all the other anthropoids. The chimpanzee has a considerably narrower shoulder-blade than has the orang, gorilla, or man, though in outline it shows many points of similarity to the human scapula. It is clear at a glance that the scapula of the hylobates possesses very little human resemblance, as it is extremely narrow and is divided into two almost equal parts by the spine (similarly to the scapula of the carnivora); indeed in many respects the scapula of the hylobates is even less human in character than that of the semi-apes, particularly the Indri of Madagascar. Among the mammals, however, with the exception of the anthropoids, the scapula of the bat most closely resembles that of man. The fossa supraspinalis is small, the fossa infraspinalis much larger. Like man, the bat uses the upper extremities only to a very slight degree as organs of support.

Man's broad, flat back is one of his most distinctive characters, and no less important is the form of the trunk, which somewhat resembles an hour glass, thus causing the abdominal organs to be entirely supported by the pelvis. The pressure of the intestines caused by the erect position has resulted in that transverse broadening of the iliac bones, which, contrasted with the narrow pelvis of the anthropoids, is so distinctive a human character, and in the human female has been still more increased through sexual adaptation.[1]

This sexual difference in the human pelvis (see Figs. 32 and 33) is a specific human character; in the lower races of man the difference is less strongly developed. Wiedersheim[2] states the case with admirable clearness, showing that in the human being the pressure of the uterus during pregnancy is sagittally directed and not ventrally as in the other mammals. The uterus is supported by the iliac bones.

It has further been shown by Wiedersheim that the number of vertebræ above the sacrum was originally greater, that the pelvis was situated more towards the back and that the forward tendency still persists. This is proved by cases where the fifth and even the fourth lumbar vertebra has joined the sacrum similarly to the case of the orang, chimpanzee and gorilla. In man the coccyx generally consists of four, in rare cases of five, vertebræ, in all of which, with the exception of the uppermost one, the true vertebrate form is rudimentary. More than five coccygeal vertebræ have never been observed in man, even in the embryo.

The absence of a tail is no distinctive character of man, for

[1] Wiedersheim, *loc. cit.*, p. 41. [2] *Ibid.*, p. 86.

there are tailless animals in other orders, and the backward curve of the coccygeal vertebræ (named by Waldeyer "inner tail" or *cauda occulta*) is shared by the tailless anthropoids. Embryological research has proved that the early progenitors of man, and the anthropoids, undoubtedly had outer tails. The human embryo of from four to six cm. has a real tail outwardly visible and projecting, with segments, medullary canal and caudal intestine.[1] The spot where the point of the os

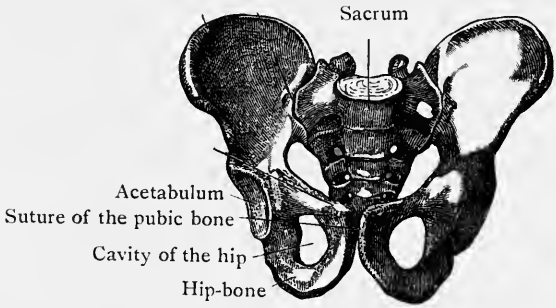


FIG. 32. Male pelvis. (Ranke, *D. M.*)

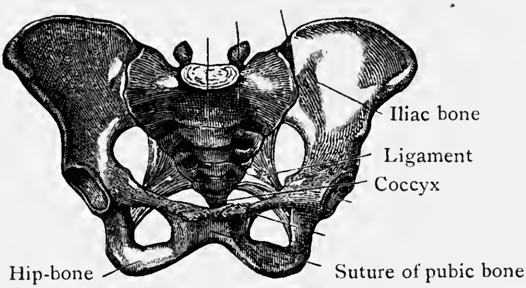


FIG. 33. Female pelvis. (Ranke, *D. M.*)

coccygis presses outwards against the skin, where formerly the tail actually passed through before the subsequent curving of the sacrum, is indicated in the embryo by the vertex coccygeus. As the time of birth approaches, this vertebra disappears and is replaced by a smooth hairless spot (glabella coccygea) which often assumes the form of a small depression (foveola coccygea).[2]

[1] Wiedersheim, *loc. cit.*, p. 27. [2] *Ibid.*, p. 7.

To enter more thoroughly into the distinctions between the human pelvis and that of the apes we cannot do better than quote the definition of the same as formulated by Albrecht,[1] "Man alone possesses a fossa iliaca interna".

In the apes the superficies iliaca interna is more or less convex, the fossa interna in man being due to the pressure of the intestines caused by the erect position. Similarly, in man alone is the anterior section of the superficies iliaca externa convex.

Again, only man and not one of the apes possesses a spina superior anterior ossis ilei projecting above the incisura interspinalis anterior, and of all the Primates he has relatively the smallest space between the superior and inferior anterior spines. When we consider further that man possesses the smallest space between the cornu posterius acetabuli and the tuber ischii, and that the dorsal surface of the symphysis is convex in man, and concave in all apes, we have sufficient proof that the erect position of man has led to marked modifications of the pelvis.

To Ranke[2] we owe the formulation of still another distinction between the human and anthropoid skeletons, namely, the relation of the trunk to the entire stature and to the length of the leg. Taking the stature at 100, the length of the trunk is:—

In the male gorilla	50·40
„ chimpanzee	44·80
„ orang-utan	44·50
„ pure negro	36·98
„ German	36·27

Hence in man the trunk is shorter than in the anthropoids. We may now consider the proportion of the trunk to the leg. Taking again the stature at 100, we obtain the following figures:—

A South German is to a gorilla as	134·6 : 69·2
„ „ to a chimpanzee as	134·6 : 78·5
„ „ to an orang as	134·6 : 78

Hence in man the leg is longer than the trunk, in the anthropoids shorter.

[1] *Corr.-Blatt f. Anthrop.*, etc., 1883, p. 100. [2] Ranke, *loc. cit.*, ii., p. 7.

Extremities.

Next in importance to the head and vertebral column, as regards distinctive human characters, come the extremities.

In the first place, the head of the humerus differs widely from that of the anthropoids and other mammals. The head of the human humerus is almost a perfect segment of a sphere; that of the gorilla, according to Aeby, is like a transversely placed cycloid. In mammals, as a rule, the articular cavity of the scapula is placed downwards, in man it has an outward direction. In the quadrupeds, the head of the humerus during walking is pressed into the joint; in man, the head is free, thus rendering a backward and forward rotatory motion possible, in addition to the up and down motion. Another distinctive character of man is the length of the humerus, which in the human body is shorter, but in the anthropoid longer than the femur. Man in his more highly developed state is further distinguished from the anthropoids by the shortness of the fore-arm in proportion to the upper arm (see Fig. 34).

According to Wiedersheim, taking the humerus at 100, the length of the radius is as follows:—

In the European	73
„ Aino	77·4
„ Veddah	80
„ Chimpanzee	90·94

In the gibbon the forearm even exceeds the upper arm in length, and to this the fact is due that in an erect position the finger-tips touch the ground. The perforation of the fossa olecrani, peculiar to the anthropoids and lower apes, occurs very seldom in the higher races of man, but its absence cannot rank as an absolutely distinctive character, since it is frequently observed in the lower races (S. Africans, Veddahs) and occurs in pre-historic skeletons. "In man the fore-foot, fitted exclusively into the radius and thus rendered movable, has developed into the hand" (Pfitzer). The rare cases where an articulatio ulno-carpea occurs (*i.e.*, where the ulna is connected with the trapezium and pisiform) must be regarded as cases of atavism.[1]

In man the os centrale, which appears in the embryo,

[1] Wiedersheim, *loc. cit.*, p. 85.

unites with the os naviculare in the second half of the third month, whereas in the orang and the majority of the other apes, it occurs regularly as an independent bone and is absent only in the gorilla and chimpanzee.

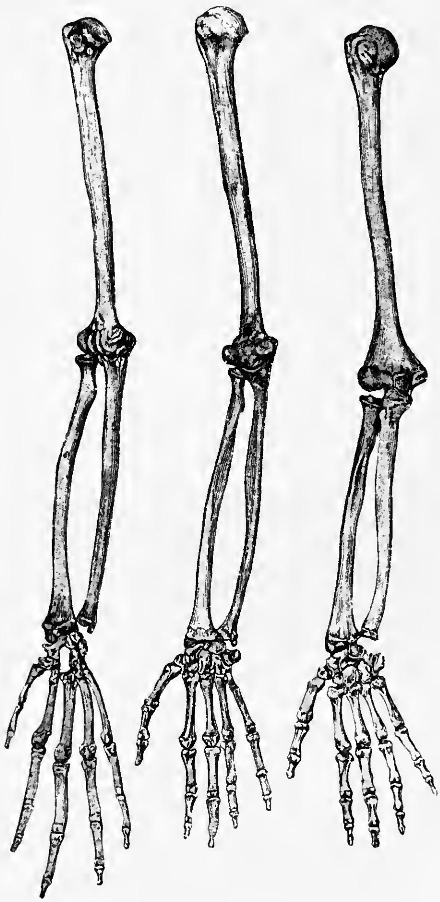


Fig. 34. Arm and hand of three anthropoids. I. Chimpanzee. II. Veddah. III. European (Mediterranean). (From Haeckel, *Anthropogenie.*)

With respect to the evolution of the human hand, Darwin believes it to have been brought about in accordance with the principle of the division of labour, in proportion as the hands were perfected for prehension the feet became adapted for support and progression. Klaatsch, however, asserts that in the Eocene Period even the carnivora possessed a hand with an opposable thumb, very similar to the human hand, and that later a reversion of the hand to a claw took place. Thus in Klaatsch's [1] opinion the human hand has not been evolved from the foot of a quadrupedal progenitor; it is no new acquisition nor is it the peculiar property of man, but a very ancient heritage from the remote ancestors of man and the mammals. From the earliest times the hand has held an important place in the development of the land vertebrates owing to the opposable thumb.

[1] *Corr.-Blatt f. Anthrop.*, 1901, p. 102.

The prototype of the carnivora (arctocyon) like the prototype of the ungulates (phenacodus) had a hand which closely resembled that of the prosimiæ and primates of the present day. When the human hand is compared with the hand of an anthropoid many points of difference may be observed. Man alone possesses a perfect hand fitted for the most delicate uses. The hand of the highest anthropoid, the gorilla, is broad and clumsy, and, in the opinion of R. Hartmann, is more like a lion's paw. The length of the palm is considerable, but the fingers only become independent from the middle of the first phalanx; between the third and fourth fingers the skin is continued almost to the second phalanx. The dorsal surface of all the fingers is convex.[1] In the chimpanzee also the four fingers are connected with each other by a membrane which sometimes extends as far as the joints between the first and second phalanges. As in the gorilla, the horny skin of the palm is furrowed with countless wrinkles, and the gorilla has numerous small callosities deeply imbedded in the lines of the hand.

Another of the typical features of man is the thumb, surpassing as it does in length and anatomical structure the thumb of even the highest anthropoids. In man the thumb extends as far as, or even past, the middle of the first phalanx of the index finger. In the gorilla it reaches but a short way beyond the base of the first phalanx of the index finger, while in the chimpanzee and other anthropoids it is still shorter. The human thumb alone has remained stationary throughout the ages and has thus not increased in perfection. In all the apes, without exception, the thumb has undergone retrograde changes, so that the hand, even of the gorilla and the gibbon, is no longer a perfect organ of prehension. In all apes the index finger is shorter than the third finger, though, it must be admitted, cases are sometimes found in man betraying very similar apelike conditions.

Distinctively human is the power of bending the hand so as to form a kind of scoop, and the power of completely encircling a ball (suited to the size of the hand) with the curved fingers (A. Ecker). In his book Ranke [2] advances several points, of

[1] Ranke, *loc. cit.*, ii., pp. 15, 24. [2] *Ibid.*, p. 7.

great value in comparing the upper limbs of man with those of the anthropoids. Taking the stature at 100, the length of the arm together with the hand is:—

In the gorilla . . .	64·9
,, ,, chimpanzee .	67·67
,, ,, orang . . .	80·72
,, man	45·16-45·43

Again, given the stature at 100, the length of the hand is:—

In man	11·6
,, the gorilla . . .	17·4
,, ,, orang . . .	22
,, ,, chimpanzee . .	23

Hence we see that relatively to his stature man has the shortest arm and the shortest hand.

No less striking and equally valuable as distinctive characters are the differences between the lower extremities. With respect to the human femur it is much longer than the anthropoid, and is much more extended in the hip-joint (see Figs. 35 and 36). The trochanter tertius for the insertion of the musc. gluteus maximus is absent in the anthropoids, but it cannot be regarded as peculiar to man since it is found also in the horse, ass, rhinoceros, tapir, certain rodents, and some other mammals. Moreover the trochanter tertius is not uniform in all races of man, being more markedly developed in the higher races, though, strange to say, it is to be found even in the man of the reindeer period,[1] in whom also the characteristic curve of the shaft of the femur was already present. The femur discovered by Dubois in Java, which gave rise to so much discussion as to whether it had belonged to a man, or an ape, or to some intermediate being, led to the inevitable inquiry as to what constituted the distinctive signs of the human femur anatomically and histologically. In the following paragraph I give Bumüller's (*Das Menschliche Femur*, *Inaug.-Dissertat.*, Augsburg) definition of the differences between the human and anthropoid femur (hylobates excepted).

The human femur is not only longer but thinner and more

[1] Houzé, "Le troisième trochanter de l'homme et des animaux". *Bulletin Soc. Anthr. de Belgique*, Bruxelles, 1893.

slender than the anthropoid femur. The transverse section of the diaphysis is in man triangular, in the anthropoids a broad,

Human Skeleton. Skeleton of a Gorilla.

FIG. 35. Man. FIG. 36. Giant gorilla.
(From Haeckel, *Anthropogenie*).

sagittally compressed oval; the popliteal transverse section is in the anthropoid much broader and lower than in man.

The differences in the condyles is very striking: in man the lateral condyle is usually the longer and the median is apparently rudimentary, whereas in the anthropoid the conditions are exactly the reverse. The human femur is usually sharply bent at the top, but in the anthropoid femur the curve is slight and occurs sometimes at the lower end. The anthropoid radii of the lateral knee ligaments are exactly the opposite of the human. This rough anatomical sketch may be followed by Professor Walkhoff's[1] "Studien über die Entwicklungsmechanik des Primaten-Skelets," which open with a differential diagnosis of the human femur as compared with the anthropoid. Walkhoff combined with his studies the application of the Röntgen rays, and found, as Culmann and H. Meyer had done before, that the femoral spongiosa corresponds, in its tractive curves and curves of pressure, to the structure of a crane.

Now in man, according to Walkhoff, the bony crest which extends from the inner angle of the neck of the femur along the inner side of the bone and through the head is quantitatively by far the most important and is proportioned to the great pressure borne by this part of the limb in standing and walking. The anthropoid femur does not possess this trajectorium ; its spongiosa is coarser and its cells circular.

Another characteristic attribute of man is the great extensibility of the knee-joint which has been of the first importance in enabling man to adopt the erect position. The platycnemia of the tibia peculiar to all anthropoids, with the exception of the orang, is only found in the lower races of man as may be seen from the prehistoric tibiæ. A similar case is that of the retroversio tibiæ, a retroverse position of the upper surface of the tibial joint. This may always be observed, as the investigations of Wiedersheim show, in the human embryo from the third month onwards; it disappears in the sixth or seventh month in children of the Caucasian race, but in the lower races remains and is to be seen in prehistoric skeletons.

The fibula of man, during the earlier phases of embryonic development, is connected with the femur together with the tibia. But the weight of the body having been gradually transferred to the tibia alone the fibula slipped, as it were, down to

[1] *Corr.-Blatt f. Anthrop.*, 1904, p. 73.

the tibia itself. Hence in man the tibial malleolus gains the ascendancy over the fibular and remains predominant. By means of the two malleoli, the astragalus and os calcis are held as in a vice in the same line with the tibia.

Markedly developed in man is the os calcis (heel) for the reception of the important tendon of Achilles. The arched formation of the foot, which occurs only in man, causes the weight of the body to be supported by the heel and the balls of the great toe and small toe. The arched foot is incompatible with the free movement of the great toe, possessed by the apes (A. Ecker). In man the great toe together with its metatarsal bone is strongly developed, the other toes being quite short. In certain lower races (Veddahs, Australians), the great toe forms a kind of organ of prehension similar to that of the apes, but in all the higher races the power of prehension has been lost; the great toe is an organ of support, the whole foot is a foot adapted for support.

On examining the foot of an anthropoid, *e.g.*, that of a gorilla, we are struck by the essential differential characters. Here the great toe diverges from the longitudinal axis of the foot at an angle of 60°. The opposability of the great toe is shown by a furrow running lengthwise along the sole. Besides this there are transverse furrows revealing still more clearly the resemblance of the gorilla foot to the human hand. The other toes are relatively small and slender, and are connected together by a membrane which extends as far as the base of the second phalanx.[1] Wiedersheim[2] has briefly summed up the characteristic attributes of the human foot as compared with the anthropoid:—

(1) More complete development of the great toe;

(2) Reduction of the length of the toes owing to their having lost the power of prehension;

(3) Fuller development of all the tarsal bones;

(4) Parallel position of the axis of the great toe with respect to those of the other toes;

(5) Greater breadth;

(6) More pronounced arch formation.

That the length of radii is absolutely, and relatively, greater

[1] Ranke, *loc. cit.*, ii., 16. [2] Wiedersheim, *loc. cit.*, p. 95.

in man than in woman must be considered as a sexual character attained in the course of man's progress.

The human foot is perfectly adapted for support, and as such forms one of the most distinctive characters of the human body. But all anatomists unanimously agree that it was not originally an organ of support but of prehension as it still is in the apes. This view is most vigorously upheld by Klaatsch, the Heidelberg naturalist. The human foot is to be traced to the same original form as is that of the other Primates; even the fossil remains of the Tertiary Period show that the mammals already possessed a foot with the Primate character of an opposable great toe. In the opinion of Klaatsch, it is clear that the human foot was originally adapted to semi-erect climbing, and that at a later period when man's progenitors had attained the human state, and lived in scattered groups, the adoption of the erect position necessarily involved an adjustment of the foot to the new conditions. That man's ancestors did undoubtedly possess a prehensile foot is irrefutably proved by embryology. In a human embryo of about one inch in length examined by Wyman[1] the great toe was shorter than the others, and, instead of being parallel with them, projected at an angle from the side of the foot, thus corresponding with the condition of this part in the quadrumana. Hence Darwin concludes that the foot belonging to man's prototype was prehensile, and that our early progenitors without doubt led an arboreal life in some warm, forest-clad land. If they were from the beginning semi-erect, their mode of progression was probably similar to that of the orang, who swings his body forward with bent knees and rests on the outer margin and knuckles of the bent hands.

In conclusion I may quote some comparative tables from Ranke's[2] work, showing the relative lengths of the upper and lower extremities in man and the anthropoids. Taking the stature at 100, the length of the leg is:—

In the gorilla	34·9
,, ,, orang	34·72
,, ,, chimpanzee	35·20
,, man	48·47-48·83

The arm together with the hand is in man shorter, in the

[1] Darwin, *loc. cit.*, vol. v., p. 14. [2] Ranke, *loc. cit.*, vol. ii., p. 7.

anthropoid longer, than the leg. The forearm in man is shorter, in the anthropoid longer, than the tibia. Again taking the stature at 100, the length of the foot is :—

In man	14·5
„ the gorilla	20·4
„ „ chimpanzee	20·5
„ „ orang	25·5

Hence man relatively to his stature has not only a smaller hand but also a smaller foot than the anthropoids.

II. Muscular System.

Before proceeding to the comparison of the muscles of man with those of animals we cannot do better than again quote Gegenbauer's[1] words: "In the physical structure of man there is no justification for assuming a fundamental difference. In the construction of the human body we meet with far more than mere resemblances to the organisation of animals; we find indeed a great and manifold correspondence in all those organs which perform the same functions. This correspondence extends to the most minute structural details. Absolute uniformity of all parts is not to be expected, since it is not found even among closely related animals." Gegenbauer goes on to treat of various characters of the human organism which are either present in a rudimentary state or are entirely absent, and points out that this is not necessarily a loss, since the rudimentary structures are not only made good by compensation but even open the way for new forms possibly of greater value to the organism, thus helping towards its ultimate perfection. Of special interest, viewed from this standpoint, are the conclusions given by Wiedersheim (see below) in his frequently mentioned book on the regressive and progressive muscles of man. The number of muscles proper to man (including those whose several origins bear special names) is:—

In man	316 paired	and 7	single
„ woman	315 „	„ 8	„

As was to be expected, the human muscles, both the striate

[1] Gegenbauer, *Lehrbuch d. Anat. d. Mensch.*, vol. i., p. 33.

and the non-striate, possess histological peculiarities. The striate muscular fibres in man are 20·40 mm. long with an average diameter of ·06 mm.; those of animals have a diameter of ·001-·008 mm.

The non-striate muscles of man are ·045 – ·225 long, ·004 – ·007 wide; of animals, ·002 – ·009 long, ·007 – ·015 wide. It should further be observed that the muscles of certain mammals are not uniformly red, but appear more or less pale in some groups. The pale muscles exhibit distinct transverse striæ but almost indistinct longitudinal striæ, while the red muscles show exactly the opposite conditions (rabbit, guinea-pig). The gradual predominance of the red over the white muscles may be traced from the fishes up to the mammals. Birds may be divided into graminivorous with white muscles and carnivorous with red muscles. Wiedersheim,[1] who has made a special study of the comparative anatomy of the muscles of man and the mammals, divides the human muscles with their extraordinary variability into three main groups:—

(1) Regressive, rudimentary.
(2) Rare, atavistic.
(3) Progressive.

Among the regressive, or rudimentary, the cutaneous muscles must first be mentioned, as in man—and occasionally also in the anthropoids—only enfeebled remnants thereof occur. The cutaneous muscle of the neck has shrunk into one with the platysma myoides, the tendinous galea aponeurotica has been developed at the cost of a part of the musc. occipitalis, and of the musc. epicraneus, the muscle which moves the scalp, only the m. frontalis (the corrugator of the brow) is properly developed (see Fig. 37, *a*). In rare cases the m. epicraneus persists in man together with the power of freely moving the scalp up and down.

Rudimentary also, with rare exceptions, are the muscles which serve to move the external ear, the m. attrahens, m. retrahens and m. attollens auriculæ (see Fig. 38). The smaller intrinsic muscles of the ear have entirely lost the power of voluntary movement.

The fascia axillaris may be considered as a rudiment of

[1] Wiedersheim, *loc. cit.*, p. 125.

the panniculus carnosus of the mammals. According to Langer, the fascia axillaris divides at the outer wall of the axilla into

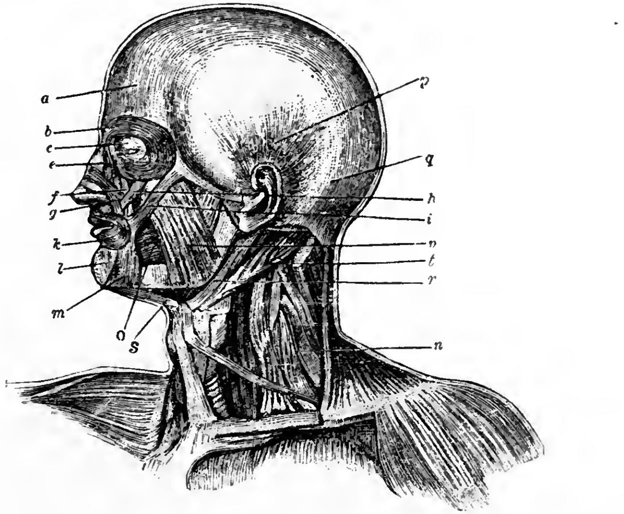


FIG. 37. Muscles of the head and neck. *a*, m. frontalis; *b*, m. sphinct. palpebrarum; *c*, levator palp. sup.; *e*, levator labii super. alaeque nasi; *f*, depressor nasi; *g*, levator labii prop.; *k*, orbicularis oris; *l*, depressor lab. inf.; *m*, depressor oris; *n*, m. mastic.; *o*, buccinator; *p*, m. temporalis; *q*, m. occipitalis; *r*, m. styl. hyoid.; *s*, m. digastricus; *t*, do.; *h*, risorius min.; *i*, risorius maj. (Thomé.)

two branches which unite in the fascia brachialis. They may be considered as together forming a fibrous crescent-shaped arch, concave in the direction of the arm. Langer also met with cases where muscular fasciculi, following a comparatively independent course, crossed the axilla and formed a fleshy, connecting bridge between the edge of the m. latissimus dorsi and the lower surface of the m. pectoralis major.

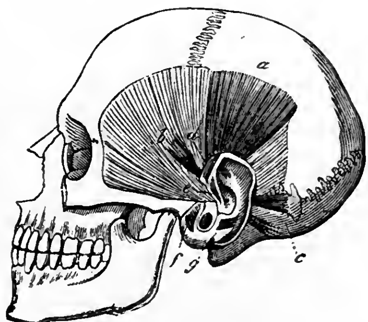


FIG. 38. Rudimentary muscles of the human ear. (Haeckel.) *a*, m. attollens; *b*, m. attrahens; *c*, m. retrahens; *d*, m. helicis maj.; *e*, m. helicis min.; *f*, m. tragicus; *g*, m. antitragicus.

English and French anatomists apply the name fascia axillaris to this anomalous muscle which is but loosely connected with the fascia proper. Hyrtl and others held it to be an aberration of the m. lat. dorsi. Comparative anatomy, however, supplies the explanation. As early as 1867, Turner declared the fascia axillaris to be a rudiment of the panniculus carnosus of the mammals.

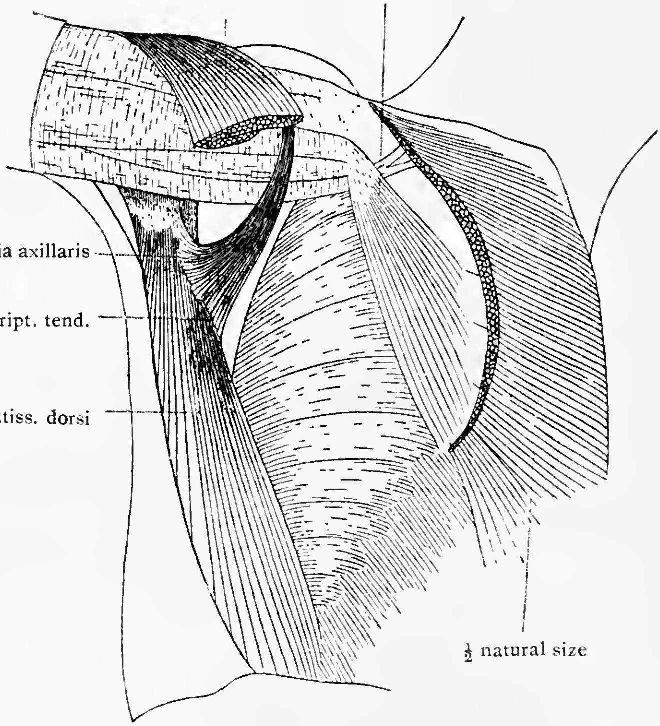


FIG. 39. Muscles of the human axilla (thorax from the side). (Ludwig Tobler, *The Fascia Axillaris of Man.*)

The higher we proceed in the scale of the mammals the more rudimentary do we find the cutaneous muscles. They are highly developed in the monotremata and marsupials, but show signs of retrogression in the lower Primates. Speaking generally, the whole group of the anthropoids has lost the fascia axillaris and indeed every vestige of a cutaneous muscular system. The gorilla, on the other hand, possesses certain points of resemblance to man. Normal structures of certain of the other Primates occur in man as fairly frequent variations (see Fig. 39).

In man, as in the Primates and gorilla, we sometimes find a flat, triangular muscle extending from the m. lat. dorsi through the axilla to the m. pectoralis maj., supplied in the great majority of cases by branches of the plexus brachialis.[1]

Other rudimentary muscles in man and the anthropoids are

FIG. 40. Anterior muscles of the human neck. (Heitzmann-Zuckerkandl.)

the m. palmaris and m. plantaris, and still more regressive are the mm. interossei pedis, which are divided into plantares and dorsales. In certain phases of the embryonic development they are still plantar as they are in the apes and in most of the lower mammals. The change to the dorsal position, as illustrated in man, and to a lesser degree in the orang and inuus, determines the retrograde metamorphosis of these muscles.

[1] Ludwig Tobler, *Inaug. Dissert.*, Leipzig, 1902.

Regressive muscles in the human trunk are the musculi scaleni (see Fig. 40), and the m. triangularis sterni, the m. rectus abdominis (see Fig. 41) and pyramidalis, the vertebral and dorsally situated remnants of those muscles which in the caudate mammals serve to move the tail. Occasionally in man the m. caudo-femoralis is still found, a muscle which plays a great part in many of the caudate mammals. All the remaining caudal muscles of the mammals are to a greater or lesser degree degenerate in man, and the m. levator ani (or diaphragma pelvis) in man, and the anthropoids, must be considered as a remnant of the m. pubo-coccygeus and ileo-coccygeus.

FIG. 41. M. rectus abdominis. (Heitzmann-Zuckerkandl.)

Darwin has drawn attention to numerous muscles of the human arm and hand which show a strong tendency to vary so as to resemble the corresponding muscles in the lower animals. He attributes these variations to reversion (atavism), and in support of his opinion refers to the views of Wood, who considers that notable departures from the ordinary type of the muscular structures run in grooves or directions, which must be taken to indicate some unknown factor, which is of much importance to a comprehensive knowledge of general and scientific anatomy.

Indeed, many a remarkable variation in the human muscles is only to be understood when regarded as a remnant of a former state of existence. Wiedersheim[1] includes among the atavistic muscles the m. cleido-occipitalis between the m. trapezius and sterno-cleido-mastoideus; the m. latissimo-condyloideus, an appendage of the m. latissimus dorsi, very rare in man, but constant in all anthropoids; the m. epitrochleo-anconeus; the levator claviculæ, and the glutæus quartus (ischio-femoralis). Klaatsch regards the short head of the m. biceps femoris as atavistic in the strictest sense of the term (see Fig. 42). In man the long head of this muscle proceeds from the tuber ossis ischii united with the m. semi-tendinosus, but the short head springs from the middle region of the posterior femoral surface, directly from the linea aspera. Now, as this muscle, which is possessed only by man, the anthropoids and the American prehensile-tailed monkeys, had originally no connection with the long head of the m. biceps which is supplied by the nerv. tibialis, but belonged to the glutæi and was innervated by the nervus peroneus, Klaatsch thinks it to be a remnant from the period when the ancestors of the lower mammals more closely resembled the Primates.

According to Professor Eisler of Halle, the short head of the biceps finds its homologue in the other mammals in the m. tenuissimus, a muscle springing from the caudal vertebræ, or from the gluteal fascia and inserted into the fascia at the distal third of the tibia. This muscle is well developed in the carnivora, in certain marsupials, rodents and insectivora, as well as in all the lower apes of the Old World.

To the progressive muscles of man belong most of the facial muscles of mimicry, such as the m. frontalis, and especially those surrounding the eye, and the orifices of the mouth and nose, as well as those placed below the cheekbone, namely, the corrugator supercilii, orbicularis palpebrarum, pyramidalis nasi, levator labii superioris alaeque nasi, levator labii proprius, zygomaticus, triangularis oris quadratus menti and risorius (see Fig. 43).

These muscles are undergoing progressive metamorphosis corresponding to the development of man's cranium, intelligence and powers of speech, though they vary considerably in arrangement, number, and function.

[1] Wiedersheim, *loc. cit.*, p. 126.

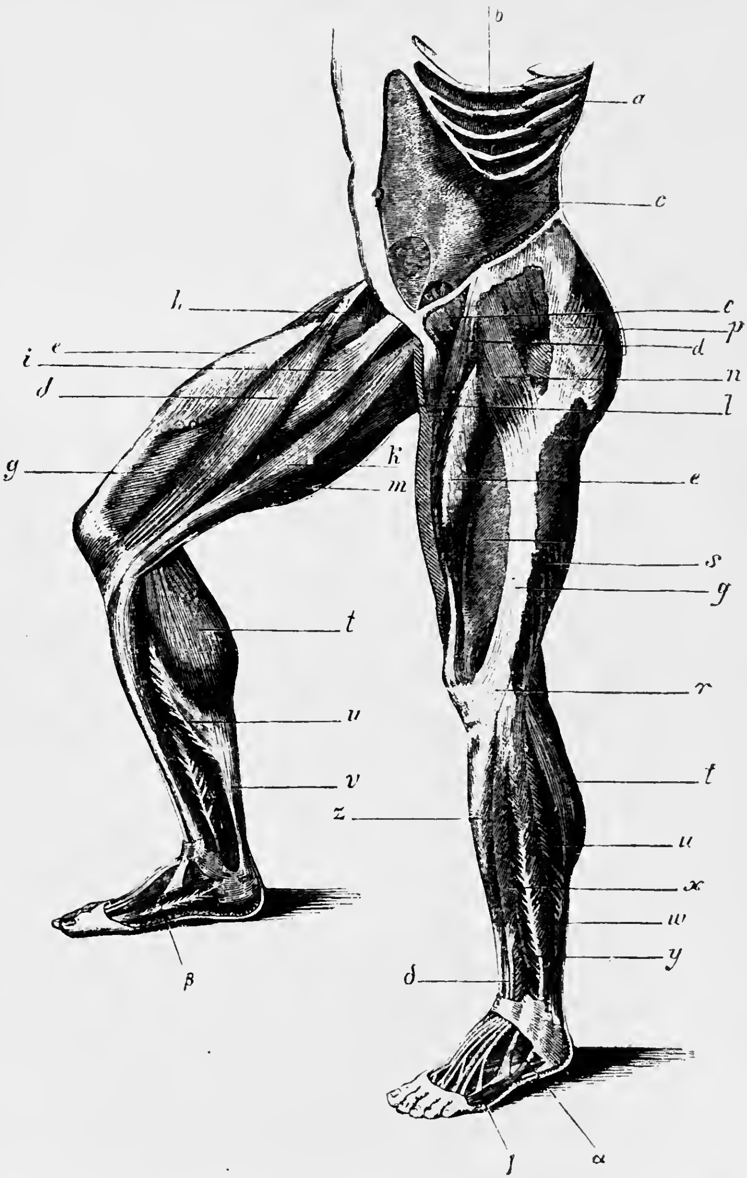


FIG. 42. Muscles of the trunk and lower extremities. (Thomé.) *a*, serratus max.; *b*, m. intercost.; *c*, m. abdom. transv.; *d*, m. sartorius; *e*, m. rectus femoris; *g*, m. quadratus femoris; *h*, m. ossis pub.; *i*, m. adduct. femor. long.; *k*, m. semimembranosus; *l*, adduct. longus; *m*, semi-tendinosus; *n*, tensor femoris; *p*, glutaeus; *q*, *r*, ilio-tibial band; *s*, biceps femor.; *t*, gastrocnemius; *u*, soleus; *v*, Tendo Achillis; *w*, peroneus long.; *x*, ext. long. digit.; *y*, extens. hallucis; *z*, m. tibial. ant.; α, ext. brev. digit.; β, abductor hallucis; δ tendo extens. digit. pedis.

All anthropologists are agreed that man alone possesses the power of giving animated and varied expression to the mouth and eyes, and that he owes this power to the perfection of the above-mentioned muscles. Progressively modified are the muscles of the hand, particularly of the index finger and thumb. The extensor of the index finger, of which the anthropoids have but a mere suggestion (in the gorilla) ranks as the specifically human muscle, *par excellence*, on account of the power of gesticulation it bestows.

The flexor proper of the thumb (m. flexor pollicis long. propr.) is also thoroughly developed in man alone. In most human subjects the two flexors of the fingers (m. flex. dig. comm. subl. and m. flex. digit. comm. prof.) are separated in such a manner that the four tendons of the profundus are inserted through slits in the four tendons of the sublimis. When this is not the case, the conditions are similar to those prevailing in many of the mammals; for instance, in most of the apes (see Figs. 44 and 45).

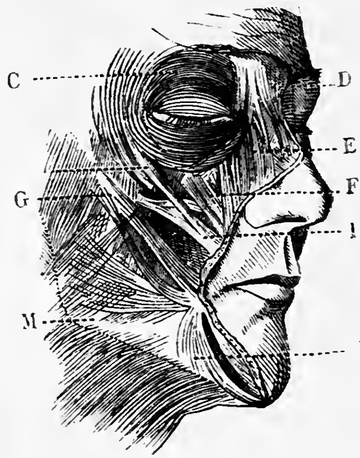


FIG. 43. Facial muscles of mimicry. (Henle.) C, orbicularis palpebrarum; D, pyramidalis nasi; E, levator labii sup.; F, levator labii prop.; G, zygomaticus; I, zygomaticus minor; K, triangularis oris; M, risorius.

The great muscle of the lower extremity in man, the gluteus maximus, so superior to the corresponding muscle in the anthropoids, owes its massive formation and progressive development to its influence on the erect position. The gastrocnemius and soleus with their insertion into the calcaneum exhibit similar distinct human characters.

In conclusion we may mention the flexor of the great toe (m. flex. hallucis long.) as another characteristic acquisition of progressive development (see Figs. 46, 47, 48).

If we compare the gorilla, the highest of the anthropoids, with man we are immediately struck by the formation and development of the muscular system peculiar to the latter. In the face of the gorilla we miss the play of expression peculiar to the human countenance, and it consequently appears dull and lifeless.

The thick muscular neck is clumsy and has but few joints. The pectoralis major is enormously developed as are also the muscles of the whole arm. In man, the upper arm, as well as the fore-arm, tapers finely towards the hand and the muscles of the fore-arm terminate in slender tendons, whereas in the

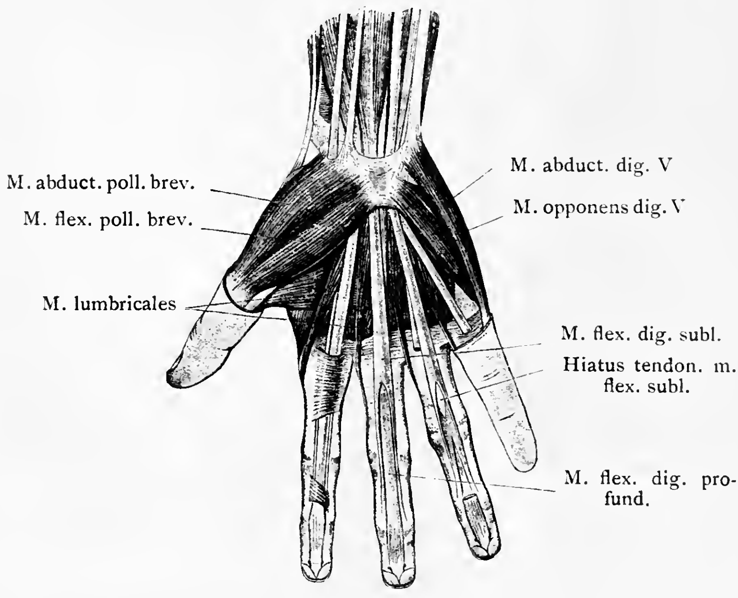


Fig. 44. Muscles of the human thumb and fifth finger. (Heitzmann-Zuckerkandl.)

gorilla the two parts of the arm are almost equal in size throughout their whole length.

The nates, so well-developed in man, and the rounded finely tapering femur, present a strong contrast to the corresponding parts in the gorilla, where the nates are meagre and the adjoining thigh bones are pressed inwards.

In man the lower part of the leg becomes smaller from the rounded calf towards the ankle, whereas in the gorilla the conditions are exactly reversed, the leg being even somewhat larger at the ankle than at the knee, and the muscles are equally fleshy from origin to insertion.

Aeby has tabulated the measurements of the tibial muscles, taking 100 as the unit of measurement and arranging the distinct groups of muscles accordingly. With regard to the

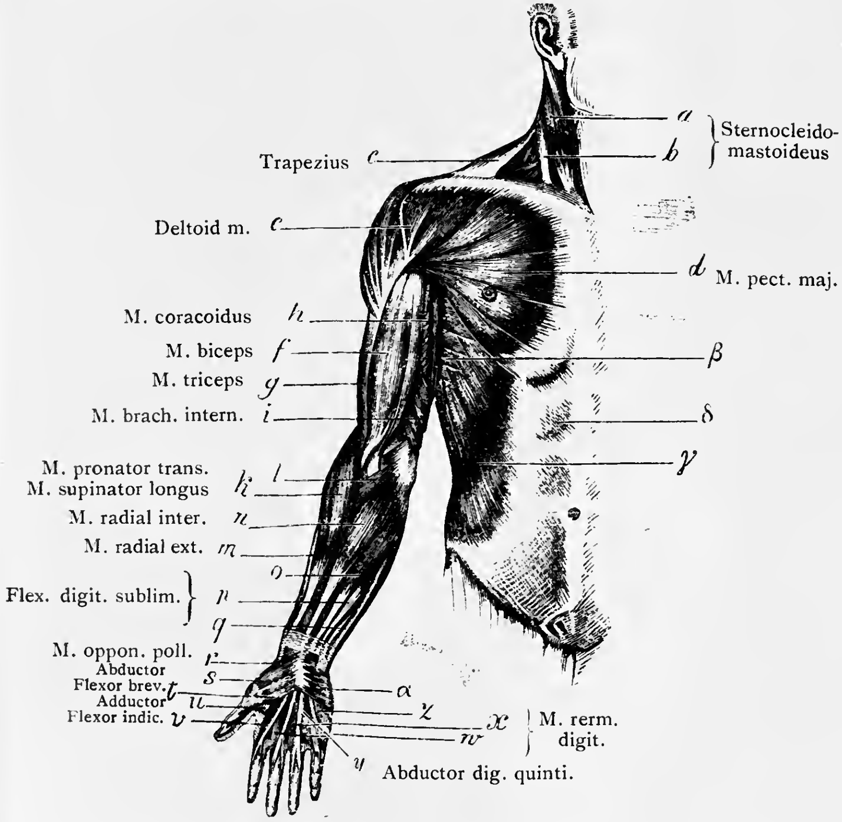


FIG. 45. Muscles of arm and hand, front aspect. (Thomé, *Zoologie*.) α, m. palmaris brev.; β, serratus maj.; γ, m. abdom. obliq. ext.; δ, fibrous sheath of rectus abdom.

gastrocnemius muscle, man shows the highest figures with 57·2 per cent., as opposed to 35 per cent. for the chimpanzee and 27·8 per cent. for the orang; in the pronator muscle of the foot both animals surpass man, but in the supinator, man comes first with 10·4 per cent. against 7·9 per cent. for the orang. With respect to the extensor and flexor muscles of the toes, however, man is considerably inferior with 14·8 per cent. to 31·3 per cent. for the chimpanzee and 49·1 for the orang.

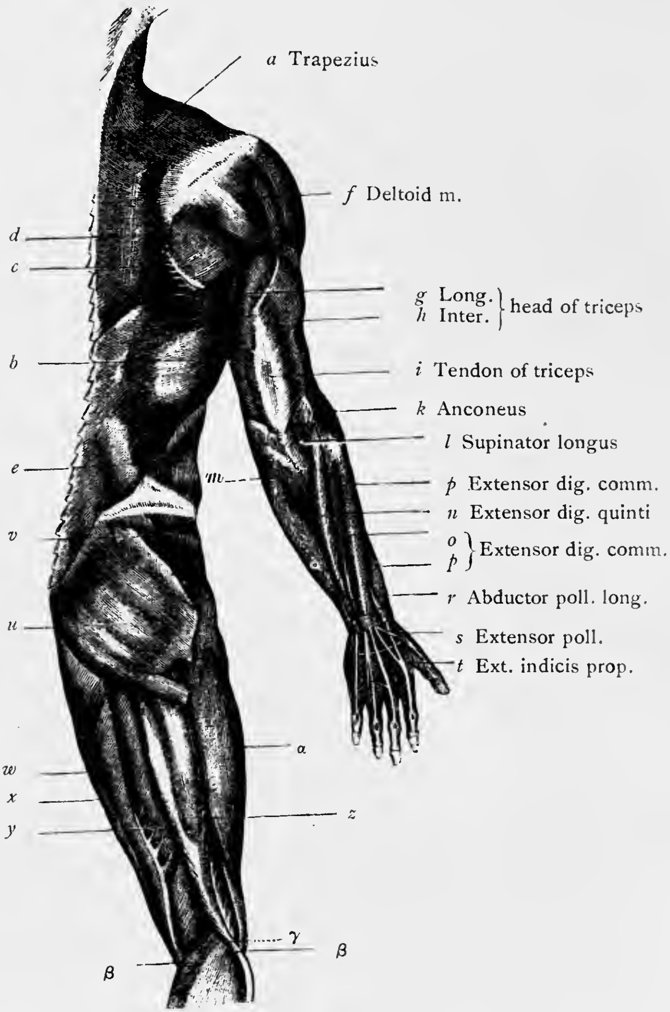


FIG. 46. Muscles of trunk, etc., back aspect. (Thomé, *Zoologie.*) *m*, flexor carpi uln.; *c*, rhomboid; *d*, infra spinatus; *b*, m. latiss. dorsi; *e*, m. abdom. obliq. ext.; *v*, m. glut. med.; *u*, m. glut. max.; *w*, m. semimemb.; *x*, m. crur. ten.; *y*, m. semitendn.; *z*, m. biceps femoris; *α*, m. vastus externus; *β*, gastrocnemius; *γ*, m. popliteus.

Man does not stand at the head of the animal world as regards all parts of his organisation, but what he has lost on one side he has gained on the other, through the improved state of those organs which determine his place in nature as homo sapiens erectus.

On the whole, as R. Hartmann (*Menschenähnliche Affen*) has shown, the muscular system of the anthropoids, in spite of many apparently constant peculiarities, in spite of great manifold variation, does exhibit close resemblances to that of man, even in the face of the conflicting statements of different writers. Notwithstanding their incapacity for an erect gait and their

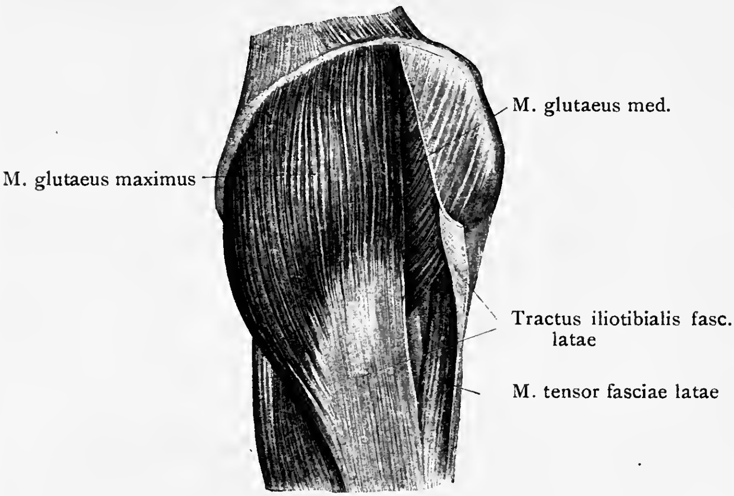


FIG. 47. Posterior muscles of the thigh. (Heitzmann-Zuckerkandl.)

many animal characteristics, the chief feature of these muscles is still their great resemblance to human muscles, although, it need hardly be said, the experienced anatomist immediately distinguishes any anthropoid muscle from its corresponding human muscle.[1]

III. Integumentary System.

The comparison of the skin of man with that of animals forms one of the most interesting chapters in comparative anatomy. A skin composed of three distinct layers (epidermis,

[1] Ranke, *loc. cit.*, i., 450.

basement membrane, and corium) (see Fig. 49), man shares with the other vertebrates, from the fishes to the mammals, but in spite of an extensive general correspondence, on histological examination the human skin presents, nevertheless, certain peculiarities in one direction or another, as well as finer distinctions.

To the ordinary observer the chief distinguishing feature of

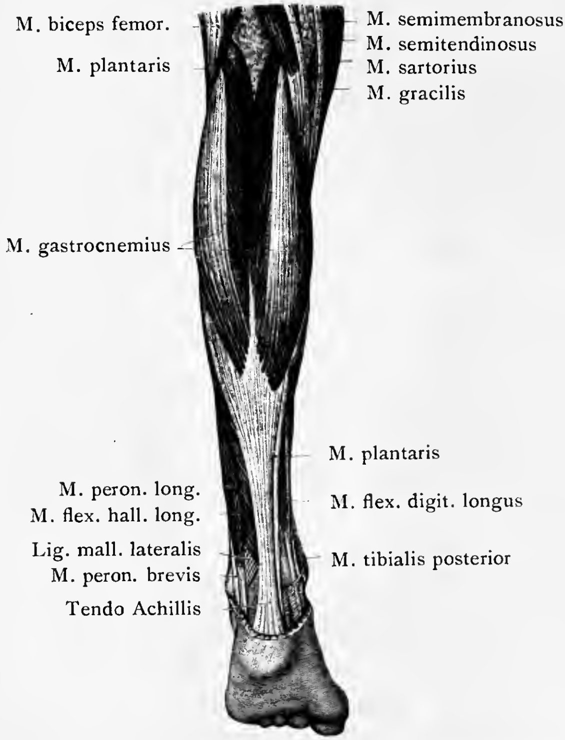


Fig. 48. Muscles of human calf. (Heitzmann-Zuckerkandl.)

man as opposed to most of the mammals (with the exception of the whale, dolphin, dugong, hippopotamus and rhinoceros) is the comparative nakedness of his skin, only the beard, head, pubes and axilla being covered with hair. But this is not strictly true, for on a closer examination of the surface of the body we find that it is everywhere covered with very fine hairs, even in the apparently smooth face of a girl, and these hairs are naturally more noticeable the more the individual inclines towards the brunette type.

This fact justifies our including man among the hairy animals, especially when considered in conjunction with certain phases of his embryonic development. In the seventh month of intra-uterine life, the human fœtus is covered with a coat of fine, downy hair, which, on the authority of Eschricht, is arranged in crests and circles that determine its direction. The hair is then most thickly developed in the region of the ischial tuberosities, while the palms of the hands and the soles of the

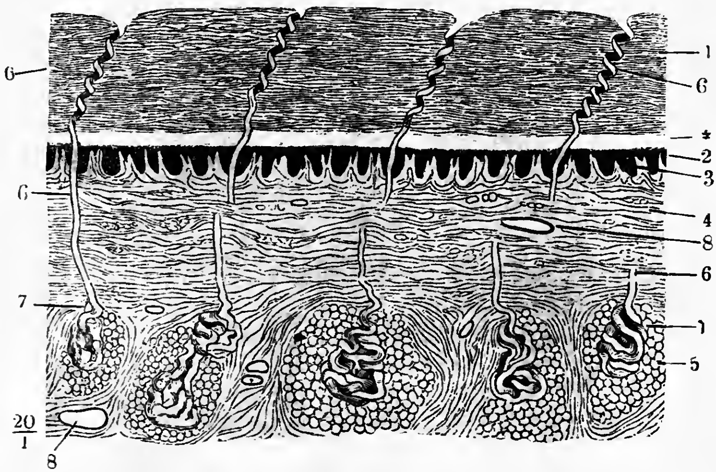


FIG. 49. Section of skin of finger tip. (Magnified twenty times). (Thomé, *Zoologie.*) 1, Epidermis; *, Lowest layer of same; 2, Basement membrane; 3, Papillæ; 4, Corium; 5, Adipose membrane; 6-6 Sweat ducts (pores of the skin); 7, Sweat glands; 8, Section of a vein.

feet, the red part of the lips and the glans penis and clitoridis are quite bare.

This first coat of hair eventually disappears, and makes way for a new permanent one acquired during the first few years of life, the hairs of which gradually increase in size and become deeper in colour. Thus arises, besides the pale-coloured downy hairs, the darker hair of the head, eyebrows and eyelashes. On the approach of puberty the axillary hair and pubes are developed, these being peculiar to man and possessed by no other mammal, and as full maturity is reached the growth of hair increases on the chest, back and extremities in the male sex; this latter peculiarity may be considered as a secondary sexual character like the long hair of the head in the female sex. Darwin[1] infers from the lanugo of the human fœtus, and the rudimentary hairs scattered over the entire body during maturity, that the progenitors of man were completely covered with hair and that its gradual loss was probably due to sexual selection, the character of nudity being first acquired by the female sex and transmitted equally to both sexes; Darwin concludes that man first became divested of hair in the ab-

Fig. 50. Transverse sections of hair (magn.). (Waldeyer.) I. *Hair of the head: a-c*, of a brunette Jew; *d-k*, of brunette and blonde Germans; *l-n*, of a Negro; *o-q*, of a Japanese. II. *Hair of the beard: r-v*, of brunette and blonde Germans; *w-z*, of a brunette Jew.

dominal region, since the young chimpanzee is almost hairless on the under surface of the body.

A variety of reasons might be assigned for the loss of the hairy covering, but to whatever cause it was actually due, the process must have taken place in a warm climate. Klaatsch suggests that it might also have been encouraged, or hindered, by food as well as by climatic conditions. Sexual selection may have played a part through the persistent eradication of the hair from certain parts of the body (in the face of the woman,

[1] Darwin, *loc. cit.*, vi., 354.

for instance) and inheritance of the tendency. Isolated cases are recorded where, by a curious persistence of embryonic conditions, certain parts of the body retain an abnormal covering of hair throughout life. Such are those human beings with tufts of hair in the inguinal region and the so-called hairy men or "poodle-men," whose faces are completely clothed with hair, resembling the faces of poodles (see Figs. 51 and 52). Formerly, no satisfactory explanation of this condition could be offered, and still less of the correlated abnormal condition of the teeth which resemble those of the edentata. But since the influence of the N. trigeminus on the development of the hair on the face and of the teeth has been made the sub-

Fig. 51. Russian hairy man. (Ranke, *Der Mensch.*)

Fig. 52. Julia Pastrana. (Haeckel, *Anthropol.*)

ject of special study, we are inclined to attribute such phenomena to a disturbance of the N. trigeminus during fœtal development. It is a striking fact, however, that the strange condition is strongly inherited. Hence the explanation of atavism is involuntarily suggested to our minds, together with Darwin's conclusion that the ape-like ancestors of man must have been completely covered with hair, and that both sexes possessed a beard.

The hair on the forearm is in man, as in the anthropoids and most of the mammals, directed upwards towards the elbow (Schwalbe).

Man is distinguished from the anthropoids by the arrangement of the hair on the head. In man the hair is arranged circularly, radiating generally from one crown but sometimes from two, corresponding to the two parietal eminences. The hair on the scalp grows only as far as the beginning of the forehead which itself remains smooth and naked, whereas in the anthropoids the hair grows down to the superciliary ridges. A correspondence with human conditions is shown by the anthropoids in the fact that on reaching maturity a beard and whiskers are developed (see Fig. 53); the anthropoids, however, rarely possess a moustache, only the Cercopithecus cephus having a moustache as well as whiskers. In most of the apes,

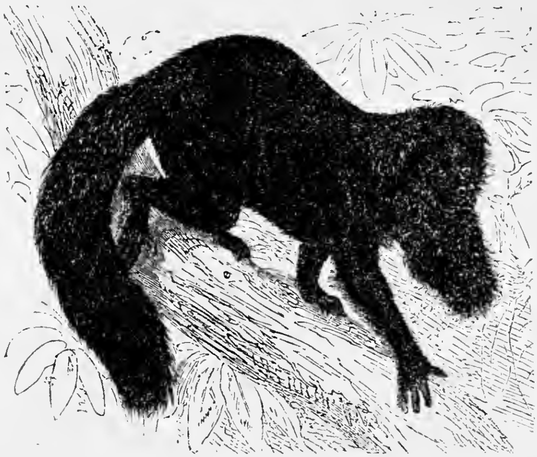


FIG. 53. Pithecia satanas. (Brehm, *Tierleben.*)

the distribution of hair in and about the face is the same in both sexes; in some, as for instance, in the black howler monkey and certain species of macacus, the male has a somewhat better developed beard than the female.

In no animal is the sexual difference in the hairiness of the body so marked as in man. Man's beard generally ranks as a secondary sexual character. From the fact that certain tribes (Hottentots, Nigritos, aborigines of America, Malays, Mongolians) are beardless, or at least have not *yet* attained to the possession of a beard, Alexander Brandt infers that the beard is to be considered as a progressive sexual character, but it is open to doubt whether perhaps exactly the opposite is not the case, whether the sexual character has not been gradually lost in consequence of the hair having been persistently removed for ornamental purposes, in accordance with a certain standard of beauty. Among the aborigines of America, the custom of carefully eradicating every hair from the face is well known to be practised, and the same custom probably prevails among the other tribes quoted above, thus causing gradual atrophy of the hair papillæ. Assuming Darwin to be correct in his view that both sexes of the anthropoid ancestors of man possessed a beard, it is to be inferred that the transmission of this character to the male sex alone, as is the case among the higher races, has been brought about by sexual selection, and that the absence of a beard in the above-mentioned lower races is to be regarded as a regressive phenomenon, though equally the result of sexual selection.

It was formerly asserted that eyebrows were not present in any of the monkeys. It has been shown, however, by R. Hartmann that tufts of hairs are to be found in the apes in the region of the middle section of the arcus supraorbitalis similar to those in the other mammals (beasts of prey, ruminants, etc.).

Yet another character possessed by man in common with the other mammals is the arrangement of the hair in groups of two, three, or five hairs together. In the fœtus this is invariably the case,[1] and Wiedersheim[2] has found that it is frequently retained to adult age, each single hair on the head being accompanied by one to three fine short hairs, analogous to the group of hairs in an animal. Hence we find[3] that from each follicle spring several hairs, which are either similar or dissimilar as a complex follicle produces one thick hair together with a number of fine wool-like hairs, but there is no justification for the view that this arrangement of the hair on the head is exclusively characteristic of man.

The so-called woolly hair of the negro in no way resembles the wool of the sheep. Sheep's wool consists of close tufts of fine, wavy hair; the hair of the negro is also curly and arranged

[1] Kölliker, *Handbuch d. Gewebelehre d. Menschen*, 1859, p. 120.

[2] Wiedersheim, *loc. cit.*, p. 8.

[3] C. Gegenbauer, *Grundzüge der vergl. Anat.*, 1873, p. 88.

in tufts, but the tufts consist of coarse, matted hair, spirally curled.

A further distinction between man and the animals is the absence of sinus hairs in man. In the lower animals these hairs occur in the neighbourhood of the nostrils, on the lips and throat, above the eyebrows and on the cheeks, and are distinguished by having large, ant-egg-like follicles penetrating to the subcutis (see Fig. 54). Owing to the fact that the nature of the pith of the hair is invariably characteristic of a species, it is possible to distinguish between the hair of different animals and between that of animals and man. In a human hair the proportion of medullary substance to the whole hair is as 1 : 3-5 (see Fig. 50).

The structure of the nails, both finger and toe nails, must not be ignored as it forms a distinctive character of man, especially as opposed to the apes. Among the semi-apes, which, it is true, stand nearer the rodents and insectivora, the thumb is furnished with a broad, flat nail, while the nail of the index finger forms a claw, resembling an awl in shape, and sometimes the other fingers are also provided with claws. The New World monkeys are similarly provided, the thumbs of all four hands being furnished with flat nails and the other fingers with sharp claws. With the exception of the gibbon, which has a broad flat nail on the thumb and great toe, all the New World platyrrhines, as well as the Old World catarrhines, possess curved, claw-like nails on all the fingers without exception. Careful observation shows us, however, that also in man the nail of the little finger at least is more arched than the rest.

Fig. 54. Sinus hairs of the Norway rat. (Thomé, *Zoologie*.)

Various other structures exist in the human body closely resembling those of the lower animals;[1] among others may be

[1] Since the completion of the present work an interesting treatise has appeared: *Zur Morphologie und Anatomie der Halsanhänge beim Menschen und bei den Ungulaten*, by K. Fröhner, Stuttgart, 1907. With 72 illustrations and 11 plates.

mentioned the "swimming membrane," that web or skin extending between the fingers and linking them together. As we have seen above, in the hand of the gorilla the fingers are webbed as far as the middle of the first phalanx, and between the third and fourth fingers the skin extends almost to the second phalanx; similarly in the chimpanzee all the fingers with the exception of the thumb are connected by a membrane extending to the joints between the first and second phalanx. Cases of excessive growth of this membrane in man are very rare. The normal web-like skin between the fingers can best be observed by viewing the back of the hand with extended fingers.

Grüning has measured the extent of the membrane between the fingers, and found, in the case of the index finger, the length of the free finger to be 6 mm. less than that of the entire finger, and the second finger at the second division 21 mm.; in most cases the third finger proved to be on an average 4 mm.[1] longer at the second division than at the third.

The pigmentation of the skin cannot rank as a distinctive character of man in contrast to the lower animals, particularly to the mammals, for the same brown colouring matter, differing quantitatively, is found in the rete Malpighi, and in the uvea and posterior surface of the iris in all mammals, and among all the peoples of the earth. By far the greater number of human beings are brunette, or darker. Red-haired people and red-skinned, or copper-coloured, races have a special deposit of red pigment in the hair and in the rete Malpighi. The Albinos, human and animal, are the only instances of complete absence of pigment; this peculiarity is frequently inherited. The members of the so-called white races possess in reality, under the epidermis, a supply of darker, or lighter brown pigment which appears, varying in intensity, in certain parts of the body (axillæ, genitals, plica ani).

Klaatsch assumes the colouring of the oldest races to have been intermediate between the present extremes, and proceeds to discuss the probable causes which may have led to the decrease of pigment in the white races, and thinks it to have been frequently brought about by the same agencies. The

[1] Ranke, *loc. cit.*, ii., p. 53.

influence of the sun cannot have been the sole cause of the difference in colouring; still less can we regard the paleness as due to a deficiency of light, for the aboriginal race of the Eskimos is dark, in spite of living for several consecutive months of the year in snow-huts. Klaatsch therefore suggests other factors: on the one hand, food; on the other, the immunity against certain poisons and infections imparted to the body by a particular colouring of the skin. This character, acquired by natural and sexual selection, was first theoretically assumed, but later abundantly confirmed by observations made in the tropics.

One of the most interesting discoveries of modern times is that of the blue Mongolian spots in European children. These spots are dark blue in colour and were first found imbedded in the corium of the inguinal region in Eskimo children of West Greenland, and later on in other Mongolian children; B. Adachi and K. Fujisawa[1] have now found them to be present in European children also.

Adachi has devoted special study to the pigment in man and gives his results as follows:—

In Europeans the pigment of the epidermis is generally limited to the rete Malpighi and is deposited in and between the cells in the form of peculiar pigmentary structures consisting of a thick body with branches (Adachi's *Chromatophores*). Circular, spindle or star-shaped cells are rarely observed in the upper layers of the corium, and never occur in the epidermis. Those large pigment cells which cause the Mongolian spots and colour the skin even of adult Europeans are situated deep in the corium. The only difference is that Mongolian children possess more numerous and more strongly coloured pigment cells in the lower layers of the corium, than do European children.

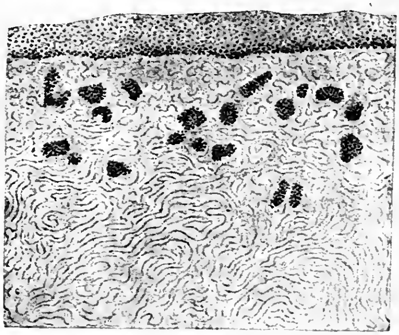


FIG. 55. Inguinal skin of a European woman, blonde, thirty-eight years. (Adachi.)

[1] *Zeitschrift f. Morphologie und Anthropol.*, vol. vi., p. 132.

Hence, pigment is present in the skin, both in basement membrane and corium, of men of all races although certain differences are perceptible. The distribution of pigment in the skin differs locally. Generally speaking, the trunk is of a deeper colour than the extremities, and, as in the animals, there is a greater accumulation of pigment in the back, especially at the nape of the neck and in the lumbar region than in the chest and abdomen. The part of the body possessing least pigment are the palms of the hands and the soles of the feet, and this is also the case among the coloured races.

The presence of an accumulation of pigment cells in the corium, giving rise to the Mongolian spots, constitutes no essential point of difference between man and the apes, for they are found in many though not in all apes, but the cells are not confined to the inguinal region.

The one great distinction of colouring between man and the anthropoids is that of the lips. Among the lower apes the lips are usually brownish black, and even in the gorilla they are of the same dark, blackish colour, with a somewhat polished surface, as the rest of the face. In the chimpanzee the edge of the lower lip is of a dirty flesh-colour, and in the orang a narrow edge of the inner mucous membrane of the mouth is visible. No ape nor any other mammal possesses the red edge of the upper and lower lip which is so eminently characteristic of man. The red colouring of the lips is due to a greater supply of blood in that part and to a certain transparency of the epithelium, this condition being possibly caused by a deposit of eleidin in the epidermis, as in the nails. In the negro the transition zone between the skin and the mucous membrane is much more extensive than in the European and has the same colouring as the skin, being very rich in pigment.[1]

Another distinctive human character is the bosom, formed by the development of cushions of fat in the neighbourhood of the mammary glands (see Fig. 56), and the human female alone has a nipple surrounded by an areola. In order to trace the gradual evolution of the mammary glands in the mammals we must go back to the lowest members of the class, namely, the

[1] A. Oppel, *Lehrbuch der vergleich. mikrosk. Anat. d. Wirbeltiere.* Jena, G. Fischer, 1900, part 3, p. 52.

Monotremata. They possess proper milk-secreting glands with orifices but no nipples, these being first found in the marsupials. Now, on the authority of Kölliker and Langer, the mammary glands are developed in the human embryo before the mammæ; hence Darwin[1] concludes that the fundamental form from which man arose had mammary glands but no nipples. Wiedersheim[2] goes still farther, and points out that the double breasts, possessed by man in common with the elephants, sirenia, edentata, bats, beavers, apes and certain semi-apes, have been gradually acquired in the course of his history. That man's early ancestors were furnished with more than one pair of mammæ is proved not only by the frequent occurrence of supernumerary mammæ in men and women, which are generally regarded as cases of reversion,[3] but far more conclusively on ontogenetic grounds, the investigations of H. Schmidt, E. Kallius and H. Strahl having revealed the fact that the bilateral ventral lactatory line (Milchlinie) plainly visible in the embryos of other mammals is also to be seen in the human embryo of 15 mm. long, only here it is not quite so strictly bilateral and symmetrical. In an embryo of this size, besides the mammary glands proper, which are visible to the naked eye, eight smaller modifications of the epithelium may be seen on either side. The investigations of E. Bresslau[4] are also of great interest. Bresslau traces the above-mentioned line to the marsupial pouch, which in its turn is derived from the mammary sacs of the Monotremata, those small bag-like depressions in the epidermis each of which encloses a nipple.

FIG. 56. Trunk of a girl of Vista. (Hartmann.)

[1] Darwin, *loc. cit.*, v., p. 212. [2] Wiedersheim, *loc. cit.*, p. 23.

[3] Bonnet, "Die Mamma-Organe im Lichte der Ontogenie und Phylogenie," *Anat. Ergebnisse*, 1892, pp. 604-58.

[4] Wiedersheim, *loc. cit.*, p. 25.

Since on the authority of Bresslau this line has been brought about by a coalescence of the marsupial sacs, Klaatsch is justified in defining it as a marsupial character.

Characteristic of many of the lower animals (ruminants, pigs, carnivora), and entirely absent in man and the apes, are the serous cutaneous glands which secrete a watery fluid and thus keep the outer terminal part of the nose in a moist state.

The anal sac in the carnivora and the inguinal fold in sheep, with their tubulous and aciniform glands, correspond to the axillary and perineal glands in man, in so far as they emit a secretion with an offensive odour, and first become functionally active in the adult, thus standing, apparently, in close relation with the reproductive functions.

IV. Vascular System.

In common with the other vertebrates man possesses a complete system of closed canals, or vessels (see Fig. 57), containing the nutritious juices of the body, while in the invertebrates, with the exception of the higher worms and some members of the arthropoda, this system is absent. Another leading distinction between the vertebrates and invertebrates is the situation of the heart; in the latter it is formed from a dorsal vascular trunk, or part of such, whereas in the former the heart is developed from a section of a ventral vascular trunk. The tunicata are the only invertebrates possessing a ventrally placed heart. Moreover, the vertebrata did not attain to the possession of a heart simultaneously with that of a vertebral column, for in the headless amphioxus, which stands at the very base of the class, all the greater vascular trunks are contractile, and the circulation of the blood is carried on from several points and not confined to any special one. In the Craniata, on the other hand, the heart forms a distinct organ for regulating the flow of the nutritious fluid in the blood and lymph vessels.

The heart of the Craniata has been developed from a simple tube which became gradually divided into two parts: a posterior part, the auricle, and an anterior, the ventricle, both being enveloped in the pericardium which invests the whole.

In the fishes there is still only one auricle and ventricle, but in the double-breathing animals, a muscular partition divides the auricle into two parts, a right and a left auricle. In the reptiles we find not only the auricle but also the ventricle thus divided, and in the crocodile the two parts are quite separate. In birds the division, both in the heart and in the larger arteries, is so complete that arterial blood nowhere mingles with venous blood. The auricles of the mammals have been formed through retrograde development of the anterior auricular division, and in the interior of the heart, in the higher mammals, the muscular trabeculæ lie closer to the wall of the chamber and there form the so-called papillary muscles with their tendinous endings attached to the membranous valves. In reptiles and birds, the aortic arch is on the right, but in all mammals and in man, on the left. The carotis interna is more important than the externa, the latter taking the form of a mere branch of the carotid artery, mainly for carrying on the work of circulation in the tongue and the region of the lower jaw. In man and the apes the vessel called the carotis externa may be said to form a trunk with numerous branches proceeding from the carotis communis.

The distribution of the upper arteries differs, in some respects, in man and certain of the apes and semi-apes, and, in other respects again, there is a distinction between man and certain other of the apes and semi-apes. A truncus brachiocephalicus dexter, a carotis sinistra and subclavia sinistra are special characteristics of man, the anthropoids, a few Prosimiæ (*e.g.*, Aye-aye), the seal, many rodents, certain of the edentata (Bradypus and Dasypus), the hedgehog, some of the marsupials (Phascolomys) and the monotremata. On the other hand, a truncus brachiocephalicus dexter and a subclavia sinistra with separate origin of the two carotids from the truncus brachiocephalicus is present in certain apes, (*e.g.*, Macacus) and in many of the prosimiæ (Loris, Galago), as also in many of the carnivora and rodents, in pig, pangolins and muskdeer.[1] The arteria saphena which man originally possessed has disappeared during the course of his history owing to the erect position and the consequent expansion of the vessels (Popowsky), and has been replaced by the larger arteria peronea and arteria glutæa

[1] C. Gegenbauer, *Vergl. Anat.*, 2nd edition, 1870, p. 843.

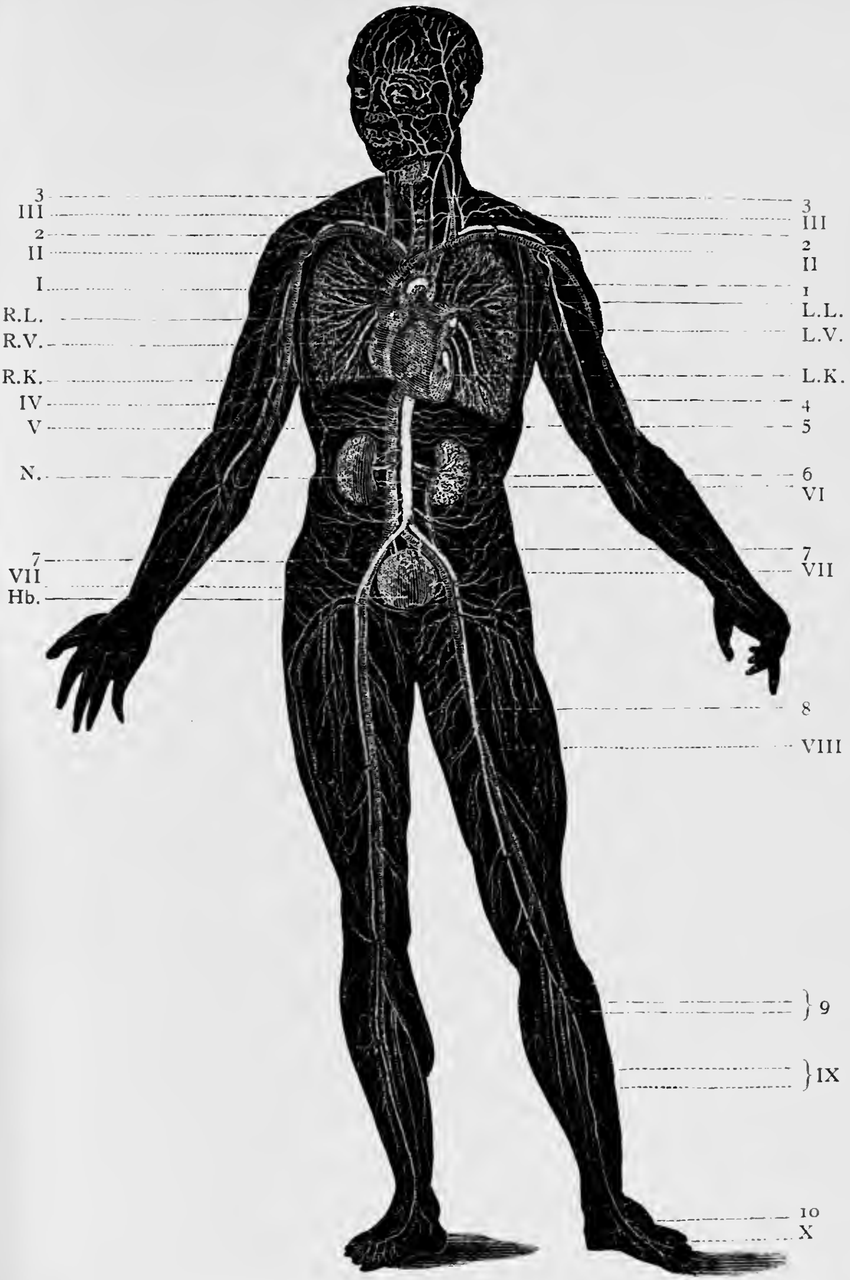


FIG. 57. Circulatory System of Man. (Thomé, *Zoologie.*) Veins of the left half of the heart, white; those of the right half, shaded. L.V., left auricle; R.V., right auricle: L.K., left ventricle; R.K., right ventricle; L.L., left lung; R.L., right lung; N., kidney; Hb., bladder; 1, aortic arch; 2, innom. and subclavian arteries; 3, carotid arteries; 4, brachial arteries; 5, descending aorta; 6, renal arteries; 7, femoral arteries; 8, crural arteries; 9, tibial arteries; 10, arteries of the foot; I., vena cava superior; II., clavic veins; III., jugular vein; IV., brachial veins; V., vena cava inf.; VI., renal veins; VII., femoral veins; VIII., crural veins; IX., tibial veins; X., veins of the foot.

inferior.[1] In the gorilla an artery branches off from the arteria femoralis high up in the thigh and extends to the back of the foot.

A further peculiarity of man is the coccygeal gland situated at the lower extremity of the coccyx. This gland was recognised by its discoverer, Luschka, as a rudimentary organ and is now known to represent an arterial plexus (rete mirabile) formed at the extremity of the arteria sacralis, the rudiment of a caudal plexus such as is found in the caudate mammals. Considerable light has been thrown upon the gradual development of the human venous system by tracing its history up through the progressive stages of the vertebrates. The fishes have four longitudinal venous trunks, two anterior (jugular) and two posterior (cardinal). These four longitudinal trunks occur also in the amphibians and reptiles, but only during the earliest embryonic periods. Further, in the birds two jugular veins, frequently unequal in size, are present for the anterior parts of the body, but, as in the reptiles, these jugular veins unite with the subclavian veins and thus form the vena cava superior. In mammals the conditions were originally very similar, for they apparently also possess the two jugular and cardinal veins, though in man, the apes, the carnivora and cetaceans, owing to a reduction of the trunk of the vena cava superior sinistra, the vena cava superior dextra has become the sole venous blood-vessel for the anterior upper part of the body.

In man and the apes the vena jugularis interna forms the main artery for conducting the blood from the interior of the skull, a peculiarity distinguishing the Primates from all other mammals, their main artery being the vena jugularis externa. The formation of the vena cava inferior must be traced in the same manner before we can decide what is possessed by man in common with the lower animals and what distinguishes him from them. First in the amphibians do the veins of the posterior parts of the body unite in a vena cava inferior and receive the hepatic veins. Proceeding to the reptiles we find renal and hepatic veins forming the trunk of a vena cava inferior, with which are connected the veins of the vertebral column and of

[1] Wiedersheim, *loc. cit.*, p. 204.

the posterior extremities. To these are added the venæ abdominales, which originate in an embryonic venous apparatus, and the veins belonging to the portal system.

The same fundamental principle is seen in the two highest classes of the vertebrates. In the birds the vena cava inferior is constructed of two venæ renales which receive the veins from the posterior limbs. Besides those branch veins which take their rise in the kidneys two venæ hypogastricæ perform the office of collecting up the blood. Similarly in mammals a vena cava very early makes its appearance and receives the blood from the kidneys and germinal glands, and later on from the left umbilical vein. Into the lower end of the vena cava flow the pelvic veins and those of the lower extremities. That portion of the vena omphalo-mesenterica which receives the mesenteric veins forms the trunk of the portal vein for the veins of the spleen and intestinal canal. No modification of this system is found in man as compared with the apes and most of the mammals. The only exceptions are the diving mammals (duckbill, weaver, otter, seal, dolphin, etc.), in which the trunk end of the vena cava inferior is considerably enlarged in order to serve as reservoir for the venous blood and thus prevent undue pressure on the heart.[1]

In discussing the circulatory system, the spleen must be mentioned as one of the organs for the production of lymph cells, which, in the spleen, are conveyed direct to the blood-vessels (see Fig. 58). Throughout the whole class of mammals, with the exception of the Primates, the spleen consists of three lobes (lobus anterior, medius and posterior). In the Primates the lobus posterior has almost disappeared, and in man has been reduced to the protuberance of the margo obtusus. In the gorilla and chimpanzee, the spleen is placed somewhat higher than in the orang, where it is broad and similar to man's in shape. The splenic follicles in man measure 0·35 mm.; in the domestic mammals they are almost of the size of a pin's head. The figures are as follows:—

In the horse . . .	0·5 – 0·6 mm.
„ cattle . . .	1 „

[1] Wiedersheim, *loc. cit.*, p. 204.

In the pig	. . .	0·6 mm.
„ „ dog	. . .	0·44 „ [1]

The lymph cells of man (see Figs. 59 and 60) possess no distinctive characters. They correspond on the whole to those of all the vertebrates, and indeed to the blood corpuscles of many of the invertebrates. On the other hand, the red blood corpuscles in man, formed by a metamorphosis of lymph corpuscles and white blood corpuscles, are characteristic both in form and size. All birds, reptiles, amphibians and fishes possess oblong, elliptical, nucleated, red blood corpuscles; the camel, llama, alpaca and other members of the same group, as well as the lamprey group of fishes, have oblong, elliptical, non-nucleated blood-cells. The rest of the mammals (with the exception of the camel, llama, etc.) have circular, bi-concave red blood corpuscles, a nucleus being present only during the embryonic period, and disappearing at a later stage of development (see Fig. 61). The red blood-cells of man may be easily distinguished, with the aid of the microscope, from those of other mammals.

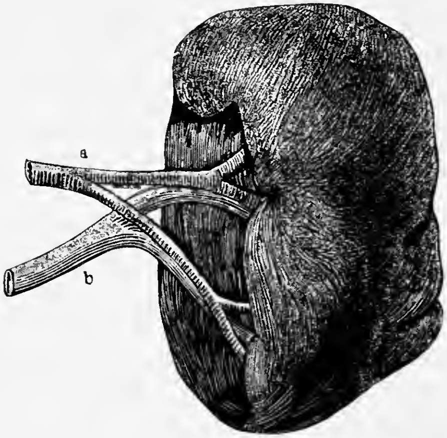


FIG. 58. Human spleen. (Ranke, *Der Mensch.*) *a* artery, *b* vein.

For instance, the blood corpuscles

of the goat	measure	0·0041	mm.
„ „ sheep	„	0·0050	„
„ „ cat	„	0·0065	„
„ „ rabbit	„	0·0069	„
„ „ dog	„	0·0073	„
„ man	„	0·0077	„

[1] M. Sussdorf in W. Ellenberger, *Handbuch der vergl. Histol. u. Physiol. der Haussäugetiere*, 1887-92, p. 491.

V. Respiratory System.

For the maintenance of life, the animal organism requires not only that the tissues be constantly saturated with nutritious juice, but also that the gases suspended in cells and tissues be constantly renewed. The organs which perform this function have all been formed on one and the same plan and gradually perfected by progressive development. The fundamental principle of the exchange of gases may be traced from the protozoa up to man. Broadly speaking, there is no great difference between the lowest and highest creature; the method of modification may be seen by studying the details.

Among the lowest forms of protozoa the entire surface of the body performs the office of absorbing and discharging

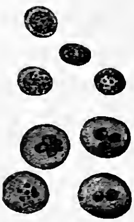


FIG. 59. Lymph cells.

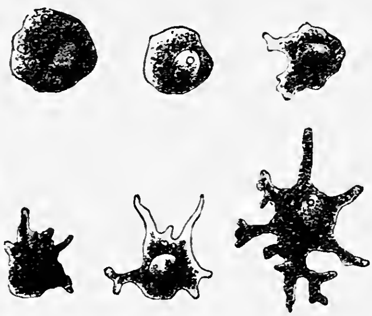


FIG. 60. White blood corpuscles, mobile and immobile. (Ranke.)

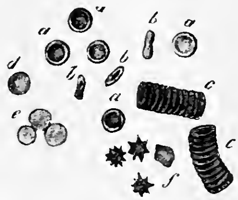


FIG. 61. Red corpuscles of human blood. *a*, whole surface; *b*, seen edgewise; *c*, arranged like piles of coins; *d*, rendered globular by water; *e*, deprived of colour; *f*, coagulated. (Kölliker, *Gewebelehre*.)

gases, but the amœba, and still more the infusoria, possess contractile vesicles filled with fluid matter, and these may safely be assumed to be organs specially designed for the exchange of gases. The cœlenterata have progressed further and possess a system of vesicles which pass through the body and are filled with a compound of chyme and water, being apparently designed for respiration as well as for alimentation.

Proceeding to the higher classes of animals we find rudimentary breathing organs. The lower worms, it is true, do not possess such, the function of respiration being performed by the integument and by means of the water which penetrates into the abdominal cavity. But the tentacles of the Bryozoa undoubtedly serve as breathing organs, and the branchiæ of the annelida and the lamelliform extension of the integument of the hirudinea must be unhesitatingly recognised as special organs of respiration.

So far, all these breathing organs have been purely external. Internal organs of the nature of gills are first found in the enteropneusta, and the tunicata possess an internal breathing pouch, forming in its highest stage of development a distinct apparatus attached to a special part of the pouch. In the echinodermata respiration is carried on inside the ciliated cavity of the body by means of a system of water vessels; similarly in the Asteroidea, but with the modification that cæcal tubes open radially from the alimentary canal, and, in the holothurians, in the form of ramifying, tree-like organs. In each case the organs are designed to facilitate the exchange of gases by protrusion of the abdominal cavity, whereby water may be poured over the external as well as the internal surface.

Remarkable conditions prevail among the arthropoda: in some members of the class (crustaceans) parts of the integument have been transformed into gills attached to the feet, some are provided with a gill-cavity closed from the side or, again, with a mantle which acts as a breathing organ unconnected with the limbs; others, such as the arachnida, myriapoda and insects, possess a system of ramifying tracheal tubes which either open outwardly at certain points and thus imbibe air, or, as is the case among the larvæ of many water-insects, the tubes are externally closed. The molluscs are also furnished with gills, whether in the form of a respiratory mantle or, as in the brachiopoda, respiratory arms, in both cases combined with the development of abundant cilia. Other cases are known where the breathing cavity has arisen from the fact of the gills being imbedded in the mantle, and, finally, in the air-breathing pulmonata, the cavity, or a separated part of the same, takes the form of a lung.

Common to all the vertebrates is the possession of breathing organs which originated in the wall of the intestinal tube and are connected therewith. Here, too, a gradual development may be traced from lower to higher forms. At the very base of the scale stands the method of breathing by gills, founded on the presence of a number of branchial arches which form parts of the visceral skeleton and are furnished with branchial lamellæ. The gradual reduction of the number of branchial arches goes hand in hand with a higher development of the actual branchiæ. The presence of a swimming bladder formed from an expansion of the primitive intestinal wall is introductory to the respiration of air and, in the dipnoi, has been transformed into a lung.

From the amphibians upwards we find pulmonary breathing steadily developing as the sole method of respiration, and conformably thereto arises a special membranous cartilaginous system of air-passages, including an apparatus for the production of the voice. The special muscles which serve to set in motion the laryngeal cartilage appear in the reptiles as constricting and dilating muscles, reaching a considerably higher development in the birds and the highest perfection in man.

In some of the amphibians the air-passages situated under the larynx are divided into the trachea and two bronchi; in the reptiles the cricoid cartilage shows an increasing tendency to meet, while in the birds the rings are clearly separated. The lungs of the amphibians are of very simple construction, resembling those of the dipnoi. But in the reptiles the lungs are subdivided into a number of small compartments, and are thus enabled to effect the increased exchange of gases involved by a greater supply of blood.

In birds the lungs are of more complex construction, but the pulmonary parenchyma is still of a spongy nature, in that the most minute cells are connected with each other.

In mammals the lobular construction of the lungs reaches a high degree of perfection. Although the respiratory organs of man correspond on the whole to those of the anthropoids they nevertheless differ in many particulars. The larynx of the chimpanzee most closely resembles the human larnyx (see Fig. 63), while that of the orang is least like man's. In the anthropoids the anterior part of the glottis proper is short, not longer than the respiratory part of the glottis.

One of the most striking differences between the anthropoids and man is seen in those broad, frequently dilatable skin and air sacs, connected with the sinuses of Morgagni, possessed by the gorilla, chimpanzee and orang (see Fig. 62). In the orang and gorilla these sacs are divided into an upper and a lower, the right one being usually larger than the left. What renders the adult gorilla so extraordinarily ugly are the front parts of the two sacs, hanging from throat to chest in the form of large, loose folds of skin.

Further distinctions between man and the anthropoids are to be found in the tracheæ and lungs (see Fig. 64). The two branches of the human tracheæ differ but little as to lumen,

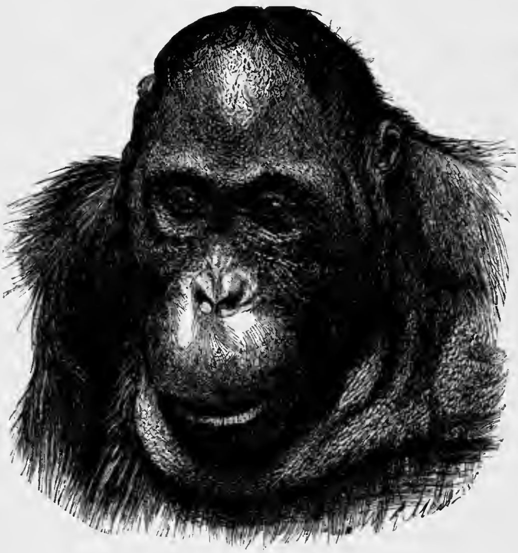


FIG. 62. Adult male oran-utan (throat sac).

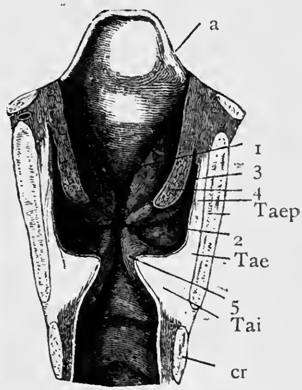


FIG. 63. Anterior section of larynx viewed from within. (Thomé, *Zoologie*.) a, epiglottis; cr, cricoid cartilage; Taep, Tae, Tai, sections of three muscles (shown white in diagram). 1, thyroid cartilage; 2, laryngeal cavity; 3, upper extremities of same; 4, ligamentum glottidis; 5, vocal cord.

whereas in the anthropoids the left branch is generally smaller than the right, from which, at a short distance from the trunk, springs a large lateral branch.

The pulmonary lobes, of which man has three in the right lung and two in the left, in the anthropoids are either more numerous or, as in the orang, are not definitely separated from one another.[1] Wiedersheim's researches reveal the fact that other conditions must have obtained among the progenitors of man than those of the present day. From the fact that the

[1] Ranke, *loc. cit.*, i., 293.

upper lobe of the left lung corresponds not with the upper but with the middle lobe of the right lung, Wiedersheim infers that a much more extensive pulmonary respiration and greater activity of the thorax must have existed at an earlier period, later becoming modified through the development of the diaphragm and its coalescence with the pericardium[1] (Primates). From the sinuses of Morgagni, which in reality represent diminished rudimentary resonance sacs such as many of the anthropoids possess in a high state of development (see above), Wiedersheim further concludes that the anthropoid progenitors of man breathed on a much larger scale and possessed a far more powerful vocal organ than does man at the present day.

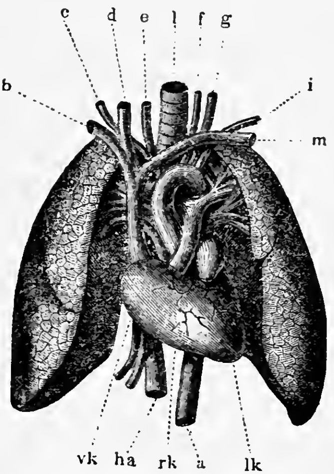


FIG. 64. Heart, large circulatory trunks and lungs. (Thomé, *Zoologie.*) a, descending aorta; lk, left ventricle; rk, right ventricle; vk, right auricle; ha, vena cava inf.; l, trachea; e and f, two carotid arteries; d and g, the two venæ jug. int., c and i, the two subclavian arteries; b and m, the two subclavian veins.

Some observations in histology yield the following figures for the dimensions of human (see Fig. 65) and animal bronchioli and alveoli.

The breadth of the *bronchioli*

in man	= 0·18	– 0·22	mm.
„ the horse	= 0·22	– 0·58	„
„ cattle	= 0·275		„
„ the pig	= 0·005	– 0·150	„

The average size of the *alveoli*

in man	= 0·2		mm.
„ the horse	= 0·13		„
„ „ sheep	= 0·06	– 0·1	„
„ cattle	= 0·17	– 0·2	„
„ the pig	= 0·15	– 0·2	„
„ „ dog	= 0·1		„[2]

[1] Wiedersheim, *loc. cit.*, p. 195.

[2] M. Sussdorf in Ellenberger, *Histologie*, pp. 516, 518.

The accessory glands connected with the respiratory system, namely, the thyroid and thymus glands, present no important points of difference in man and the mammals. Of the thyroid gland we know that it arises through segmentation of a part of the anterior wall of the primitive intestinal tube (Remak) in the form of a plexus of vesicles, which are lined with epithelium and sometimes appear in isolated groups, sometimes united in a single mass. In the lower mammals (monotremata, many marsupials and certain members of other classes) two distinct glands are found, one on either side of the larynx; in other mammals, as in man, the two lateral masses are connected by means of a bridge.

The diameter of the follicles of the thyroid gland is:—

In man	= 0·045 – 0·1 mm.	
„ the horse	= 0·050 – 0·4 „	
„ cattle	= 0·035 – 0·2 „	
„ the pig	= 0·055 – 0·5 „	[1]

FIG. 65. Terminal ramifications of the bronchial tubes with the air-cells. (Thomé, *Zoologie.*)

The origin of the thymus gland is obscure. In man and animals this organ is constructed of glandiform follicles and divided into large and small lobes; in all vertebrates it is most fully developed in youth and is, with rare exceptions, vestigial in the adult. In man it consists of two lobes unequal in size only in the embryo, and undergoes reduction and disappearance, usually commencing towards the end of the second year of life.

VI. Digestive System.

In order to form a correct estimate of the distinctive characters of the human digestive system we must first examine what man possesses, in this respect, in common not only with the rest of the vertebrates but also with the invertebrates.

[1] M. Sussdorf in Ellenberger, *loc. cit.*, p. 524.

The fundamental form is the cell with its protoplasm possessing ingestive and egestive powers. The lowest of the protozoa have no distinct organ for the reception and digestion of food. The food is either admitted endosmotically, in fluid form (gregarina), or enclosed in solid form by any part of the non-differentiated body and digested, the undigested matter being discharged at any point of the body (monera, amœba, rhizopoda).

The infusoria possess distinct organs for the reception of food in the form of tubular processes radiating from the surface of the body; indeed a mouth and anus may be said to be present but without an intestinal tube.

The porifera are furnished with a system of canals having mouthlike orifices not only for the admission and rejection of water, but also for the reception of food. The cœlenterata possess a digesting cavity in the middle of the body with a ciliated orifice opening outward; this structure may be said to constitute a stomach surrounded by parenchyma.

Combined with this primitive stomach in the majority of the cœlenterata, are canalicular or pouch-like formations, but an anal orifice opposite the mouth does not exist, the orifice of the mouth serving also for the discharge of undigested matter.

Signs of considerable progress in the development of the digestive organ are seen in the worms, whose digestive apparatus is either imbedded in the parenchyma, or situated in the abdominal cavity. The structural improvement consists not only in the fact that, in most cases, in addition to the mouth at one end of the body, a dorsal or ventral anal orifice is present at the opposite extremity, but in the far more significant fact that three distinct intestinal segments are to be distinguished, namely, the small, the large, and the terminal intestine. Indeed, in the tunicata we find an oral cavity, in the form of the sac-like anterior part of the body, and a distinct expansion of the large intestine.

In the echinodermata, even in their larval state, a further development of the intestinal differentiation which commences in the worms may be recognised. The circumstance that the oral and anal orifices, originally situated diametrically opposite each other, eventually lie on the same surface is no essential contradiction of the general plan on which the animal body is constructed, for it is exactly on this surface that the division of the two parts of the body is most clearly to be seen. The lowest members of the echinodermata are the asteroidea, in which the anal orifice is absent.

The arthropoda show certain advances in structure, though, as regards the position of the digestive organ in relation to the other parts of the body, they correspond closely to the worms. An intestine is present passing throughout the whole extent of the abdominal cavity supported by connective tissue, and even by a few muscles. The anal orifice, which is invariably present, is situated either ventrally or terminally. As in the worms, the three distinct parts of the intestine may be clearly distinguished. But the special distinction of this class is their apparatus for seizing and masticating food. This apparatus is placed at the entrance to the alimentary canal, and is formed partly by the borders of the oral aperture, in the form of projections (upper and lower lip), and partly by modifications of the articulated appendages of the body (pseudo-podia, mandibles), and is considerably in advance of the masticatory system of the asteroidea, crinoidea and echinoidea. In the crustaceans, whose intestinal canal follows a straight course, the terminal section of the small intestine is transformed into a masticating stomach by means of chitinous margins; the large intestine is short with appendicular glands and cæcal, saccular expansions; the terminal intestine is quite short with but few cæcal pouches. The narrow, small intestine of the arachnida leads into the large intestine, which is usually of relatively great length and provided with lateral cæcal sacs; the terminal intestine is expanded. The intestinal region of the myriapoda and insecta differs but little from that already described, except that in the latter the small intestine serves as masticating stomach, or crop, the large intestine is furnished with glands, and in the terminal intestine two distinct sections may be observed, the final one in the form of a rectum.

The separation of the intestinal canal from the wall of the body, which commences in the worms and arthropoda, characterises the mollusca also; equally clearly defined are the three portions of the intestinal canal, which is coiled in proportion to its length, and the oral and anal apertures are diametrically situated, approaching each other only in the cephalopoda and pteropoda.

The brachiopoda are organised on the simplest scale, having a mouth situated between the two arms, or arm-like processes. The lamellibranchiata have a short œsophagus attached to the mouth, hepatic ducts leading into the stomach and the terminal intestine coiled. Together with the development of a head in the gastropoda and cephalopoda, a pharynx with a deposit of chitine is formed, whereupon follow an œsophagus, a stomach, commonly divided into cardia and pylorus, a large intestine and a terminal intestine, generally expanded.

To arrive at a clear understanding of the nature of the digestive system of the vertebrates we must trace their embryonic development. Here we find that the entoderm and an inner section of the mesoderm form the nucleus of development, that in the higher vertebrates the intestinal sac is primarily closed and only secondarily furnished with anterior and posterior apertures. After a further differentiation into an anterior and posterior section the latter, which passes through the visceral cavity, forms the intestinal tube proper.

A further peculiarity common to all vertebrates, including man, is the fact that the anterior section of the primitive intestinal tube acts primarily (as in the tunicata) as respiratory cavity, and that the alimentary canal originates in the fundus thereof. In spite of the broad breathing cavity of the acrania being reduced in the craniata, it persists, nevertheless, up to the highest vertebrates as a cavity serving both for respiration and for the reception of food. From the reptiles upwards the cavity is reduced by the insertion of the palate. The median elongation of the velum palatinum forming the uvula (see Fig. 66) is no distinctive character of man, since it is present in the apes and in the hare, and is found in a rudimentary state in the camel and giraffe.

Except in size, the tonsils of the apes differ but little from those of man. The tonsils most closely resembling human tonsils are those of the carnivora; they are oblong and tuberculated, consisting of follicular glands invested simply in a covering of mucous membrane. In the pig the glands are disposed superficially, side by side; in the ruminants and in the horse they form more or less circular masses, though here, too, there is no saccular disposition.[1] Man possesses tonsils in common with the reptiles, birds and mammals. In man the tonsil is furnished on either side of the middle line with three or four deep longitudinal grooves and numerous nodules with a diameter of sometimes as much as 1 mm.

FIG. 66. Mouth, palate and pharynx. (Thomé, *Zoologie*.) *a*, tongue; *bb'*, palatine arch; *cc'*, palat. pharyng. arch; *d*, velum palat.; *e*, uvula; *f*, tonsils; *g*, porta pharyng.

A further peculiarity of the human mouth lies in the histology of its mucous membrane, neither a stratum granulosum, nor a stratum lucidum, being present, nor, with the exception of the lips and a portion of the lingual epithelium, is any sign of cornification to be found.

The fishes possess a rudimentary tongue in the form of a protuberance, invested in mucous membrane, above the hyoid bone, but a muscular, protrusible tongue proper we find first in the amphibians. In the reptiles and birds it undergoes further muscular development, though the apex is frequently horny, and only in the parrot is an entirely muscular tongue present.

The tongue of mammals is essentially fleshy, with its (see Fig. 67) muscular structure, its covering of mucous membrane and the numerous differentiations of the same. In all mammals we distinguish the epithelium, the mucous membrane with its papillæ (see below), the lamina propria of the mucous membrane, the glands, the muscular structure and the supporting organs (hyoid bones). In addition, many of the cheiroptera,

[1] Ellenberger, *loc. cit.*, part iii., pp. 101, 109.

semi-apes and apes, possess a so-called lower tongue, as a single or double projection. This formation, which in the anthropoids (with the exception of the chimpanzee) is but slightly developed, in children and adult human subjects easily recognisable, and in the negro variable, is, according to Gegenbauer, the rudiment of a primitive tongue, but in the opinion of Oppel to be regarded as a new character, in course of development.

Common to all the mammals, man included, and occurring also in the amphibians is the ramification of the lingual muscles, resulting in the firm structure and great mobility of the tongue. Generally speaking, in the tongue of every mammal we may distinguish external and internal muscles, and, according to their direction, vertical, transverse and longitudinal fasciculi.

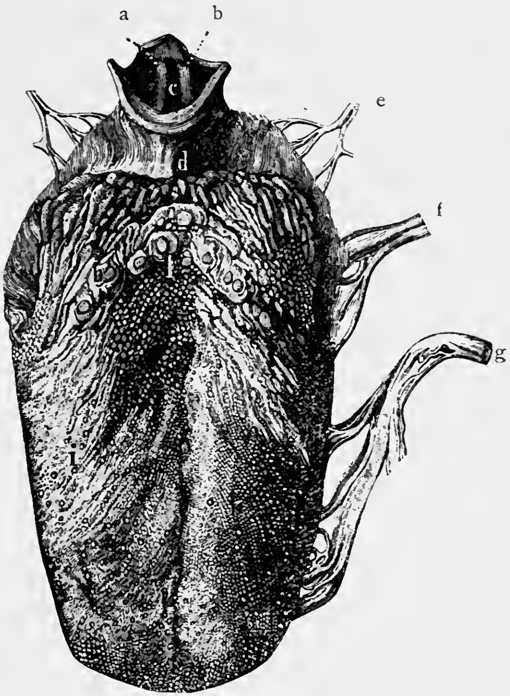


Fig. 67. Human tongue. (Thomé, *Zoologie.*) a, b, vocal cords; c, glottis; e, glossopharyngeal nerve; f, lingual; g, branch of fifth cerebral nerve; h, circumvallate papillæ; i, fungiform papillæ; k, filiform papillæ; l, thyro-glossal duct area.

The internal organ of support for this structure in man is the septum, consisting of connective and adipose tissue, and elastic fibres; its analogy with the "lyssa" of certain mammals, with the lingual cartilage of the lower vertebrates is proved by the fact that in the human fœtus of eight to nine months isolated portions of cartilage may be observed in the septum. In addition to the above-mentioned lyssa—an adipose body contained within a fibrous membrane and provided with cartilage cells—man is also without the solid plate of lingual cartilage and the lingual tuberosity of the carnivora, commonly known as a condensation of the mucous membrane with glands and macroscopically large papillæ.[1]

Those glands in the worms which open into the small intestine, similar glands in the turbellaria, the groups of glandular cells in the anterior extremities of the body in the trematoda, the glandulous formations in the so-called pharynx of the trematodes and nematodes, and the single-celled glands in the proboscis and jaws of the hirudinea, must be considered as belonging to the salivary type of secreting structure. In some classes of the arthropoda the salivary glands are either absent or very slightly developed, and they vary in development in the crustaceans, arachnida, myriapoda and insecta. Of the molluscs, only those classes provided with a head, namely, the gastropoda and cephalopoda, possess salivary glands. This fact is unfavourable to the theory that the possession of salivary glands is connected with an existence on land, as has been asserted from the absence of these glands in the fishes. In this respect, the amphibians and the majority of the reptiles occupy undoubtedly a higher place in the scale, though here the mucous glands are of first importance (Wiedersheim). The salivary glands are most highly developed in vipers and adders, three pairs of salivary glands in addition to their mucous glands being usually present. In birds the salivary glands occur at the angle of the lower jaw (corresponding to the sublingualis of the mammals), in the angle between the two jaws (corresponding to the Parotis), and in the triangular space beneath the before-mentioned glands (corresponding to the submaxillaris).

The parotid gland is in man, and in most of the mammals, a purely serous (albumen secreting) gland. Only in the dog does the Parotis possess oblong cavities with mucous-secreting cells.

The sublingual gland is in man and in most of the mammals a true mucous gland. In the pig and carnivora this gland appears combined with lobes for the secretion of serum.

Lastly, the submaxillary gland in man and all the mammals

[1] Ellenberger, *loc. cit.*, p. 654.

contains parts for the secretion both of mucus and albumen. Besides these three great glands of the oral cavity many mammals (among the rodents, insectivora, carnivora, cheiroptera and ungulata) possess a mucus-secreting glandula retrolingualis and a single excretory duct, namely, the duct of Bartholini. Zumstein[1] doubts the occurrence of this gland in man, but as it is found neither in the rabbit, hare, horse nor ass, its absence in man can still not be reckoned among the specifically human characters.

Proceeding to the œsophagus and stomach we find the separation of these two departments of the digestive system hardly more than suggested in the cœlenterata and mollusca (with the exception of the tunicata), and even in the vermes and arthropoda but little developed. There are even members of the vertebrate class (*e.g.*, the amphioxus and cyclostoma) whose first intestine shows no sign of the appearance which characterises the organ in man and the other vertebrates. In the higher fishes, the amphibians and the lower reptiles, the œsophagus is completely subordinate to the sac-like stomach. A distinct separation of œsophagus and stomach is first found in the higher apes. In many of the birds a part of the œsophagus is extended into a crop; in all the stomach is divided into an ante-stomach, abundantly provided with glands, and an adjacent muscular stomach which is most highly developed in the granivora and least in the birds of prey.

The most distinct separation of œsophagus and stomach, and most closely resembling the human formation, is that of the mammals. The muscular structure of the œsophagus in the semi-apes is very similar to that of man.

In the œsophagus of the Primates the numerous striated muscles, together with non-striated, extend almost to the Cardia, whereas in man the striated muscles are found without exception nowhere but in the upper part of the œsophagus, and the gradual transition from striated to non-striated muscles commences at the limit of the upper and middle third or quarter. Internal to these muscular strata are the non-striated fasciculi of muscular fibre belonging to the muscularis mucosæ, the numerous mucous glands situated in the lower part, the longitudinal folds

[1] A. Oppel, *loc. cit.*, part iii., p. 571.

of the lamina propria, the mucosa from ·8 to 1 mm. in thickness with numerous conical papillæ, and, lastly, the stratified pavement epithelium.

The stomach of the vertebrates is more complex in structure than that of the invertebrates, and the most highly differentiated is that of the mammals, where the essential differences may be observed with the naked eye. The case of the seal offers the sole exception to the general transverse position of the stomach. A stomach in the form of a cæcal sac produced by a high development of the curvature is absent in most of the carnivora, but is not peculiar to man (see Fig. 68) and the apes, since it

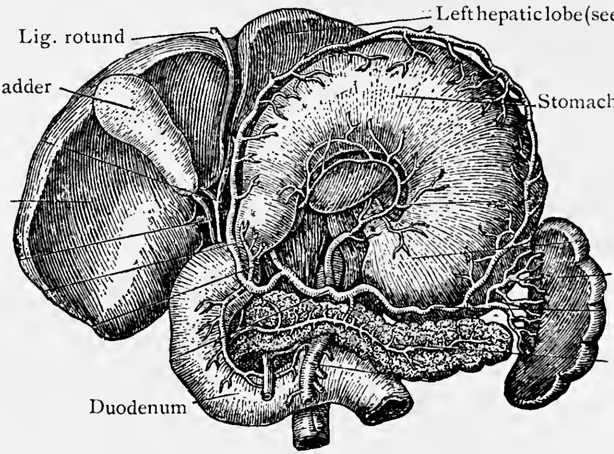


Fig. 68. Liver, stomach, spleen and pancreas (liver and stomach laid open). (Ranke, *Der Mensch*.)

is found fairly well developed in the monotremata, marsupials, edentata and rodents. Further, it is not only in man but in many other of the mammals that the so-called ante-stomach is absent, whether, as in the horse and pig, it takes the form of a portio œsophagea or, as in the ruminants, be divided by transverse constriction into cardia and pylorus with the accessory secondary expansions. In all cases there are histologically five strata to be distingüished, namely: the mucosa with its epithelium, special glands and lamina propria, the submucosa, the muscularis, the subserosa and the serosa. Those glands situated in the fundus and hence called fundus glands are of a simple tubular character. Further, there is a pyloric region with glands of a compound nature, and a cardiac region with short, slightly convoluted glands. The intermedian zone, where pyloric and fundus glands are found together, is broadest in man and the dog, narrower in the cat, and still smaller in the other mammals.[1]

Gastric glands of man. (Oppel, Part I.)

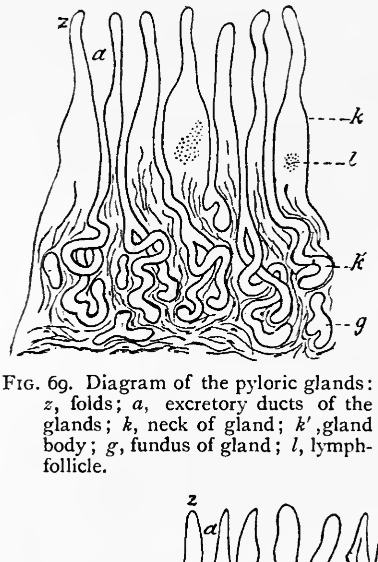


FIG. 69. Diagram of the pyloric glands: *z*, folds; *a*, excretory ducts of the glands; *k*, neck of gland; *k'*, gland body; *g*, fundus of gland; *l*, lymph-follicle.

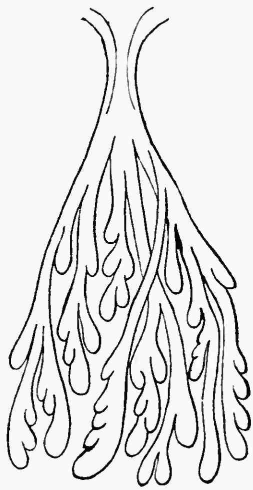


FIG. 70. Pepsine gland from middle of stomach.

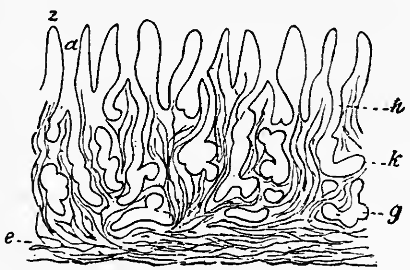


FIG. 71. Diagram of the cardiac glands: *z*, folds; *a*, excretory ducts of glands; *h*, neck of gland; *k*, gland body; *g*, fundus of gland; *e*, connective tissue.

With the exception of the species of semnopithecus, in which the stomach shows atavistic transverse constrictions, the stomach of the apes and anthropoids closely resembles that of man, the chimpanzee alone possessing the distinctive character of

[1] Ellenberger, *loc. cit.*, p. 679.

a cardiac zone double as broad as that of man. The entire thickness of the mucous membrane of the human stomach is:—

In the cardia . . .	0·37 to 0·56 mm.
„ „ middle as much as	1 „
„ „ pylorus „ „ „	1·6 to 2·2 „

In the fundus of the human stomach the thickness of the mucous membrane, including the muscularis mucosæ, measures from 0·8 to 0·9 mm., the depth of the pit of the stomach from 0·12 to 0·13 mm. In the intermedian zone the extent of the gland tubes in various functional states measures approximately 3 to 4 cm.; the extent of the pyloric gland zone approximately 6 cm.

The intestine of the vertebrates, so important for the process of digestion, is in the fishes sometimes straight and sometimes coiled; in the amphibians, reptiles and birds it forms a coiled tube varying in length. Its length varies also in mammals according to the form of food. The mucous membrane is usually transversely folded and abundantly provided with villi; the muscular tissue is, with few exceptions, smooth. The muscularis mucosæ possesses, internally, circular, externally, longitudinal fibres, the latter alone being continued into the large intestine where the ileum passes into the cæcum, while the circular stratum is completely absorbed in the valvula Banhini.

Characteristic of man and the ruminants, though of none of the other domestic mammals, as of the anthropoids (Owen, Virchow), are the closely placed, transverse folds which among the birds occur in similar form only in the Struthionidæ (Ellenberger).

The intestinal villi are largest in the carnivora, whereupon follow man and the horse, and, lastly, among the domestic mammals, the ruminants and the pig. The villi of the human intestines are on the whole not broad and but moderately oblate.

Their proportions are:—

In the Duodenum and Jejunum,	0·6 to 0·8 mm.	long
	0·4 „	broad
	0·1 „	thick
In the Ileum; . . .	0·5 to 0·6 „	long
	0·3 „	broad
	0·19 „	thick.[1]

[1] Ellenberger, *loc. cit.*, p. 692.

Lieberkühn's glands are completely absent in the fishes, but from the amphibians upwards are to be found in the large intestine of all vertebrates. In man, as also in the mouse, rat, squirrel and bat, the fundus of the Lieberkühn glands contains cells different from those which envelop the villi.[1] In man, between every two villi occur from three to seven Lieberkühn glands from 0·2 to 0·3 mm. in length. Only in man and the mammals are Brunner's glands present. In man as in many of the mammals these glands are most numerous in the neighbourhood of the pylorus. In the carnivora they cease immediately below the stomach:—

In the horse	7 to 8 mm.	below the stomach.[2]
" cattle	1 " 6 "	
" the pig	1 " 4 "	

The nodule or follicles which occur in the mucous membrane of the small intestine, either isolated, or in groups, are most abundant in the duodenum and ileum; they are present also, though to a lesser extent, in the fishes and amphibians, undergo further development in the apes and birds, and attain their highest perfection in man and the mammals.

The isolated follicles measure:—

In man	0·6 to 3 mm.
" the horse	2 " 4 "
" cattle	2 " 4 "

In the sheep, goat, dog and cat the isolated follicles are considerably smaller.[3] Peyer's patches have been studied in the domestic mammals as well as in man. In man they are from 80 to 100 mm. long and as much as 20 mm. broad; in the horse they vary in size according to the number of nodules (50-200); in cattle and sheep 20 to 50 follicles are found, in the pig 24 to 30 small groups, in the dog 15 to 30, and in the cat 4 to 7 patches.[4]

The large intestine derives its name from its greater proportions as compared with the small intestine. This may be observed even in the short terminal intestine of the fishes, apart from the sphincter which in many of the fishes divides

[1] A. Oppel, *loc. cit.*, part ii., p. 326.
[2] Ellenberger, *loc. cit.*, p. 695.
[3] *Ibid.*, p. 698.
[4] *Ibid.*, p. 698.

the large from the small intestine. In the amphibians and reptiles the large intestine is straight. In the birds and, still more markedly, in the mammals, and in man, it describes a longitudinal and transverse course, sometimes straight and sometimes coiled. The rectum alone corresponds to the terminal intestine of the lower vertebrates, while the remaining greater part (the colon), according to the latest research in comparative anatomy, is a comparatively new acquisition of mammals.[1]

Among the peculiarities of the terminal intestine the cæcum demands special attention, as its occurrence and development are extraordinarily variable, and, where it occurs, its presence, and still more that of its vermiform appendix, imparts a special character to the colon. In most of the fishes, batrachians and reptiles, the cæcum is absent, but in the reptiles traces thereof may be found. In birds its absence is rare; where present it is frequently double. Of the mammals all pachyderms and ruminants possess a cæcum as well as almost all the rodents, marsupials, sirenia, all apes, and man. In the carnivora it is either very greatly reduced, or entirely non-existent, but in the ruminants it is markedly developed.

Still more rare is the occurrence of the vermiform appendix: indeed, it may be said to be absent in the majority of the mammals, but is found in certain classes of the rodents (wombat, mouse, rat), in the anthropoids, and in man. In man this rudimentary organ varies in length from 2 to 8½ to 23 cm.; among the anthropoids the length is:—

In the gibbon	8·5 cm.
" " gorilla	24 "
" " chimpanzee . . .	14 "

Although in the rat and mouse it is considerably smaller, corresponding to their bodily proportions, all anatomists agree that, as regards the whole formation of the cæcum and appendix, the rat and mouse most closely resemble man.

In the colon of man and certain of the domestic mammals, the longitudinal muscular tissue lies in three fasciculi (Tæniæ Valsalvæ); in the pig there occur also three, in the horse first

[1] A. Oppel, *loc. cit.*, part ii., p. 591.

four and later three, but in the carnivora and cattle they are entirely absent. In man the glands cease at the upper end of the columnæ rectales, and in place of the cylinder epithelium stratified pavement epithelium is found. As regards the isolated follicles, they are larger and more numerous in the large intestine than in the small intestine.

The entire length of the large intestine, in the adult, as compared with the small intestine is as 1 : 4.

The two great glandular organs, the liver and the pancreas, stand in closest relation to the digestive system, as may be shown, ontogenetically and phylogenetically, from the invertebrates up to man. The peculiar, often coloured, cells or cell-groups, occurring in the intestinal epithelium of the worms may be considered as the primitive rudiments of a liver. Such gland formations are most highly developed in those worms where the intestinal tube ramifies (Planarians); here too may be mentioned the accessory glands peculiar to the intestine of the Tunicata. The coloured cells of the inner surface of the intestinal tube in the Echinodermata and, still more markedly, the cæcal appendix of the intestinal tube in the star-fish secrete a bile-like fluid, though neither can be said to possess a true liver in the sense of the liver of the higher animals. The glands connected with the large intestine of the arthropoda are admitted by all anatomists to be hepatic glands.

The gradual development of the liver may be traced in the different classes of the mollusca. In the Brachiopoda and Pteropoda, consisting still of a number of tubes, the liver appears in the Lamellibranchiata as an organ constructed of acini and lobes surrounding the stomach and a great part of the intestine. The liver of the Gastropoda is equally important, and in the Cephalopoda, in the form of a compact gland with excretory ducts from the separate lobes, it has already assumed the character of the liver of the vertebrates. As in the invertebrates, the liver appears in its most primitive form as a tube-like appendage of the intestine, so also in the vertebrates, its development from the wall of the rudimentary intestine may be traced in the embryo. In its simplest form (as in the Amphioxus) it is a cæcal appendix of the first portion of the intestinal tube, invested in epithelium of a greenish colour. In the embryo of other vertebrates (reptiles, birds, mammals and man) it consists of a double expansion of the intestinal tube where the latter forms the stomach; two hepatic lobes gradually develop and later combine into one organ. Although, on the whole, the human liver closely corresponds to that of the anthropoids, there still exist certain fine distinctions, to which Ranke[1] has drawn attention in his frequently quoted work. For instance, he regards it as worthy of mention that the **H**-shaped arrangement of the sulci on the

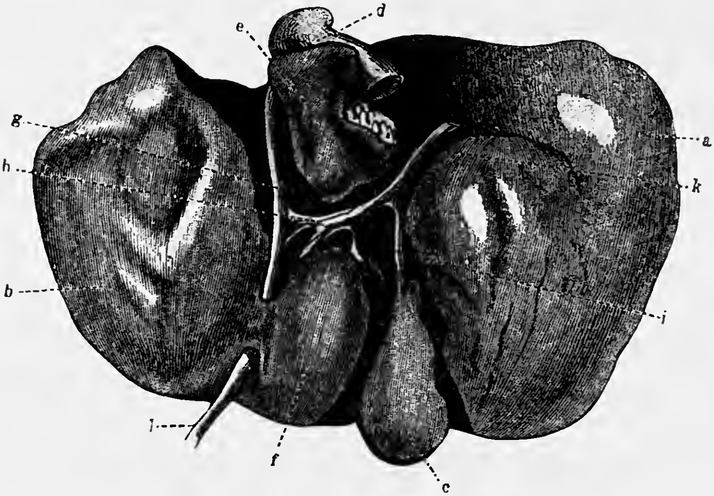


FIG. 72. Inferior surface of the liver. (Ranke, *Der Mensch.*) a, right hepatic lobe; b, left hepatic lobe; c, gall-bladder; d. vena cava; e, Spigelian lobe; f, quadrate lobe; g, porta hepatis; h, hepatic duct; i, cystic duct; k, common duct; l, lig. teres.

posterior surface (see Fig. 72) is absent in the gorilla (Bischoff), chimpanzee and oran-utan (R. Hartmann). The liver of the gorilla differs further from that of man in that, in addition to the two principal lobes, it sometimes possesses other lobes indenting the margins.

In conclusion it may be observed that the gall-bladder of the chimpanzee is larger than the same organ in the other anthropoids and in man. The close resemblance of the human liver to that of the pig has frequently been emphasised, but

[1] Ranke, *loc. cit.*, i., p. 293.

microscopic research reveals fine distinctions which are not to be ignored. Thus, the hepatic lobes are:—

In man . . .	1·1 to 2·3	mm.	long
	·8 „ 1·5	„	broad
In the pig . .	1·5 „ 2·5	„	long
	1 „ 1·5	„	broad [1]

Oppel [2] also mentions the similarity between the human liver and that of the pig, but draws attention also to its resemblance to that of the dog.

He regards as the distinctive characters of the human liver (see Fig. 72) the frequent union of the lobes to double and three-fold formations; further, the circumstance that the

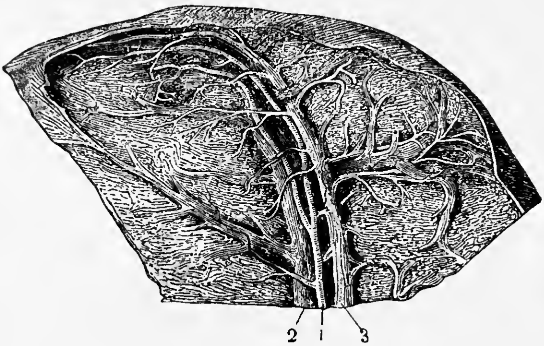


Fig. 73. A portion of the liver. (Thomé, *Zoologie.*) 1, artery; 2, portal vein; 3, bile duct.

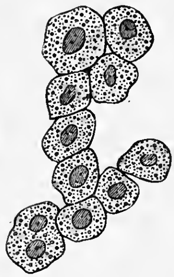


Fig. 74. Liver cells. (Haeckel, *Anthropogenie.*)

majority of the intralobular biliary ducts are situated in the marginal surface of the hepatic cells, though, between the margins, biliary ducts also occur on which border three or four hepatic cells.

The average diameter of the human hepatic cell (see Fig. 74), which frequently shows two distinct nuclei, is from 18 to 26 m., the lobes measuring 1 mm. crosswise and 1·5 to 2 mm. lengthwise.

The first appearance of a pancreas among the invertebrates is in the molluscs (Gastropoda and Cephalopoda), either in the form of gland lobules attached to the excretory ducts of the hepatic lobes, or in that of a pouch provided with a folded

[1] Ellenberger, *loc. cit.*, p. 710. [2] A. Oppel, *loc. cit.*, part iii., p. 1067.

wall (Aplysia, Doris) and discharging itself into the stomach.[1] In all the vertebrates the pancreas originates in an expansion of the intestinal wall, occurring behind the rudimentary liver. In man also there first exist two rudiments, a dorsal and a ventral. In the domestic mammals the dorsal rudiment becomes eventually the duct of Santorini, the ventral the duct of Wirsung; in man, with rare exceptions, the latter duct alone persists.

In man, as also in the fishes, birds and mammals, small aciniform glands, assumed to be mucous glands, are found in the wall of the Wirsung's duct.

VII. Urogenital System.

In the foregoing chapters we have seen that, in spite of man's position at the summit of the organic scale, he stands, nevertheless, in close connection with the more lowly organisms, being able to present few specific peculiarities in his structure. His urogenital system is no exception in this respect. Here, as before, we must go back to the lower forms of the animal organism in order to fully understand how the human organs have acquired the form we know them to possess. In the very lowest organisms, the Protozoa, with their extreme simplicity of structure, an organ of excretion is hardly to be expected; in the Cœlenterata the excretory functions are performed by the general gastro-vesicular apparatus, and only a few possess organs which may be regarded as rudimentary kidneys. Such are the Actinia possessing mesenteric filaments, which have been ascertained to contain guanin, and, among the Siphonophora, the Porpita with their curious spongy organ situated beneath the discoid air cavity.

It is clear that in the lower marine animals, whose organism freely communicates with the surrounding water, an excretory organ of the nature of a kidney could not be developed to any great extent. Among the Echinodermata there are only a few types in which special organs of excretion are found; such, apparently, are the interradial tubes with glandular walls as possessed by the Asteroidea, with and without an anal orifice,

[1] C. Gegenbauer, *Vergl. Anat.*, p. 533.

and the variously formed canals which penetrate into the cloaca of certain classes of the Holothurians.[1] There is sufficient ground for the assumption that these act as primitive excretory organs, even though the nature of the excreta be not as yet fully ascertained. The higher we rise in the organic scale the greater is the importance assumed by these organs and the more clearly are the excreta to be recognised. In the worms these latter take the form of granules and concrements corresponding chemically to the matter excreted by the kidneys of the higher animals and of man.[2]

"According as the body is articulate or inarticulate the excretory apparatus is complex or simple."

Where the body-cavity is not clearly defined the ends of the tubes as well as the finest ramifications of the canals are closed, otherwise the canals, simple or ramifying, open on to the surface of the body, and, where the body-cavity is very clearly defined, into the interior also, when a special ciliated organ is seen; indeed, in the Trematoda and the Radiata a common contractile bladder is found. The Nematoda exhibit a pore in the linea alba through which the contents of the two united lateral canals are excreted; the Annelida have two canals regularly divided and almost invariably provided with an internal, ciliated orifice and an external orifice at the opposite extremity of the body; the Gephyrea, lastly, possess two separate organs of excretion, the walls of the canals being of a glandular character; one organ acts as a kidney, the other as a reproductive organ. Thus early do we find indications of the urogenital system of the higher animals.

Among the Arthropoda little is definitely known as to the urinary organs of the Crustaceans. It has been ascertained that the larvæ of the Copepoda possess a temporary excretory organ in connection with the extremity of the large intestine, and the excretory nature of the so-called testaceous glands in the double shell of the Daphnia, in the head-shield of the Apus and in the shell-valves of the Limnadiacea cannot be doubted, but it is still uncertain whether the looped canals of certain Crustaceans are true organs of excretion or not. On the other hand, the so-called Malpighian vessels, occurring in

[1] C. Gegenbauer, *Vergl. Anat.*, p. 342. [2] *Ibid.*, p. 253.

other members of the Arthropoda (Arachnida, Myriapoda and Insecta) and formerly thought to be bile ducts are now ascertained to be urinary organs, for they undoubtedly excrete uric acid, as is seen, for instance, in considerable quantity, in the red or yellowish moisture of the Lepidoptera, on their leaving the chrysalis.

Typical organs of excretion are the looped canals of the molluscs; they commence externally and after a course of varied length open into the body-cavity; the chemical composition of their excreta confirms the view that they act as kidneys.

In the Brachiopoda and Otocardia the kidneys are represented by one or two pairs of canals; in the Pteropoda and Heteropoda a kidney of a spongy nature is found, while of still more markedly spongiform construction are the renal bodies which occupy the two final, branchial branches of the vena cava as far as the branchial heart.[1]

Proceeding from the Invertebrates to the Vertebrates we find the organs of excretion bearing an increasingly close resemblance to those of man. In the Myxinoidea, belonging to the Cyclostoma, the simplest of conditions still prevail, it is true, but in the Bdellostomata the cæcal transverse canaliculi of the ureter enclose a vascular convoluted body, or glomerulus, and the kidneys of the Petromyzontidæ[2] are still more highly convoluted, though as regards their uriniferous tubules they are very similar to the above. Peculiar to all members of the vertebrate kingdom is the early development of an excretory organ which, however, retains its original function of excretion only in the lower vertebrates, being superseded in the higher by a new organ, whereby the first either remains with a new function, or disappears from the organism.

In the fishes the two symmetrical, bilateral, lobular Wolffian bodies of glandular character situated at the lower part of the vertebral column originate from the posterior parts of the primordial renal ducts on either side of the vertebral column. The Wolffian bodies combine to form a single duct which opens either into a cloaca or separately behind the anal aperture. Thus an expansion in the form of a urinary

[1] C. Gegenbauer, *Vergl. Anat.*, p. 355. [2] *Ibid.*, p. 861.

bladder can be formed either in each separate ureter, or at their point of union, or at a still lower point. The Amphibians retain only the posterior part of the Wolffian bodies in a perfect state, either as a coherent mass or in the form of consecutive segments. Moreover, a secondary duct in addition to the primary Wolffian duct either remains on either side of the Wolffian bodies, at that point where it communicates with the Wolffian duct, or arises through the union of the transverse excretory ducts.

In the Amniota the Wolffian bodies are permanent, but in the Amnia they do not persist beyond the embryonic period (see Fig. 75). The permanent kidneys arise from the Wolffian ducts in the form of a bud, near the opening into the cloaca.

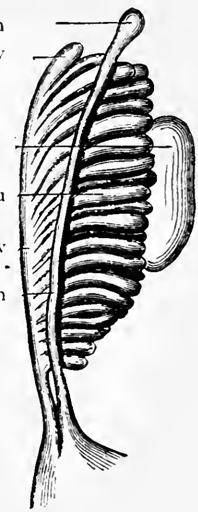


Fig. 75. Wolffian bodies of the human embryo. (Kobelt.) u, Tubuli urinif.; m, Müllerian duct; w, Wolffian duct.

In the reptiles the kidneys are placed far back and generally in the neighbourhood of the cloaca, and possess a considerable number of longitudinal convolutions, or lobes. The lizards and tortoises, like the amphibians, have a bladder springing from the wall of the cloaca.

In birds the kidneys are embedded in the cavity between the transverse processes of the coccygeal vertebræ and consist usually of three lobes, sometimes united; the ureters, which generally originate at the inner margin, open separately into the cloaca. The development of the mammalian kidneys does not differ from that of the reptiles and birds.[1] At first the kidney is unilobular; later it is divided into lobes through separation of the glandular parenchyma, whereby the tubuli uriniferi in each lobe (see Fig. 76) combine to form a papilla, and the renal calyces unite to form the pelvis of the kidney (see Fig. 76). The number of lobes varies considerably but can always be ascertained from the number of the different papillæ, simple and compound.

The seals, bear and otter possess a small number of dis-

[1] C. Gegenbauer, *Vergl. Anat.*, p. 867.

tinct lobes. When the lobes are partly united the surface of the kidney becomes tuberculated, as in hyæna, ox and elephant; when the cortical substance of the lobes is completely fused the surface of the kidney is quite smooth. If the lobes coalesce to such an extent that the majority thereof or the entire number are affected the result is a much smaller number of papillæ, indeed there is sometimes but one single papilla present, as in the Marsupials, Edentata, Rodentia and certain of the Carnivora, *e.g.*, the dog and the cat.

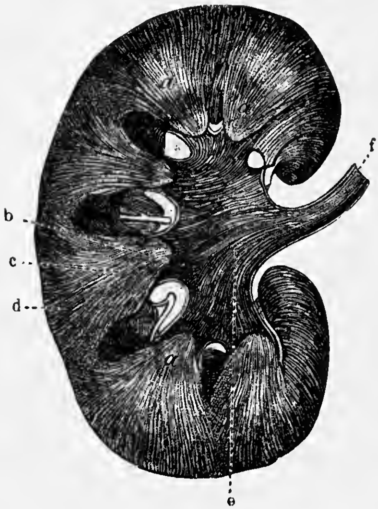


FIG. 76. Section of human kidney (Ranke). a, renal papillæ; b, apex; c, middle part; d, cortical layer; e, pelvis renalis; f, ureter.

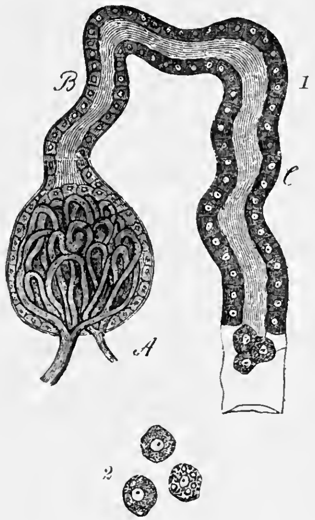


FIG. 77. (1) Malpighian body of man. A,B,C, Tubuli uriniferi; magnified 300. (2) 3 epithelial cells from convoluted canaliculi; magnified 350. (Kölliker, *Gewebelehre.*)

A peculiarity shared by man with all the mammals is that at first the ureters are embedded in the urachus section of the allantois, from which the urinary bladder is gradually developed, the process of the urachus towards the umbilicus and umbilical cord becoming ultimately obliterated. The consequence is that the bladder originally projecting far into the abdominal cavity gradually retreats to the pelvis. The size of the urinary bladder, as well as its general structure, varies in the different mammals. In the Bovidæ it is highly convoluted, in the Carnivora smaller, more muscular and almost circular.

The human urinary bladder occupies an intermediate place and measures, according to its contents, 50 to 100 mm. in height, 40 to 80 mm. in breadth, and is capable of containing 200 to 400 cubic cm. The lobes of the human kidney being united into a single whole, as is the case in most of the mammals, the human organ has the same bean-like form and smooth surface as that of the mammals, and only in rare cases is its construction of separate lobes revealed by an uneven surface. The human kidney, however, on being compared with the kidney of the mammals presents certain structural peculiarities, as, for instance, the number of papillæ. These, in man, are to the Malpighian Pyramids always as 10 : 15, whereas the oran-utan, rabbit, dog, cat, cavy, hyrax, lutia, Rhyzæna and gryson possess but one papilla, and some rodents, Mus, for instance, have two, while the elephant has three, the hedgehog five, and the pig nine to eleven. Tereg[1] gives the following diameters for the glomeruli of man and of various domestic mammals:—

Man	0·2 mm.
Horse	0·187 „
Cattle	0·221 „
Sheep	0·210 „
Goat	0·180 „
Pig	0·175 „
Dog	0·136-170 „
Cat	0·122 „

As regards the convoluted tubules the difference is less important. Their diameters are as follows:—

In man	0·05 mm.
„ the horse	0·051 „
„ cattle	0·05 „
„ the sheep	0·06 „
„ „ goat	0·051 „
„ „ pig	0·05 „
„ „ dog	0·048 „

The kidney of the Oran-utan has neither lobules nor Columnæ Bertini; further, no renal calyces are present, and only

[1] In Ellenberger, *Vergl. Histol.*, p. 264.

one single papilla, very broad and smooth, discharges the urine into the pelvis. Whether similar conditions obtain in the other anthropoids has not been ascertained up to the present.

Reproductive System.

In a comparison of the reproductive organs of man and the animals it would be a mistake to ignore the non-sexual mode of reproduction which prevails among many animals, from the Protozoa to the Annelida and Arthropoda, for the same process of segmentation in the cell, which precedes the asexual budding, or gemmiparity, takes place also in the gradual maturing of the human ova and spermatic cells. Of far greater significance certainly are the points of contact between man and the animals when we come to sexual reproduction, or reproduction based on differentiation of the sexes, which, commencing in the Infusoria and Sponges, continues throughout all classes of animals up to man.

In the Sponges, ova and spermatic cells are produced from the parenchymal cells without the mediation of special reproductive organs; in the Infusoria, the nucleus acts as the female, the nucleolus as the male element, which combine after the conjugation of two individuals.

In the Cœlenterata, which are either bisexual or of distinct sexes, special organs for the production of generative matter appear only at fixed periods; when the germinal glands are situated on the surface the generative substance immediately reaches the exterior, but is discharged through the gastro-vascular system when the glands are more deeply situated.

In the Echinodermata, with the exception of the Synapta, the sexes are distinct, and the reproductive organs are radially arranged. In the absence of sexual organs, the ova are fertilised in the water by the round-headed spermatozoa.

Of considerably higher organisation are the worms: the hermaphrodite Bryozoa, Turbellaria, Trematoda, Cestoda, Hirudinea and Tunicata. The testicles, varying in number, and the ovary, together with its vitelline cavity, are generally united at a common opening; there is also a vas deferens, a kind of vesicula seminalis, and sometimes at the common excretory duct of the ovary and vitelline cavity an expansion appears which may be regarded as a uterus. Preliminary to the separation of the sexes an unequal development of the double sexual apparatus in one and the same individual takes place, being on the one hand unduly increased, on the other arrested. The Nematoda, Chætopoda and Radiata, in all of which the sexes are separate, possess tubular testes and ovaries; the Nematoda having seminal vesicles, oviducts and uterus. The spermatozoa of the Annelida are clearly motile and have frequently a condensed head part. In the Arthropoda, in spite of their variability, progress from a lower to a form more closely resembling the vertebrates is to be traced, one of the most important signs thereof being the increased tendency to separation of the sexes, hermaphroditism occurring only among the lower types. Where the sexes are distinct, the reproductive organs are either single (of the Crustaceans, the Copepoda and certain of the Arachnida), or paired and bilateral-symmetrical (Branchiopoda, Arthostraca and, of the Arachnida, the Galeodes and Araneida, besides all the Insecta). The Insecta are more highly organised, in that they possess a vesicula seminalis in the male sex, and a receptaculum seminis in the female sex. The Brachiopoda, parts of the Lamellibranchiata, and a large proportion of the Cephalophora are hermaphrodite; in the remaining Cephalophora, and all the Cephalopoda, the sexes are separate. To the latter belongs the peculiarity of having the spermatozoa enclosed in a spermatophore.

We have seen that in the Invertebrates the germinal glands are at first undifferentiated, and that, even after this character has disappeared, hermaphroditism is still very widely spread. Now it is one of the most eminently distinctive characters of the Vertebrates that the germinal glands are strictly differentiated into organs for the formation, respectively, of ova and semen, and the sexes are represented by separate individuals, although, as far as has been ascertained, both the germinal glands originate in the same embryonic rudiment, the Wolffian duct. Another character common to all the Vertebrates is the development of ovarian follicles from groups of cells in the primitive ovarian tube. Common to man and the mammals is the peculiar construction of the ovarian follicle—the ovum being contained within a Graafian follicle filled with fluid—and the minuteness of the ovum, wherein, however, the nucleus ovi (blastodermic vesicle) and the nucleolus (germinal spot) may be distinguished.

The diameter of the Graafian follicle is :—

In man . . . . 10-12 mm.

„ other mammals as much as 1 cm. and more.

The mature human ovum measures 0·1-0·3 mm.

„ „ animal „ „ 1-1·5 „

These figures show that the human ovum is easily distinguishable from animal ova.

A general survey of the entire vertebrate kingdom, including the most highly developed mammals and man, reveals extremely primitive conditions as regards the sexual organs of the lower forms of life. Thus in the Cyclostoma the testicles unite and form a simple organ which, in the absence of excretory ducts, discharges its contents when mature into the abdominal cavity, whence the semen is eventually evacuated. The Selache, Chimæra and Dipnoi have paired but small testicles with epididymis and on either side a vas deferens, and paired, symmetrical ovaries which, however, are not connected with the oviducts in spite of these being also paired. From the fact that each oviduct becomes dilated at its lower extremity there results, on the right as on the left, a kind of uterus, each of which opens into the cloaca. The Ganoidei appear extremely backward in their development, being so simply organised that the ovaries as well as the testicles discharge their products immediately into the abdominal cavity, without the aid of special excretory ducts, and thence through a short canal into the ureter ; in certain species the ureter can open into the above-mentioned canal (Müllerian duct). The highest fishes are the Teleostei with their usually elongated testicles and ovaries, the latter in many species even serving as brood cavity for the development of the embryo. The amphibians in many respects resemble the fishes, the convoluted oviducts being situated beside the paired ovaries and, after uniting with the permanent and active Wolffian ducts, open into the cloaca. On the other hand, the testicles are united with the Wolffian bodies, one part secreting the semen and another part performing the function of kidney. The Wolffian bodies do not persist in the Vertebrates higher than the reptiles. The male sexual organs consist of testicles generally oval in form, lying close to the vertebral column, and the epididymis with the vasa efferentia and vasa deferentia opening into the cloaca. The ovaries are aciniform; the oviducts (appearing as Müllerian ducts developed from the original Wolffian ducts) form as a rule important passages, each furnished with an abdominal infundibulum and a short excretory duct opening into the cloaca.

The conditions prevailing among the birds are very similar, with the peculiarity that (with the exception of a few birds of prey) both the ovary and oviduct on the right side are undeveloped. This peculiarity occurs also in the Monotremata. Each of the two Müllerian ducts forms a canal (oviduct), which opens into a sinus urogenitalis communicating with the cloaca and forms a uterus at its lower end.

In the Marsupials the two Müllerian ducts are so connected that on each side a uterus, oviduct and vagina are formed, or the lumina unite into one cavity, whence they again separate to reach the sinus urogenitalis. The Monotremata and Marsupials are mammalia aplacentalia.

In the Placentalia, to which homo sapiens also belongs, the embryo communicates with the vascular system of the mother through the placenta and remains enclosed in the uterus until fully developed. The germinal glands transformed into testicles are situated at first, like the ovaries, at the inner margin of the Wolffian bodies. When the Wolffian body unites with the testicle the former develops into the epididymis, the Wolffian ducts into the vasa deferentia and the Müllerian ducts remain rudimentary.

Thus, only in the Monotremata do the testicles retain their original position; in the Cetaceans, Hyrax, elephant and certain of the Edentata the testicles are placed below the kidneys; in many rodents, the camel and certain of the Carnivora, they occur in the inguinal region of the abdominal wall; lastly, in many of the mammals and in man they are contained in a scrotum.

Other conditions obtain among the female members of the mammalia placentalia. The Wolffian ducts do not develop, while the Müllerian ducts form the oviducts, the uterus and vagina. Signs of an earlier structure are seen in the bicornuate uterus opening into a single vagina, as found in many of the rodents, and in the partially divided uteri of other mammals, occurring also not infrequently in the human subject.

With regard to the copulative organs, animals as low down in the scale as the worms possess a penis, to which corresponds in the female a vagina with bursa copulatrix for the admission of the penis. In the Crustaceans (Arthropoda) a canal in the sexual organ (in the form of a foot) serves as penis for the introduction of semen; in the Insecta the male is furnished with a copulative organ, varying in form, which is introduced into the bursa copulatrix of the female. Of the Mollusca only the Gastropoda and Cephalopoda possess a male copulative organ; among the latter one of the arms undergoes a curious metamorphosis in order to serve as such. We find a similar transformation of an organ in the fishes (Selache and Chimæra) where a part of the ventral fin acts as spermatic duct and sexual organ. Other of the Selache have a protrusile organ, sometimes cartilaginous, similar to that of the Crustaceans, to which corresponds in the female roach a smaller organ resembling a clitoris. Surbeck considers the sexual organ of the Cottus gobio, a sub-species of the Teleostes, to possess the character of a penis, but Hyrtl points out that in the absence of corpora cavernosa this structure in the Teleöstes cannot be regarded as a penis.

Of the amphibians the salamanders possess a papilla opening into the cloaca, while the reptiles have sexual organs either proceeding from the wall of the cloaca in the form of tubes, or constructed of fibrous tissue.

In the saurians and snakes the protrusile tubes, furnished with a spiral, seminal sinus, are dilated in the middle and bifurcated at the extremity, the glans penis being provided with spinous epithelium, which, however, is absent in the homologous female gland, the clitoris. Both here, and in the tortoise and crocodile, the higher vertebrate form of corpora cavernosa cannot be said to be present.

The copulatory organ of the birds bears a close resemblance to that of the reptiles, being usually in the form of a tube supported by fibrous tissue; the didactylous ostrich possesses a penis consisting of two bodies united together and enclosed with a mucous membrane. The male organ of reproduction in all mammals up to man possesses similar fibrous corpora cavernosa abundantly supplied with veins. Moreover, these corpora cavernosa (except in the case of the Marsupials, which differ also through their double penis) are connected with those of the urethra, which in all the higher mammals has been caused by the development of the sinus urogenitalis into a long narrow canal, and with its corpora cavernosa and the glans penis has been most instrumental in the formation of the true penis, whereas the homologous female organ, the clitoris, also provided with corpora cavernosa, is not united with the urethra (except in the Lemur and some of the Lemuridæ), nor has it any connection with the urinary discharge. In the bats, carnivora, seals, whales, many rodents and apes, the penis contains internally a supporting bone, but whether this is the case in the anthropoid apes I have been unable to ascertain.

In most of the rodents the penis is either entirely or partially surrounded by the sphincter ani; in most of the other mammals it is attached, varying in extent, to the median linea alba, and only in the bats, the apes and man depends from the pubic arch. This cannot, therefore, be reckoned among the distinctive characters of man, but it has been ascertained that the hymen, in its characteristic form, is possessed exclusively by the female human subject, the horse, ruminants, carnivora and apes having only what may be called vaginal valves.

In addition to the organs of excretion and reproduction, the accessory gland organs present many points of similarity and difference. Düsselhorst[1] has made these interesting organs the subject of exhaustive study, and to his work I shall refer as being the most reliable source of information. The Littré urethral glands are present not only in man, in the upper wall of the pars prostatica and in the pars cavernosa of the urethra, but also in the mole and Cheiroptera (Insectivora), in the Leporidæ, Muridæ and Cavia (Rodentia) and in the Bradypus tridactylus, all Marsupials and Monotremata (Edentata). The Cowperian glands are very widely spread throughout the kingdom of the mammals. In man these aciniform glands are

[1] A. Oppel, *loc. cit.*, vol. iv., 1904.

about the size of a pea (5-9 mm. in diameter), having an excretory duct with a diameter of 0·5 mm.

The Bartholini glands of the female corresponding to the glands of the male are absent in the female ape, being replaced by numerous cavities, which, in their turn, are absent in the human female. On the other hand, the Cowperian glands are larger in the apes than in man, though, compared with the corresponding glands in most of the other mammals, they appear smaller. Among the Carnivora they are found well developed in Felis and Herpestes; among the Insectivora, in the hedgehog and mole; all Cheiroptera; in the ruminant and non-ruminant Ungulata, and in many of the rodents. In the Equidæ where the glands are well developed they have from six to eight ducts opening into the urethra. In the Edentata but little is as yet known of them, as they have been found only in the Myrmecophaga tridactyla, Chlamydophorus truncatus and Dasypodida, but in the Marsupials and Monotremata they are undoubtedly present and are confined to the male sex.

The Prostate is not a specifically human organ; indeed, it occurs in almost all classes of the mammals. The only point characteristic of man is that this tubular aciniform gland contains strands of muscular fibres. The separate acini have a diameter of 0·21 to 0·30 mm. In the apes the prostate is always well developed, bearing no trace of having originally consisted of two halves; only in the orang, where it is longer and narrower than in man, is it divided into two lobes by a longitudinal sulcus.

The bilobular construction is also peculiar to the Cheiroptera. Among the Insectivora the gland is clearly of double construction, as shown in the mole and hedgehog; in the non-ruminant Ungulata it sometimes appears fourfold, and in the Proboscidea consists of even more lobes, while in the sub-ungulata, Cetaceans, ruminant Tylopoda (with the exception of the giraffe) and Bovidia, as well as in the majority of the rodents, the prostate forms a solid independent mass. The form varies greatly in the Carnivora, the prostate of the Canidæ, enclosing by means of its spiral form the whole of the urethra, presenting a sharp contrast to that of the Felidæ and Herpestes where the dorsal half of the gland is entirely absent. In the majority of the ruminants, with the exception of those mentioned above, the prostate is replaced by a glandular layer between the urethral mucous membrane and the urethral muscle; similarly in the Marsupials and Monotremata a stratum of urethral glands occupying the urethral wall supplies the place of a prostate.

One of the most remarkable structures in the province of the urogenital system of the male human subject is the vesicula prostatica, known to Morgagni and Albin, the small membranous vesicle situated in the prostate and discharging at the colliculus seminalis between the ejaculatory ducts; according to Weber the history of evolution proves the vesicula prostatica to be a uterus masculinus. Rüdinger has compared the vesicular fundus with the uterus and the lower section with the cervix and vagina, and is of opinion that the organ is not of so rudimentary and unimportant a nature as is generally assumed.

In man the ejaculatory ducts only in rare cases open into the vesicula prostatica, but in the rodents where the vesicula seminalis is absent this is the rule. Little study, apparently, has been made of this organ in the other mammals, and with regard to its presence in the anthropoids no information has come to my notice. If, however, the theory of Reliquet and Guépin were to be confirmed, that only the human vesicula prostatica possesses follicles analogous to the alveolar depressions of the spermatic duct and the ejaculatory duct, this would indeed constitute a new specific human character. Glands in communication with the wall of the spermatic duct (ductus deferens) occur not only in man but in several of the classes of mammals and amphibians. In man these glands take the form of large cavities distributed over the wall of the spermatic duct, filled with secretion and furnished with excretory ducts. These glands form a distinctive character of man as contrasted with the rest of the Primates, they being absent in the latter. The glands of the spermatic duct constitute a distinction between the otherwise nearly related Insectivora and Cheiroptera, in that they are absent in the former and well developed in the latter. In the ruminants they occur in varying form and are absent only in certain of the Tylopoda.

The possession of spermatic duct glands, with or without ampullaceous dilation of the duct, belongs to the peculiarities of the Subungulata and many rodents (rabbit, beaver, true Muridae and hamsters). In birds and reptiles no spermatic duct glands are formed, but they abound in the amphibians. In the male Anura either the caudal or oral extremity of the urethro-spermatic duct expands; during the spawning season it forms a sinus of considerable size, but disappears during the winter. In the Urodeles there is no sign of this ampulla in the spermatic duct.

The reproductive organs of the Vertebrates possess also other special glandular vesicles serving as receptacles of semen and hence called seminal vesicles. These vesicles attain full development in the embryo of six months, and their occurrence is not peculiar to man but common to the apes, lemurs (with the exception of Cheiromys), Insectivora, ruminant and non-ruminant Ungulata, Subungulata, rodents and Edentata. In the birds the dilation of the posterior wall of the spermatic duct before the opening into the cloaca is not of glandular construction but acts merely as a seminal reservoir. Of the same nature is the olive-shaped expansion of the lower end of the ureter, which receives the ductus deferens, in the snakes. With regard to fishes, the Selache have no seminal vesicles, properly speaking, but in a number of Teleosteis (gobies, blennies, Cobitis, pike, etc.) Hyrtl has discovered seminal vesicles in connection with the testicles.

In conclusion, the odoriferous glands of the anal and cloacal regions deserve consideration. It would seem at first sight that anal glands are absent in man unless we regard as such those sebaceous glands embedded in the hairy perinæum which emit a secretion with a strong odour. True anal glands are absent in the apes, lemurs, ruminant and non-ruminant Ungulata, Subungulata, Proboscideæ, Cetaceans, Sirenia and Edentata, while in the remaining classes of mammals they are sometimes very well developed, especially in the Carnivora, where they occur in both sexes. Further, certain of the rodents (Leporinæ) possess special inguinal glands varying in colour and emitting a secretion which probably, like that of the anal glands, is connected with the reproductive system. Of the reptiles, the lizards in both sexes have small sebaceous glands situated ventrally from the cloaca, the tortoises simple non-glandular anal vesicles, and the crocodiles rather large glands, called musk glands, opening into the cloaca near the anus.

In the opinion of Düsselhorst the cloacal glands of the male Urodeles may be compared to the prostate, but up to the present nothing has been recorded as to the abdominal and pelvic glands and their functions.

VIII. Nervous System.

The faculty of receiving impressions from the outer world is common to all organisms up to man, but the possession of special organs for perceiving and conveying sensations (nerve fibres and nerve cells) does not extend to the lowest grades of the organic scale, for, though undoubtedly capable of sensation, the plants, the Protozoa and the lowest of the Cœlenterata (fixed Hydroidæ, Lucernaria, Anthozoa) are constructed of tissue so differentiated as to exclude the possibility of the ultimate development of a nervous system. Such a structure is first found in the higher Cœlenterata, the Ctenophora and Medusæ. The nervous system of the Cœlenterata, so far as has been ascertained, consists of ganglia, or small aggregations of nerve tissue, in the fundus of the digestive cavity, and nerve fibres proceeding from the ganglia. In the Medusæ the system takes the form of a ring following the margin of the disc, and consisting of ganglia placed at regular distances, and nerve fibres connected with these ganglia. Such simple structures represent the fundamental type on which the nervous system of all organisms, from the Invertebrates up to man himself, is constructed. The nerve ganglia act as central organs receiving sensations by means of certain nerve filaments, and promoting action by means of others. The simplest example of this structure may be seen in those worms in which the body is not segmented (metameres); where, however, the body is articulated an almost uniform repetition of the central organs (ganglia) takes place. Moreover, the chief ganglia are, in all the worms, situated in the anterior part of the body, and herein we recognise the prototype of the central nerve organs of the animals of all the higher classes and orders.

In the Echinodermata nerve trunks tapering towards the ends are situated at the mouth or orifice for the admission of food, and in accordance with the radial structure are likewise radial. These radial nerves surrounding the mouth have been named by Joh. Müller "ambulacral brain," and the term fitly describes the structure as compared with the true brain of the higher animals. With still more justice can we speak of a primitive brain in the Arthropoda, whose nervous system corresponds on the whole to that of the Annelida, for of the two pharyngeal ganglia connected by commissures, the upper, or head ganglion, is always of more importance than the lower. Proceeding from the two pharyngeal ganglia, there is a chain of abdominal ganglia arranged in pairs and connected by commissures; sometimes, by means of transverse coalescence, these ganglia form an abdominal cord, corresponding to the spinal cord of the Vertebrates, and send off nerve fibres for the muscles, intestines and skin.

In the insects the beginnings of a sympathetic system are evident, the system taking its rise in the abdominal ganglia and connected otherwise with the usual nerve fibres.

In the Mollusca also a sympathetic system is present. At first sight their nervous system appears extremely complex, especially in the Bivalves, but closer examination reveals the fact that it is constructed on the same plan as that of the worms. It consists of two upper and two lower pharyngeal ganglia connected by commissures, and various distinctions are present, particularly with regard to the peripheral nervous system. As a rule, the nerve fibres proceed from the central parts of the pharyngeal ring and are connected with one another, and also with various independent ganglia.

Distinctively characteristic of the Invertebrates are the ganglia surrounding the oral aperture, and representing in their relation to the other ganglia a primitive order of central nerve organ, and distinctive of the Vertebrates is the symmetrically arranged nerve matter of undoubtedly central character enclosed in bony casement. In the Acraniata the nerve substance is distributed equally throughout the entire length of the body; in the Craniata it is divided into brain and spinal cord, but in all the Vertebrates alike the nerve masses originate in the upper blastoderm, first three and subsequently five consecutive cerebral vesicles being formed by expansion at the first section of the spinal canal. The cerebral vesicles are: the prosencephalon, thalamencephalon, mesencephalon, epencephalon and metencephalon.

These vesicles at first form a continuation of the longitudinal axis of the spinal cord, but subsequently stand at an angle thereto and remain connected with one another both during their original form and subsequently to their transformation into the different cerebral sections (ventricle, cavity of the brain). The central canal of the spinal cord, which is developed from the posterior part of the primitive spinal canal, is similarly connected with the brain. In the lower classes of Vertebrates the medulla spinalis often exceeds the brain in bulk, but decreases in proportion as the brain develops. The centre of each half of the spinal cord consists of grey nerve matter with lateral processes (cornua) directed forwards and backwards (see Fig. 78). The peripheral nervous system originating in the spinal cord is arranged according to the vertebrate articulation of the body; from each vertebra springs a pair of nerves each consisting of two roots: an anterior (motor) and a posterior (sensory) nerve which unite together and form one trunk, dividing afterwards into two branches, a dorsal and a ventral nerve.

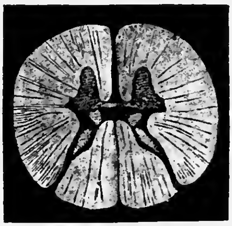


Fig. 78. Transverse section of medulla spinalis from the region of the back. Twice natural size. (Thomé, *Zoologie*.) Fma, anterior; Fmp, posterior longitudinal sulcus. Grey matter with cornua enclosed within white. Dark point represents spinal canal.

Each of the extremities is supplied with a nerve plexus formed of a number of anterior spinal nerves; for the anterior extremities there is the cervical plexus and the brachial plexus, and for the posterior extremities the lumbar, sciatic and brachial plexuses. There where the spinal nerves spring from the spinal cord protuberances appear in the latter, in the fishes to a slight degree but increasing in the higher Vertebrates (cervical, thoracic and lumbar swellings) (see Fig. 79).

A peculiarity possessed by man in common with the Amphibians, Insectivora and Cheiroptera is the disappearing of the posterior section together with the formation of the so-called cauda equina consisting of spinal nerves which do not immediately leave the vertebral canal but are contained therein for a part of their course (see Fig. 79).

The Brain.

Among the Vertebrates, the brains of fishes are of simple structure, especially in the lower orders, the five divisions of the brain corresponding in order to the five primitive cerebral vesicles. In the more highly organised forms a gradual development of bilateral, symmetrical arches takes place, particularly in the anterior or first vesicle, and later also in the second and third. The first vesicle (cerebrum) begins to overlap those parts posterior to it, and folds forming in its surface represent the first signs of convolution; the posterior, or fourth, cerebral vesicle (cerebellum) develops slowly; the fifth vesicle (medulla oblongata) may be distinguished from the spinal cord by its breadth.

In the amphibians the cerebellum is divided laterally into two halves. During the larval state the differentiation of the second and third vesicles commences, the latter in the Anura increasing in bulk and dividing into two halves. The cere-

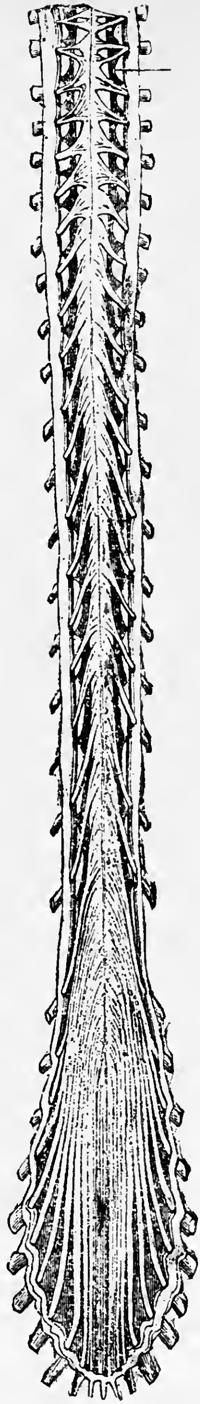


Fig. 79. Spinal cord; front view. One-third of natural size. (Thomé, *Zoologie*.)

bellum and medulla oblongata, however, remain somewhat primitive in type.

Characteristic of the reptiles are the two curves of the brain, one occurring where the second vesicle separates from the third, the other in the neighbourhood of the medulla oblongata; the separate divisions of the brain also increase in volume and in complexity of structure. The cerebrum with its two hemispheres covers the second vesicle and the lateral ventricles are well developed. The third vesicle (mesencephalon) is divided into two hemispheres by a deep fissure. In lizards and snakes the cerebellum is little developed, being more clearly differentiated in the tortoise and crocodile; in the latter a median protuberance is distinguishable from the two lateral ones.

In birds the cerebrum is more complex; it consists chiefly of ganglion cells of the corpora striata, and with its hemispheres covers the small second vesicle. Here, too, the mesencephalon, or third vesicle, which is still of considerable size in the embryo, is divided into two halves as in the reptiles; the cerebellum, however, is, in its middle part, still more highly developed than in the crocodile and almost completely covers the medulla oblongata.

A glance at the embryonic brain of the mammals, with its manifold points of resemblance to lower forms, will show that we are not justified in assuming that an essential difference exists between the brain of the mammals and that of the lower Vertebrates. At a later stage of development extensive modifications take place, it is true, especially as regards the cerebrum, where the two hemispheres, separated from each other by a deep fissure, overlap the two olfactory lobes and are connected by a broad band of nerve tissue, the corpus callosum.

Proceeding from the Monotremata up to the higher forms of life we find the cerebrum steadily encroaching on the mesencephalon, till finally, in the apes[1] and man, it covers the cerebellum. The second vesicle becomes the optic thalamus, the third the corpora quadrigemina, and the fourth, or posterior, develops into the relatively important cerebellum, the lateral lobes of which are developed, especially in the apes and man, at the expense of the middle lobe.

As the cerebrum increases in volume its surface begins to assume folds, and the convolutions and fissures develop, these being the standard of the position of the different orders in the organic scale.

The anatomist Huschke,[1] speaking of the importance of the convolutions, says: "The more complex the convolutions, the more impressions and branches they exhibit, the deeper the fissures between them, and the more symmetrical their structure, the higher is the organism".

The convolutions reach their highest development in man, the insula cerebri, for instance, only in man attaining its four to five fanlike branches. Now it is of special interest to ascertain in how far the human brain (in spite of a certain general correspondence) differs from the brain of those apes most closely resembling him. (See Plate iii.) An exhaustive study, "Ueber die typische Anordnung der Furchen und Windungen auf den Gehirnhemisphären des Menschen und der Affen" ("On the typical distribution of the fissures and convolutions in the cerebral hemispheres of man and the apes"), has been published by Pausch, and a second

FIG. 80. Nervous system of man. a, cerebrum; b, cerebellum; c, spinal cord; on either side of the same the sympathetic ganglia.

[1] Huschke, *Schädel, Hirn und Seele*. Jena, 1854.

one by Ecker, "Ueber die Entwicklungsgeschichte der Windungen und Furchen der Grosshirnhemisphären im Fötus des Menschen" ("On the evolution of the convolutions and fissures of the hemispheres of the cerebrum in the human embryo"), in the *Archiv für Anthropologie*, iii., 1868. A comparison of the results of their investigations has been drawn up by Huxley, and incorporated by Darwin[1] in his work, *On the Descent of Man*. Huxley gives the following definitions:—

(1) In the human fœtus the fossa Sylvii develops in the course of the third month. During this period and in the fourth month the hemispheres of the cerebrum are smooth and rounded in form and project far over the cerebellum.

(2) The true fissures first make their appearance between the end of the fourth month and the beginning of the sixth. This, according to Ecker, varies individually. In no case are the frontal or temporal fissures the earliest to appear. The first fissure is either the occipito-parietal or the Hippocampus major.

(3) Towards the end of this period the fissure of Rolandi is developed, whereupon follow in the course of the sixth month the chief fissures of the frontal, parietal, temporal and occipital lobes.

Hence Huxley concludes that man is descended from an ape-like type and moreover from one which differed in many respects from all members of the existing order of Primates. The brain of the human embryo in the fifth month may be said to be not merely the brain of an ape but the brain of an Arcopithecus, or of a member of the Marmoset species, though it differs from that of all existing Marmosets by virtue of its open fissure of Sylvius. With respect to the true Platyrrhines, Pausch records that in the brain of an embryonic Cebus Apella only one very shallow fissure was found in addition to the fissure of Sylvius and the Hippocampus. Of great interest in studying the origin of the human brain, is the fact that before temporal, or frontal, sutures appear, the fœtal brain of man presents characters otherwise only found in the lowest groups of the Primates (apart from the Lemuridæ), and this is precisely what we are led to expect on the theory that man has been

[1] Darwin, *loc. cit.*, v., p. 266.

evolved through graduated modifications from the same type as that from which the rest of the Primates have sprung.

As early as 1866, in his *Leçons sur la Physiologie* (p. 890), Vulpien remarks: "Les différences réelles, qui existent entre l'encéphale de l'homme et celui des singes supérieures, sont bien minimes. L'homme est bien plus près des singes anthropomorphes par ses caractères anatomiques de son cerveau, que ceux-ci ne le sont seulement des autres mammifères, mais même de certains quadrumanes, des guenons et des macaques."[1] In Huxley's opinion, the anatomical differences between the brain of the highest apes and that of man consist, broadly speaking, of the superior size, absolute and relative, of the hemispheres of the human cerebrum, as compared with those of the orang and chimpanzee, in the smaller cavity of the human frontal lobes, caused by the upward projection of the supraorbital ridge, in the abundance of the human convolutions and fissures of the secondary folds together with less symmetry in their order and in the usually slight development of the human tempero-occipital fissure. As further distinction Wiedersheim[2] adduces the fact that the third frontal fold in the anthropoid brain differs from that of man in that a small, isolated gyrus occurs at the base between the sulcus fronto-orbitalis and the sulcus opercularis. This gyrus forms the surface of the insula cerebri. In all apes the insula lies deep and shows an inferior development to that of man. The anterior region of the insula, like the operculum, has been acquired during the later periods of man's history undoubtedly in connection with the development of the organs of speech (see Fig. 81).

The finer anatomical distinctions in man's favour are based on differences in the structure of the cortex cerebri, the most important psychical organ. With respect to the structure of the brain, the mammals are divided into two great classes, the Gyrencephala and Lissencephala. In the Gyrencephala (apes,

[1] "The actual differences existing between the brain of man and that of the higher apes are extremely slight. Man is much nearer the anthropomorphous apes, as regards the anatomy of his brain, than are the latter not only to the other mammals but even to certain of the quadrumana, the long-tailed monkeys and the Macacus species."

[2] Wiedersheim, *loc. cit.*, p. 137.

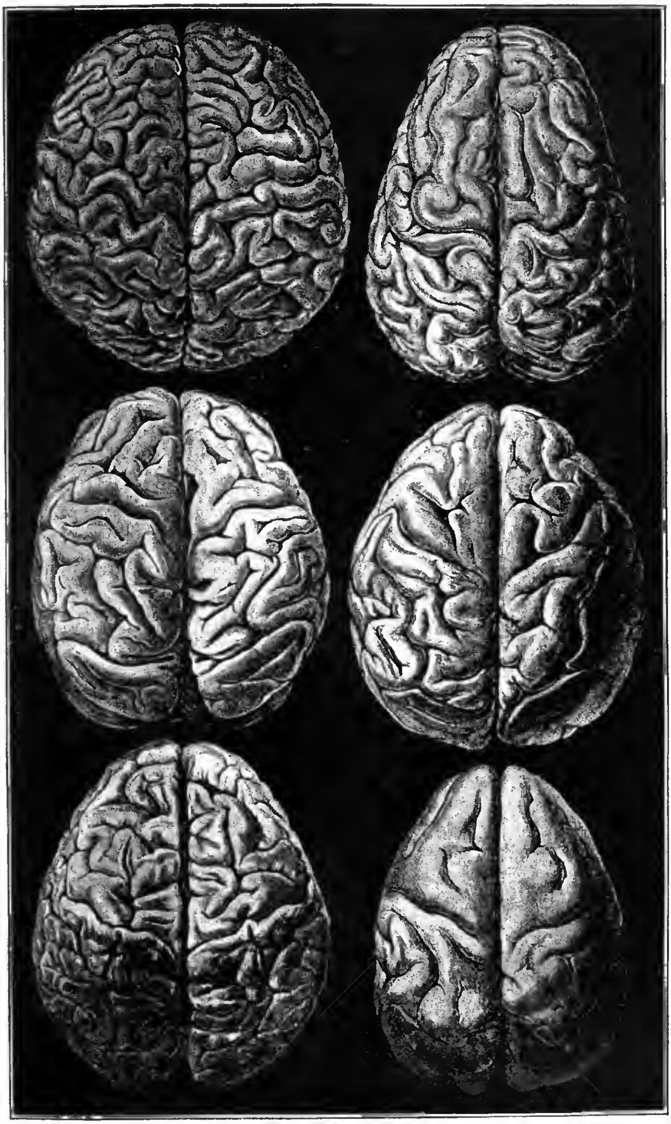
PLATE III.

Brains of mammals and of man.

M L

K I

H G



M, German ; L, Bushman ; K, Gorilla ; I, Orang; H, Chimpanzee; G, Gibbon.

beasts of prey, Ungulata, etc.) the convolutions are relatively well developed; in the Lissencephala the cerebrum does not cover the cerebellum, and the convolutions are either very slightly developed, or are completely absent. To this class belong the Cheiroptera, Insectivora, Rodentia and Edentata. Hermanides and Köppen have published [1] an admirable work

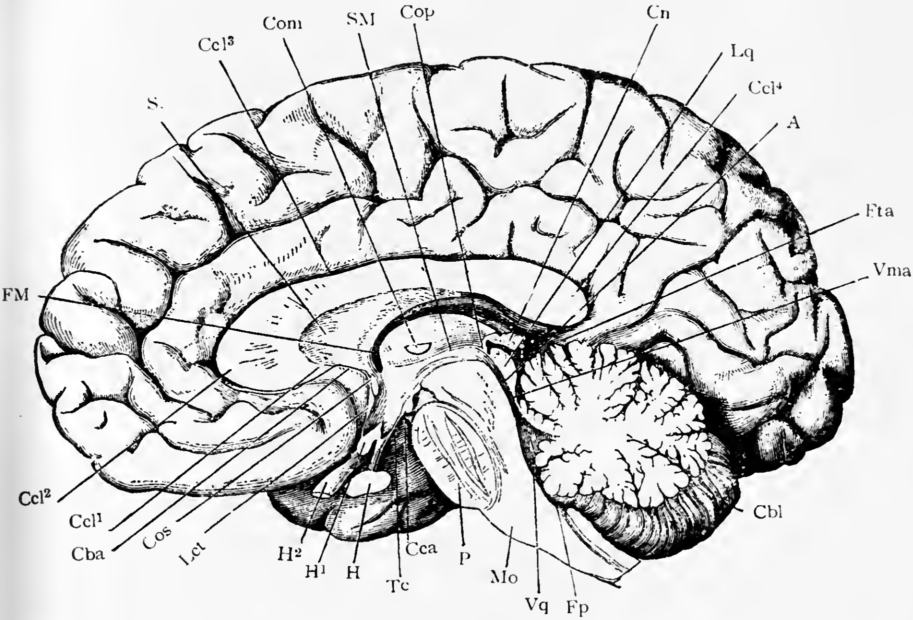


FIG. 81. Median section of brain. (Two-thirds natural size.) Vq, Fp, Fourth ventricle; Mo, Medulla oblongata; P, Pons Varoli; Cca, Corpora mam.; Tc, Tegmentum of grey matter; H, Hypophysis; H^1, Optic chiasma; H^2, N. opt.; Lct Grey com. bas.; Cos, Comm. ant.; Cba, Comm. bas. alb.; Ccl^1, Anterior end; Ccl^2, Genu; Ccl^3, Body; Ccl^4, Posterior swelling of corpus callosum; FM, Foramen of Munro; St, Septum lucidum; Com, Median commissure; SM, Sulcus Monr.; Cop, Posterior commissure; Cn, Pineal gland; Lq, Lam. quadrig.; A, Aqueduct Sylv.; Fta, Fissura cer. ant.; Vma, Vel. med. ant.; Cbl, Cerebellum.

on the fissures and structure of the cerebral convolutions in the Lissencephala. These two authors, after investigating the brain of the rabbit, rat, mouse and mole, have obtained the following results:—

(1) In these animals there exist fissures so connected with the cortical structure that where they occur either the cells

[1] *Archiv für Psychologie*, 37, 2.

are arranged in a special order or the cortical structure assumes a new form.

(2) In the structure of the cortex there are several distinct types to be recognised: the motor type, the type of the upper occipital cortex, that of the optic region and that of the olfactory cortex. The distinction between these various structures is shown by the differences in the strata of the large cells (stratum of the large pyramid cells in man), in the presence of the stratum granulosum and in certain peculiarities of the stratum of small cells (small pyramid cells in man) lying immediately under the molecular layer.

(3) In the cerebrum a transverse fissure was found, a second occurring near the occipital pole, its position bearing a striking resemblance to that of the fissura occipitalis. It marks approximately the boundary between the cortical region named "motor" by the authors, and that situated nearer the occiput, and hence termed by them the upper occipital cortical region.

(4) A fissura occipitalis in the lower surface of the occipital lobe in the rabbit is probably identical with the fissura calcarina. The cortex is here distinguished by the presence of innumerable granule cells, closely crowded together and separated from the molecular stratum only by a thin layer of dark-coloured large cells. In the other lissencephalous animals subjected to examination the stratum granulosum was not so highly developed as in the rabbit, but was nevertheless clearly recognisable.

(5) The fissura rhinalis marks the commencement of a very striking modification in the cortical structure, indicated by the abundance of dark, large cells in the second stratum, and by the narrowness of the fourth cellular layer. In those cases where a distinct fissura rhinalis is absent the same abrupt change in the cortex nevertheless appears in the corresponding place.

(6) In the posterior cornu large, dark-coloured ganglion cells are found with large and long-pointed processes, which occur nowhere else in the whole brain.

(7) The results of the investigations show that the study of the structure of the cerebral cortex, which varies greatly in character, is of the highest importance in studying the con-

struction of the cerebrum of the various animals and must always be taken into consideration in homologising the fissures.

A comparison of the weight of separate portions of the brain with that of the large hemispheres, or of the entire brain, yields very instructive figures. Thus Meynert (following Joh. Müller) takes the proportion borne by the cerebral hemispheres to the corpora quadrigemina as the unit of measurement, and finds that in proportion as the hemispheres develop, the peduncle of the crus cerebri (containing the voluntary motor nerves) surpasses in bulk the tegmentum of the crus cerebri.

On the authority of Huschke,[1] the weight of the optic thalamus and corpus striatum is as follows:—

In man	5 °/₀	of the weight of the cerebral hemispheres.
„ the ape	8 „	„ „ „ „ „
„ „ dog	11 „	„ „ „ „ „
„ „ cat	13 „	„ „ „ „ „
„ „ horse	13 „	„ „ „ „ „
„ „ calf	13 „	„ „ „ „ „
„ „ sheep	14-15 „	„ „ „ „ „

Huschke[2] has further tabulated the proportion of the cerebellum (Vermis, lobes, Pons Varoli and Medulla oblongata) to the entire brain. His results are the following:—

In man . . .	12-13 °/₀	cerebellum.
„ the gibbon . .	13·91 „	„
„ „ cow . .	12 „	„
„ „ dog . .	11-17 „	„
„ „ horse . .	15-17 „	„
„ „ fox . . .	15-18 „	„
„ „ goat . .	17-18 „	„
„ „ pig . . .	18 „	„
„ „ sheep . .	17-21 „	„
„ „ bear . .	19 „	„
„ „ cat . . .	20-23 „	„
„ „ rabbit . .	24 „	„
„ „ rat . . .	25-27 „	„
„ „ duck-bill . .	25 „	„
„ „ raven . .	10-13 „	„
„ „ wood-pecker .	14 „	„

[1] Huschke, *loc. cit.*, p. 104. [2] *Ibid.*, p. 73.

As to the proportion of the Pons Varoli (Fig. 82) to the cerebellum, the higher the mammal stands in the organic scale the narrower and shorter is the Pons Varoli in proportion to the cerebellum.[1] Man possesses the broadest cerebellum, the next in order being the cats, and then, although at some distance, the ruminants.

Each lobe of the cerebellum in man as in the animals consists of six parts. The difference between man and the mammals consists in the medulla being much less extensive in man than in the animals, and the central lobe in man occupies a more central position. In man, too, the vermis is somewhat triangular in shape, the apex of the triangle being posterior.

A further study of comparative anatomy shows that the vermis and the cerebellar hemispheres in man develop in inverse ratio to the same in the animals. In fishes the cerebellum begins with the formation of the vermis, while in birds and mammals the hemispheres are developed at the cost of the vermis. In the lower mammals the cerebellum gradually becomes circular in shape, owing to the increasingly lateral position of the hemispheres; in the higher mammals it increases in breadth, and finally, in the apes and man, attains its characteristic transverse expansion. Huschke[2] gives the following figures for the proportion of the vermis to the hemispheres :—

Otter . .	25·6 °/₀	vermis	74·4 °/₀	hemispheres.
Pig . .	32·8 ,,	,,	67·2 ,,	,,
Dog . .	39-42 ,,	,,	61-58 ,,	,,
Fox . .	43·7 ,,	,,	56·3 ,,	,,
Horse . .	45-54 ,,	,,	55-46 ,,	,,
Cat . .	47-51 ,,	,,	53-49 ,,	,,
Goat . .	50 ,,	,,	50 ,,	,,

In the anthropoids the cerebellum usually projects from under the margins of the occipital lobes, owing to the cerebellum being particularly broad, but in man this rarely occurs. On the other hand, the vermis of the human cerebellum is invariably more perfectly developed than that of the anthropoids.

The thickness and curve of the corpus callosum (see Fig. 81) bears an exact proportion to the height and curve of the cere-

[1] Huschke, *loc. cit.*, p. 85. [2] *Ibid.*, p. 77.

bral lobes. In the mammals as compared with other animals the corpus callosum increases in thickness rather than in length.

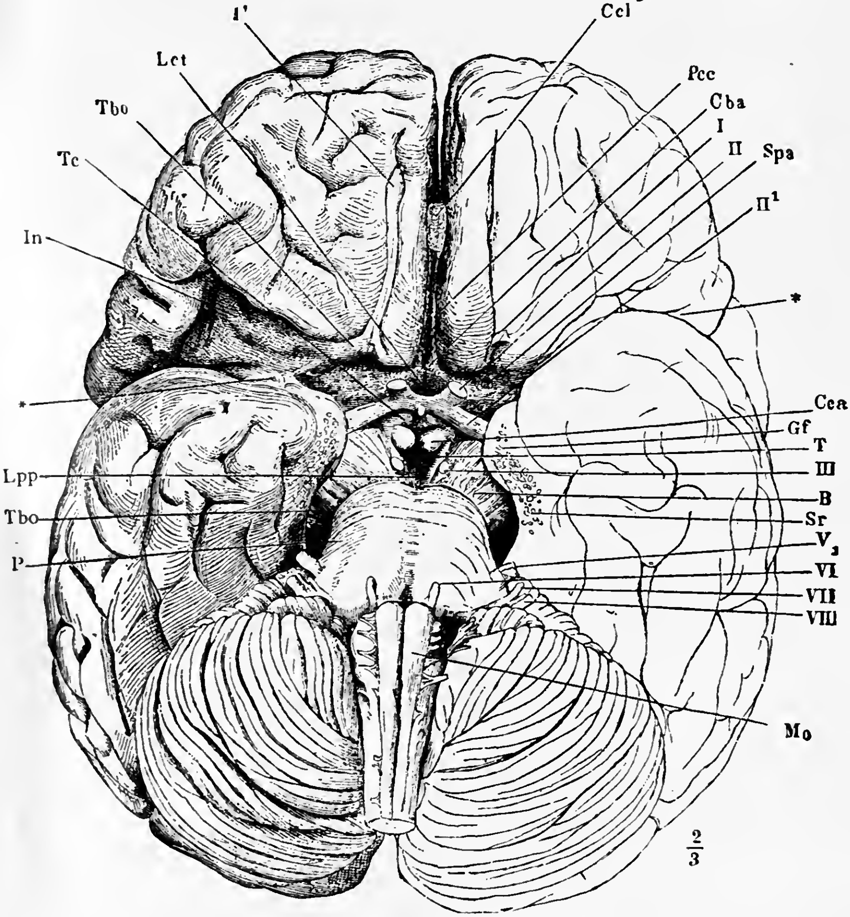


FIG. 82. Human brain viewed from beneath. P, Pons V.; Tbo, Tractus opt.; Lpp, Grey lamina between Pons V. and corpora mam., Cca; * In, Insula cerebri: marginal elevations of deep cerebral stratum; Tc, Tuber ciner.; Tbo, Tuber olfact.; Lct, Grey commissure; Ccl² and Pcc. Parts of corp. call.; Cba, White basal commissure; Spa, Transverse gyrus consisting of white substance interspersed with vascular orifices; Cca, Corpora mamm.; Gf, Cerebral gyri; T, Tegmentum of grey substance; B, Crus; Sr, Reticular white substance of the temporal lobe; Mo, Medulla obl. The Roman figures represent the cerebral nerves. The hypophysis is absent.

In proportion to the thickness of the human corpus callosum, which corresponds to the greater height of the human brain, the corpora callosa of the other mammals are thin.[1] In all Vertebrates the medulla oblongata, originating in the fifth cerebral vesicle, exists previous to the formation of the Pons Varoli; in proportion, however, as the matter increases, it being the more vital part of the brain, the medulla oblongata is less prominent.[2]

Two peculiar cerebral formations which have recently aroused special interest have still to be considered. These are the hypophysis cerebri and the glandula pinealis. In man peculiar conditions prevail with respect to the hypophysis. It is worthy of remark that the cavity in the hypophysis, corresponding, to a certain extent, to a sixth ventricle, has almost disappeared in man, and the organ is comparatively small.

Huschke[3] gives the following figures for the proportion of the hypophysis cerebri to the cerebrum :—

In man	= 1 : 2304
„ beasts of prey	= 1 : 723-960
„ the pig	= 1 : 450
„ „ horse	= 1 : 352
„ „ rodents	= 1 : 104-360
„ „ ruminants	= 1 : 77-121
„ „ birds	= 1 : 52-99

In animals the hypophysis consists of an anterior lobe, having the character of a vascular gland, and a small posterior lobe of grey matter containing nerve fibres in its fine-grained, nuclear tissue. Tumours and other diseases arising in the tissue of the hypophysis are associated with the occurrence of acromegaly; I do not know whether the same conditions have been observed in animals.

The glandula pinealis, which is situated on the anterior pair of corpora quadrigemina, has from the earliest times attracted the attention of anatomists far more than has the hypophysis; indeed, the philosopher Descartes[4] raised it to the dignity of the seat of the soul. Although we can hardly attribute so great a significance to it nowadays, it has attracted the notice of anatomists from another point of view, in that it has been

[1] Huschke, *loc. cit.*, p. 110. [2] *Ibid.*, p. 85. [3] *Ibid.*, p. 106.
[4] Descartes, *Les passions de l'âme*, 1649.

recognised as the homologue of the so-called parietal organs of the other Vertebrates. There is an exhaustive work on this subject by Dr. Studnicka in Oppel's *Text-book of Comparative Microscopic Anatomy*, Part V.[1] By the term "parietal organs" are apparently understood unsymmetrical structures, in saccular or vesicular form, arising by means of protrusion from the cerebral cortex, or in the roof of the mesencephalon, and originally serving to receive and transmit sensations of light; in the majority of Vertebrates, however, they contain but the merest rudiments of organs for the reception of light, and are finally transformed into organs of an entirely different character, namely, into glandular tissue of unknown function. As a rule the parietal organs tend to lie superficially, and at this point the skull becomes markedly attenuated; indeed, an opening sometimes occurs in the bone or in the cartilage (foramen parietale). In the region of the parietal organ the tissues are much more transparent and colourless than elsewhere. Almost invariably a close connection with the brain is found, and the organ is generally enclosed in the interior of the skull. In certain of the Vertebrates (*e.g.*, Anura) the parietal organ lies above the roof of the skull, immediately under the skin.

The general structure of the parietal organs corresponds to their origin in a protrusion of the cerebral lining and to their original function of (unsymmetrical) visual organs. The walls are found to be constructed of the same elements as those composing the nervous parts of the cerebro-spinal canal and the retina of the permanent eyes.

The lens-cells of the parietal eyes resemble those of the true eyes, and the content of the lumen of these primitive eyes may be considered as the rudiments of vitreous bodies.[2]

Following, in the light of Studnicka's treatise, the parietal organs from the lowest to the highest classes of the Vertebrates, we are not astonished to find the Cyclostomata (with the exception of the Myxinoides) furnished with well-developed parietal eyes in the form of pediculated vesicles with a retina, or so-called Pellucida, and even a plano-convex lens.

[1] Dr. Studnicka, "Die Parietalorgane der Wirbeltiere," Oppel, vol. v., 1903.
[2] Studnicka, *loc. cit.*, pp. 9, 10.

The position of the parietal eye in the Petromyzon species is indicated by a white parietal spot between the permanent eyes, and by the epidermis and corium being destitute of pigment.[1]

In the Selache the vesicle has neither retina nor pellucida nor a true cornea, and only in the Spinax is a parietal spot without pigment to be recognised.[2]

The parietal organ has the same form in the Ganoidea, but in the Teleostei it is a somewhat reduced organ, very defective in structure, without cornea and parietal spot, connected with the roof of the skull either by the distal extremity of the terminal vesicle, or by the entire upper surface of the same, whereby the roof of the skull is rarely perforated.[3] Of still simpler organisation is the parietal organ of the Urodelian amphibians, being merely a sac with slight folds, lying in close proximity to the roof of the mesencephalon, but, on the other hand, the conditions prevailing in the Anura prove beyond a doubt that their progenitors possessed parietal eyes, for the white parietal spot between the existing eyes is, with very few exceptions, plainly visible.[4] In reptiles the parietal organ varies greatly. Of the two parietal organs of the Saurians and Prosaurians only the anterior organ can claim to be a true parietal eye, but this claim has far more justice than in the case of any other vertebrate, for, where it does occur, all the attributes of the true eye are present, namely, the cornea above the foramen orbitale, lens, retina and pigment, and a corpus vitreum, and the nerves connected with the brain are clearly recognisable (see Fig. 83).[5]

Contrasted with this third eye of the Saurians the parietal organ of the Ophidians is only a solid structure abundantly furnished with blood vessels with a strand of nerve fibres in its peduncle, and is probably to be considered as a secreting gland. Of a foramen parietale and a parietal spot there is no trace.[6] Nor can the Chelonia and crocodiles be said to possess a true parietal eye, only rudimentary sac-like appendages to the cerebral cortex being present without peduncle. Rudimentary

[1] Studnicka, *loc. cit.*, pp. 42-44.
[2] *Ibid.*, p. 48.
[3] *Ibid.*, pp. 82-85.
[4] *Ibid.*, pp. 110-120.
[5] *Ibid.*, pp. 134-198.
[6] *Ibid.*, p. 199.

also is the corpus pineale of the birds; it is either large and in the form of a sac, or small and constructed of follicles, or quite solid. In the embryos of certain swimming birds temporary rudiments of a parietal spot are present in the form of a small pigmental area, while only in the crested goose is the skull perforated by a foramen parietale above the place of the parietal organ. In mammals the parietal organ is a solid, conical body, wherein but a proximate part of the earlier lumen is present. A special peduncle is generally absent, except in the common chimpanzee, where the conditions are still simpler

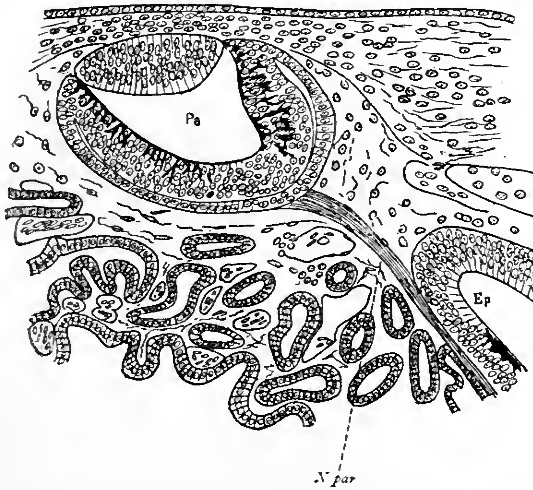


FIG. 83. Sagittal section of the parietal eye, parietal nerves and distal extremity of the epiphysis of an almost mature embryo of Hatteria punctata. (Oppel, *Vergl. mikr. Anat.*, Part v., Fig. 83.) Pa, Parietal eye; Npar, Parietal nerve; Ep, Epiphysis.

than in man.[1] In man the upper surface of the organ is uneven, in all other mammals it is smooth.

The form of the parietal organ is liable to vary; thus in the pig it is spindle-shaped and elongated, in the sheep pear-shaped, in the dog flat, and in man (see Fig. 84) conical, with the apex directed backwards. The human pineal gland measures sagitally 8-12 mm., transversally 6-8 mm., and is larger in the female sex than in the male sex, but in the former weighs only 0·00012 per cent. of the entire weight of the cerebrum.

[1] Studnicka, *loc. cit.*, pp. 210-219.

In structure the organ consists of a framework of connective tissue furnished with cells containing pigment bodies, of striated muscular fibres, blood vessels, nerve fibres and ganglion cells. The so-called brain-sand, traceable in the parietal organ of the Cyclostomata, and consisting of minute particles of carbonate of lime, phosphate of lime and magnesia, which was formerly considered of great importance, is found in man and in certain of the mammals. Neither man nor any of the mammals possesses a foramen parietale, but Studnicka is inclined to regard

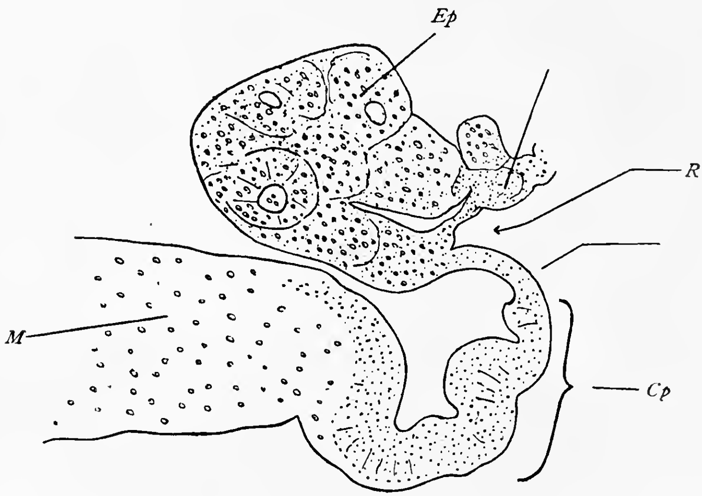


FIG. 84. Epiphysis and surrounding parts of the skull of a child of twelve years. Ep, Epiphysis; R, Recessus pinealis; Cp, Commiss. post. (Oppel, *Vergl. mikr. Anat.*, Part v., Fig. 123.)

the white parietal spot as well as the similarly placed pigmented areas of certain animals (*e.g.*, horse) as rudiments of a parietal spot.[1]

In conclusion we must mention as parts of the brain those cerebral nerves originating therein which, when completely developed, consist of twelve pairs. In spite of a general correspondence, certain distinctions are still to be noted between the higher and lower Vertebrates. Thus in the fishes, amphibians, birds and Monotremata, the nerves springing from the Bulbus olfactorius unite into a trunk, whereas in the higher mammals

[1] Studnicka, *loc. cit.*, i., 450.

and in man they pass singly through the Lamina cribrosa. In the Cyclostomata, on the contrary, each optic nerve passes separately to the eye subsequent to the formation of a commissure near the point of origin, while in the other Vertebrates an optic chiasma is always present. It must moreover be remarked that only in the reptiles, birds, mammals and man do the oculo-motor, trochlear and abducens nerves leave the brain separately and remain separate throughout their entire course.

The vagus, which appears in the reptiles (snakes excepted), is closely connected with the accessories only in the higher Vertebrates and in man. The rest of the cerebral nerves present no points of difference among the various classes of Vertebrates.

Having discussed the separate parts of the brain from the standpoint of comparative anatomy, it remains only to examine the entire mass of the human brain as compared with separate parts of the body, and with the weight of the entire body.

On the authority of Vierordt[1] the absolute weight of the brain of an individual of twenty to thirty years is:—

In the	German	man	1,461 gm.;	woman	1,341 gm.
„ „	English	„	1,412 „	„	1,292 „
„ „	French	„	1,358 „	„	1,230 „
„ „	Swiss	„	1,350 „	„	1,250 „
„ „	Russian	„	1,346 „	„	1,195 „

Davis has drawn up tables according to the races. He gives as the average absolute weight of the brain:—

European	man	1,367 gm.;	woman	1,204 gm.
Oceanian	„	1,319 „	„	1,219 „
American	„	1,308 „	„	1,187 „
Asiatic	„	1,304 „	„	1,194 „
African	„	1,293 „	„	1,211 „
Australian	„	1,214 „	„	1,111 „

The figures show that the male brain is on an average 9 per cent. heavier than the female.

The increase of size in the human brain due to its convolutions (as contrasted with a smooth, unconvoluted brain) Dumoulins reckons as twelve-fold.

[1] H. Vierordt, *Anatomische, physiologische und physikal. Daten und Tabellen.* Jena, 1888. P. 39.

The most important point is the large number of cortical ganglion cells, of which about 2,000 millions (approximately 1 million to the centimetre) are situated on the cortex of the cerebrum, and about 10 millions in that of the cerebellum.[1]

On the authority of several anthropologists (Broca, E. Schmidt and A. Schmidt) there can be no doubt that the great weight of the brain among civilised nations is a direct result of civilisation. Broca examined the skulls of Parisians from the twelfth and the thirteenth centuries and compared them with skulls of the nineteenth century, and states that the capacity has considerably increased in the course of the centuries. E. Schmidt compared skulls of ancient Egyptians with those of modern Egyptians, and obtained what at first sight seems an opposite result, the modern Egyptian showing the smaller capacity. The apparent contradiction is in reality but a further proof of the theory, since the decrease in capacity is to be ascribed to the decay of the Egyptian civilisation. Buschan[2] extended his investigations to the neolithic skulls of France and the Rhine provinces, and obtained the same results as Broca with respect to the capacity of the skulls; his research enabled him further to state that the frontal suture remains open in proportion to the increase of capacity following the rise and extent of culture.

Moreover the brain varies in size among the civilised nations according to class and profession. Buschan gives the four following classes:—

(1) Day-labourers, workmen.
(2) Mechanics, artisans.
(3) Tradespeople, clerks, teachers, lower officials.
(4) Scholars and higher officials.

Taking the figures obtained by Matiegka (Prague), Buschan reckons that a weight of 1,400 gm. is attained:—

In the	1st	class	in	26·2	°/ₒ	of	cases.
„	„ 2nd	„	„	42·8	„	„	„
„	„ 3rd	„	„	48·5	„	„	„
„	„ 4th	„	„	57·2	„	„	„

[1] H. Vierordt, *loc. cit.*, p. 44.
[2] Buschan, *Archiv für Rassen- und Gesellschaftsbiologie*, i., 5.

According to Spitzka, the brains of mathematicians and astronomers are heavier than those of any other class of intellectually cultured men.

Ranke [1] gives some very instructive tables on the authority of Carus, Joh. Müller and v. Bischoff, on the relative weight of the brain, *i.e.*, the proportion borne by the brain to the rest of the body.

In small Middle European singing birds	1 : 12-28
,, the tufted capuchin	1 : 13
,, ,, common marmoset . . .	1 : 22
,, ,, common squirrel-monkey . .	1 : 24
,, ,, smooth-headed capuchin . .	1 : 25
,, ,, magpie	1 : 28
,, ,, rat	1 : 28
,, ,, wan-wan gibbon	1 : 28(-48)
,, ,, German (woman) . . .	1 : 35
,, ,, mole	1 : 36·16
,, ,, German (man)	1 : 36·58
,, ,, teetee monkey	1 : 41
,, ,, lemur	1 : 42
,, ,, half-grown orang . . .	1 : 51
,, ,, ,, chimpanzee . .	1 : 51
,, ,, cat	1 : 82(-156)
,, ,, macaque	1 : 96
,, ,, adult gorilla	1 : 104(-170)
,, ,, tapir	1 : 104
,, ,, pigeon	1 : 160
,, ,, eagle	1 : 160
,, ,, lizard	1 : 160
,, ,, frog	1 : 172
,, ,, dog	1 : 214(-304)
,, ,, carp	1 : 248
,, ,, fowl	1 : 347
,, ,, sheep	1 : 351
,, ,, goose	1 : 360(-467)
,, ,, salamander	1 : 380
,, ,, horse	1 : 400(-700)
,, ,, young elephant	1 : 500

[1] Ranke, *loc. cit.*, i., p. 535.

In the tiger and lion	1 : 500(-600)
„ „ ox	1 : 500(-800)
„ „ gadus lota	1 : 720
„ „ ostrich	1 : 1,200
„ „ land turtle	1 : 2,240
„ „ shark	1 : 2,496
„ „ sea turtle	1 : 5,680
„ „ tunny	1 : 37,440

The comparatively great weight of the brain of small singing birds and of the small apes and monkeys is very striking, but it has been ascertained that in man also small, light individuals possess relatively heavy brains. From the above scale it is clear that man does not possess the heaviest brain in proportion to the weight of his body, nor has he, as Aristotle taught, even the greatest quantity of brain in proportion to his size (κατὰ μέγεδος), for while in an adult woman 1 gm. of brain goes to about 1·3-1·25 mm. of the whole stature, and in an adult man 1 gm. to 1·25-1·2 mm., the elephant has 1 gm. of brain to 1·18 mm. On the other hand, man stands at the head of the animal kingdom as regards the weight of the brain in proportion to the mass of the medulla spinalis, and in this respect (according to the researches of Sommering, Tiedemann, Treviranus, Meckel, etc.) possesses relatively the heaviest brain. Mies[1] has ascertained that the proportion of brain to 1 gm. of medulla spinalis is:—

In a girl	of 1 year and 14 weeks	94·32 gm.
„ „ boy	„ 6 years	73·10 „
„ „ girl	„ 10 „	68·81 „
„ „ youth	„ 18½ „	49·13 „

Mies has also carried out these investigations even more extensively in man than in animals, and has found that actually in this respect the difference between man and beast is the greatest. Ranke was able to clearly establish this: he states that the weight of the brain compared with that of the spinal cord was:—

In man	50 to 1
„ the gorilla	20 or 17 to 1

[1] *Deutsche med. Wochenschrift*, 1897, Nr. 53, p. 152.

In other mammals . . .	5-2 to 1
„ birds	10-2 to 1
„ frogs, about	2 to 1
„ the haddock	1 to 1

As a further specific human characteristic, it may be mentioned that the brain contains much more cerebral fluid than is present in other mammals; also in the spinal cord which in man only reaches to the last dorsal or first lumbar vertebra, the pyramidal tracts are particularly well developed and quite in contrast with the conditions found in all animals hitherto examined, where the decussation is incomplete.

The sympathetic nervous system, which in the Cephalochordata is absent, appears in man not to differ from that of the other Vertebrates, certainly not the Mammalia. The course of the main trunk of the sympathetic, extending on the visceral aspect of the vertebral column from the atlas to the sacrum, the course of the plexus, with or without ganglia arising from the sympathetic cord, and the connections with the cerebro-spinal nerves present as a whole the same structure.

Lastly there are the supra-renal bodies which from their relation to the sympathetic system must be regarded as nerve organs. In fishes and amphibia they are multiple organs, in the higher Vertebrates only a single pair exist, and of recent years they have come into considerable prominence from their use in organotherapy, no important differences being discovered between the glands of man and those of animals.

IX. The Organs of Sensation.

All sense organs are developed from the integument, and have nerves connected with them. This is the common bond which unites the whole animal kingdom from the highest Vertebrates down to the Invertebrates, with the exception only of the Protozoa (*Hydrozoa*, *Lucernariidae* and *Anthozoa*), which possess no differentiated sense organs but receive impressions indifferently over any part of their surface. The most primitive sense is that of

1. Touch.—It has been assumed, with perhaps but little reason, that the oral ciliary organ of many Infusoria and the cilia of others have tactile functions. However, there is no doubt that the prehensile tentacles connected with ganglia in the Ctenophora and Medusæ, especially the two tentacles at the base of the disc-like body of the Ctenophora, act as touch-organs. The worms, with their touch-bristles and rods (setæ) connected with sensory nerves and their tactile papillæ composed of sensory nerve fibres penetrating into elevations of the cuticular layer (nematoda) or ciliated depressions lying at the side of the head (nemertinea) seem particularly well supplied with touch-organs. There is no doubt, too, that the suckers and oral tentacles of echinoderms serve this purpose, as also those rod-like projections on the integument (tactile setæ) into which run nerves with ganglionic swellings (Crustacia, Myriapoda, Insecta). Molluscs are in many respects similar to the worms. So far as they have no hard covering to the body, the whole surface of the latter is capable of transmitting tactile sensations, but in addition little bristles supplied with nerves exist in various parts of the body, developed in gastropoda into the tentacles of the head, and in Cephalopods into long mobile tentacles.

The features distinguishing the Vertebrates from the Invertebrates are nowhere more pronounced than in the higher sense organs, while the organs of touch become in various parts of the body differentiated into special structures. In fishes, in addition to the feelers which many of them possess, there is the "lateral line" on each side of the body throughout its length. Among the higher Vertebrates a subsequent development is displayed in the touch-corpuscles in the superficial layers of the tough skin which receive the terminations of the cutaneous nerves (reptiles, birds and mammals).

Certain areas of the skin in mammals, where the hair is absent or scanty, are provided with papillæ, for instance, in some animals the alæ nasi, the tip of the snout, the lip-margins, the ball of the foot and toes, the nipples, mammæ, glans penis, clitoris, and the tip of the tail in cats, sheep, cows and pigs, but not in dogs.[1]

Man's relative hairlessness is associated with an abundant

[1] Bonnet in Ellenberger's *Histologie*, p. 384.

supply of touch-corpuscles (Wiedersheim),[1] for in animals the hairs which are freely provided with nerves act as touch-organs, and the touch-papillæ occur almost exclusively on non-hairy parts.

In the chimpanzee and gorilla rows of touch-papillæ lie among the rough furrows in the palm of the hand (see Fig. 85).

Pacinian corpuscles are found widely distributed in the Mammalia generally. Meissner's corpuscles, on the other hand, small oval bodies measuring in man 0·066-0·11 mm. long and 0·034-0·056 mm. broad, appear to be confined to man, apes (on

FIG. 85. Touch-bulbs in the hand of the ape. (Kollmann.)

FIG. 86. Touch-bulbs in the human hand. (After Hibert.) I, first; II, second; III, third row.

the hand) and elephants (in the papillæ of the tongue) (Corti)[2] (see Fig. 86).

The tongue serves as an organ of touch and feeling not only in reptiles but also in birds and mammals, and for this purpose the tongue is supplied partly with touch-corpuscles, and partly with free nerve endings in the epithelium. The anterior part of the snake's tongue, with its papillæ and touch-corpuscles, is specially adapted to the perception of tactile sensations. The papillæ in the bird's tongue are richly supplied with touch-buds and Pacinian corpuscles. Meissner's corpuscles occur on the

[1] Wiedersheim, *loc. cit.*, p. 149. [2] Bonnet, *op. cit.*, p. 448.

tip of the tongue in elephants and in the filiform papillæ over the whole anterior third of the human tongue.

Except in man, the epithelium of these filiform papillæ becomes quite horny, according to the animal's species and the grouping of the various papillæ.

In addition to the touch-corpuscles, there exists other apparatus for the reception of tactile stimuli, especially the free nerve endings in the lingual epithelium, which have been described in a small group of animals (rabbits, porpoise, pigs, horses and hedgehogs) but never in man.

2. Vision.—The organs for the perception of light are the next to appear in the evolutionary scale: for there can be no doubt that the marginal bodies of the Cœlenterata should be considered as such in their primitive form of simple pigment spots, or in higher structures, the pigment granules connected with refracting bodies. Numerous, symmetrically placed pigment granules are met with even in the lower worms (*Turbellaria*, *Trematoda*, *Nemertinea*, *Rotifera*), which can be shown to be connected with a nerve centre, for the granules are situated either directly on the brain ganglia, or close to it and attached by a nerve fibre. With a further differentiation of structure the pigment granules ensheath the endings of sensory nerves, forming the so-called "crystal cones," specially modified cells, or groups of cells, endowed with the functions of light-perception or refraction (*Turbellaria*, *Trematoda*, *Tunicata*). Among the Annelids, quite primitive structures are found in the leech, but for the most part actual eyes are present lying in pairs either under the integument of the "brain ganglion," or more commonly along the surface of the skin (*Syllidae*, *Nereidae*), or on the gill-tufts of the head or in bilateral symmetry on each metamere.

The majority of echinoderms have simple aggregations of pigment forming so-called "eye-spots," the star-fish alone having a true eye at the tip of each tentacle composed of numerous crystalline rods enclosed by pigment sheaths similar to the compound eyes of the articulates and certain of the worms.

The eyes of the Arthropoda are an improvement upon those in the worm, and are either refracting eyes surrounded with pigment, of simple or compound structure but possessing no cornea, or with a cornea formed by the integument over a simple, or compound eye, developing a transparency, and frequently a thickening, of its convexity which transforms it into a lens: these are invariably connected with the nerve-centres.

All free molluscs (except those that live in burrows) have visual organs; even the fixed molluscs have in some instances rudimentary eyes during the larval stage, although these may disappear later.

Well-developed eyes are met with on the sheath margin of many of the Lamellibranchiata; the eyes are placed in pairs in the gastropoda, the most typical organs being met with in the Cephalopoda. The eye of the Gastropoda consists of a globe with retina, pigment layer and cornea, while the Cephalopoda possess a globe with cornea, lens and optic nerve ganglia, lying in an orbit-like space; in many ways the eye resembles a vertebrate's eye.

The eye of all Vertebrates has essentially an identical arrangement of integument and nerve elements; first, the primitive optic vesicle appears as a process from the fore brain, and growing outwards against the integument develops an invagination of its anterior wall to form the posterior optic cup (secondary optic vesicle). Later on, from the horny layer of the skin, there is formed a lens which separates from the epidermis, while the proliferating tissues behind the lens have developed into the vitreous; the inner layer of the secondary optic vesicle becomes the choroid, and the outer the sclerotic. The transparent cornea unites with the conjunctiva, and inside the secondary optic vesicle are developed the retina and tapetum. This latter occurs only in fishes, in ostriches and certain mammals, not being found in man.

The cornea of fishes and many amphibia is flat, while in snakes, crocodiles and the majority of birds it is curved. The relation of the antero-posterior diameter to the transverse varies according to the different species of Vertebrates; in birds, as a rule, an anterior and posterior segment of the eye can be recognised, and in birds of prey the antero-posterior diameter is much greater than the transverse. The long axis is the shorter, however, in aquatic and long-legged birds, and among mammals in the Cetacea, ruminants and Equidæ (Ungulates). In most other mammals the globe is spherical; speaking roughly, it is so in the cheiroptera, apes and man (see Fig. 87). Strictly it is an ellipsoid on to whose anterior aspect a segment of a smaller sphere has been attached.

The presence of lymphoid follicles in the palpebral conjunctiva is characteristic of the domestic animals (man does not possess them); they are specially numerous towards the inner canthus at and in the neighbourhood of the transitional fold of conjunctiva (plica semi-lunaris) over the palpebra tertia (nictitating membrane).[1] This semi-lunar fold of conjunctiva—present in fishes—(shark), in amphibia (reptiles), birds and many mammals (Monotremes, Marsupials, Walrus, etc.) has atrophied in man and apes, simultaneously with the disappearance of a retractor muscle, but exists in a rudimentary form in the lower races of mankind.[2]

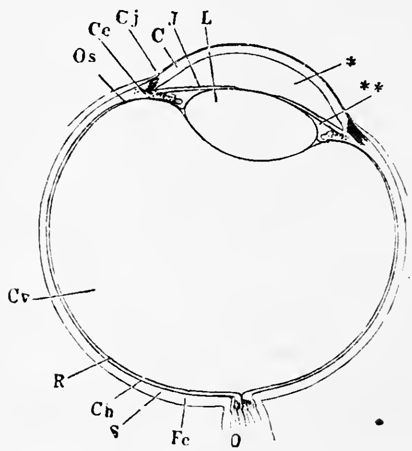


FIG. 87. Diagrammatic section of the right eye. (Thomé, *Zoologie.*) O, Optic nerve; Fc, Fovea centralis, or macula lutea; S, Sclerotic; Ch, Choroid; R, Retina; Cv, Vitreous humour; Os, Ora serrata; Cc, Ciliary bodies; Cj, Conjunctiva; C, Cornea; J, Iris; L, Lens; *, Anterior chamber; **, Posterior chamber, both containing aqueous humour.

Schlampp[3] has found minute histological variations in the structure of the granules in the pigment layer of the retina:—

In man they are spindle-shaped cylinders.

In porpoises they are short, round rods, cut off obliquely at each end.

In doves they are long, narrow and ribbon like.

In frogs they are biconical.

In pike they are truncated, stumpy rods.

The shape of the pupil is very variable.

In man, apes and dogs, it is round.

[1] Schlampp in Ellenberger's *Histologie*, p. 639.

[2] Wiedersheim, *loc. cit.*, pp. 160-62.

[3] Schlampp, *loc. cit.*, p. 639.

In horses, oxen, sheep, pigs and goats, transversely oval.

In cats and rabbits, a vertical slit.

Passing to the accessory organs of the eye, we find six muscles serving to move the eyeball, but in man one muscle, the retractor, is absent. Man and apes are peculiar in having eyes which look forwards only; the distance between the human eyeballs or separation of the axes averages 62 mm.

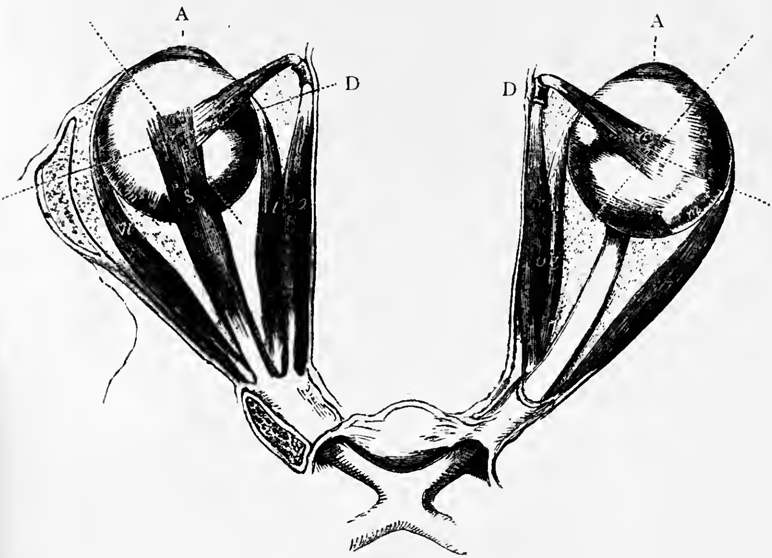


FIG. 88. The eyeballs represented as lying imbedded in the orbital fat with the attachments of the oculomotor muscles. (From Thomé's *Zoologie.*) A, cornea; n, external rectus; i, internal rectus; s, superior rectus muscle; the inferior rectus does not appear; o, superior oblique, with its pulley (D); m, is the origin of the inferior oblique muscle, which is not visible.

The protection of the eyelids is practically absent in fishes; the amphibia (salamander and tailless amphibians) have fairly well-developed lids, while reptiles and birds possess a nictitating membrane in addition to a movable upper and lower lid.

The so-called epicanthus occurs only in man; it consists of a fold of skin extending from the upper lid to the lower across the inner canthus, and is found normally among the Mongolian races and occasionally among Western nations. It produces a false impression of obliquity of the eye and a flattening of the nose.[1]

The human eye is further peculiar in permitting a part of the sclerotic to remain uncovered so that the eye appears almond-shaped ; in all other mammals, even in apes, the sclerotic is completely covered by the lids and the eye thus looks round.

The lachrymal glands for keeping the cornea moist and clean are first met with in reptiles, and attain their highest development in mammals and man.

Eyelashes are limited to a comparatively small group of the most highly organised mammals, including man and apes, though certain birds (birds of prey, parrots, ostriches, cassowaries) are provided with bristle-feathers round the eyelids which serve to protect the eye in similar manner.

3. **Sense of Smell.**—Although possibly some degree of olfactory perception may exist in Cœlenterates and Echinoderms, the true sense of smell is first found in worms, where the organs of this sense are probably the ciliated depressions in front of the dorsal portion of the suspensor of the gill in tunicates.

Pits and depressions with cilia are found among Arthropods (Crustaceans and Insects) ; judging from their habits it must be assumed that some sense of smell is present, though among the lower Molluscs this is still very problematical.

In Gastropods the olfactory organs were looked for in the tentacles, and there is no doubt that the two hollows surrounded by slight thickening of the integument on the posterior and lower eye margins of Cephalopods discharge this function.

An actual nose is first met with in Vertebrates, in its simplest form not unlike the structures found in Invertebrates, being merely shallow pits on the head supplied with special nerves.

The Cephalochordata have a single olfactory depression, all other fishes have paired pits supplied with nerves ; in the Selachii a nasal furrow extending to the angle of the mouth exists. As we proceed higher among the Vertebrates the nose gradually approximates to the human form. Amphibians possess nostrils communicating internally with the respiratory tract with rudimentary fossæ in the cartilaginous covering of

[1] Wiedersheim, *loc. cit.*, pp. 160-62.

the air-passages. In reptiles, the nasal tubes run side by side separated by a thin vertical lamella forming a nasal septum, and shut off from the mouth by a palatal plate, while true cartilaginous, though rudimentary, fossæ form the nostrils of birds.

All Vertebrates have three bony fossæ, of which the upper two are formed from the ethmoid bone, while the lowest fossa is developed independently; great differences exist among mammals as regards the development of the nasal fossæ. The highest differentiation is met with in carnivora and ruminants, the lowest in marsupials, whales, web-footed animals, apes and man.

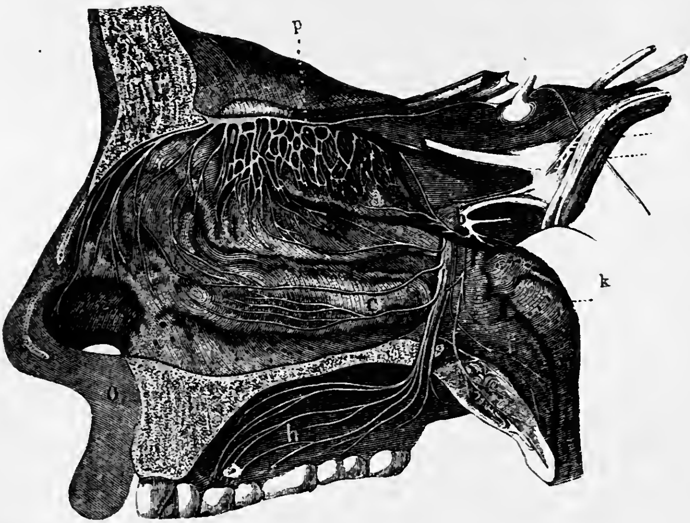


FIG. 89. Outer wall of right half of the nose. (From Thomé's *Zoologie.*) a, b, c, the nasal fossæ, covered with mucous membrane; h, hard palate; i, soft palate; f, upper part of pharynx; k, orifice of Eustachian tube; p, plexus of olfactory nerve; 9 and b′, branches of fifth nerve; o, upper lip.

In the human embryo, apart from a number of accessory sinuses, two or three other main fossæ are seen, which in later stages disappear practically completely,[1] so there would seem to be some grounds for Klaatsch's suggestion that the sense of smell in man is less highly developed than in other animals because the eyes have gradually encroached upon the nasal cavities.

The olfactory nerve is distributed in all mammals over the

[1] Wiedersheim, *loc. cit.*, p. 149.

superior fossa and the upper part of the nasal septum; this olfactory region in man is of a red colour, in horses and cattle yellowish, in sheep yellow-ochre colour, in goats black, in pigs brown, and in cats and dogs grey.

The olfactory nerve-endings consist, in Vertebrates as well as Invertebrates, of the so-called olfactory rod-cells (Fig. 90).

The shape of the external nose in man has been acquired by a process of evolution.

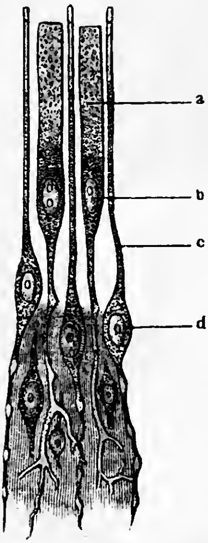


FIG. 90. Olfactory nerve-cells, highly magnified. (Thomé, *Zoologie*.) a, epithelial cells, divided below into two processes; b, nerve to cell; c, olfactory-cell with nerve-cell; and d, descending fibril.

Among apes the Hoolock-Gibbon is remarkable for its crooked nose, the nosed ape (Nasalis larvatus) has a long protuberant nose (Figs. 91 and 92), but the latter is merely a soft snout-like structure. The human nose, on the other hand, owes its prominence to the height of the lamina perpendicularis of the ethmoid bone and the vomer, as well as to the extension backwards of the lateral portions of the superior maxilla.

In the gorilla, a near ally of man, the ridge of the nose is only indicated by a slight protuberance, and the alae nasi are very well marked, yet the nose of the gorilla projects far more than that of the chimpanzee and orang-outang, and approaches rather to the type of many West African negroes.

4. **Sense of Taste.**—It may be regarded as highly probable that even the Invertebrates are led to select their food by taste, although we are still quite in the dark as to the organs which serve for this sensation, and can at most only assume that they are somewhere in the neighbourhood of the oral aperture. This is not very surprising, since even in the lower Vertebrates the "taste organs" cannot be located with any certainty, though we might expect them to lie in the area supplied by the glosso-pharyngeal nerve, in the tongue and gullet. When the tongue is absent, as in fishes, taste is most likely derived from the palate and

pharynx; in animals which bolt their food whole the sense of taste cannot be very acute.

Among the amphibia, the proteus, siren, pipa and xenopus are tongueless; but when the tongue exists either completely attached to the floor of the mouth (salamanders), or attached anteriorly and free posteriorly, as in toads and frogs, considerable importance must be attributed to it; in fact, the tongue must play a great part in tasting whenever its papillæ can be shown to contain nerve-endings.

In all reptiles with horny tongues (snakes and lizards) the sense of taste is to be looked for in the palate and gullet; even in the sea-turtle the tongue is small and hard though free, and

FIG. 91. Female nosed ape. (Haeckel, *Anthropogenie.*)

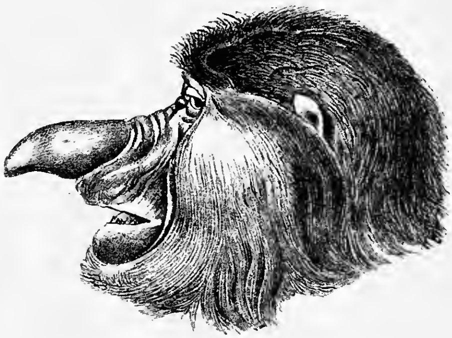


FIG. 92. Male nosed ape. (Haeckel, *Anthropogenie.*)

it is only in the tortoise that it is found to be soft and covered with papillæ so as to be adapted to taste-perception.

In birds a similar condition exists; the hard horny tongue of most birds does not admit of taste-perception, which is confined to the palate and gullet. Parrots and flamingos have, however, soft tongues beset with papillæ differing but little from the mammalian tongue; in all cases the tongue is soft, covered with mucous membrane, and except in Cetacea is well provided with taste-papillæ (circumvallate, fungiform and foliate, p. 182). The circumvallate and foliate (marginal) papillæ are the commonest, the fungiform not being very widely distributed. The circumvallate papillæ show the highest degree of differentiation as taste-organs (see Fig. 93), and according to Münch[1]

[1] A. Oppel, *loc. cit.*, Part III., p. 194.

their number is definitely fixed according to the various species, so that animals of a kind possess the same number, while the number increases as the animal stands higher in the zoological scale. Moreover, each species seems to have a definite plan of arrangement for these papillæ, differing in the various genera. Oppel contests the accuracy of this statement on the grounds of inadequate series of observations.

In man, and in the gorilla among Anthropoids, the arrangement of the circumvallate papillæ is that of a V open to the front.

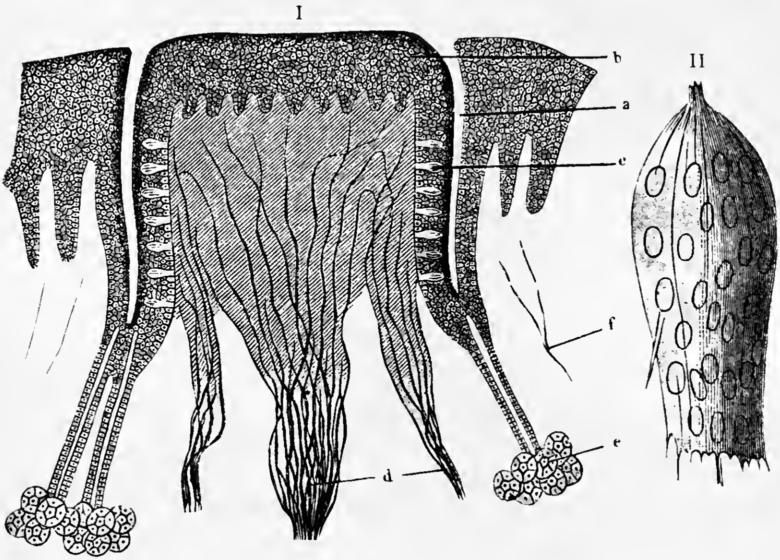


Fig. 93. Highly magnified. (Thomé, *Zoologie*.) I., Circumvallate papillæ; b, vertical section; a, surrounding vallum; e, gland itself; c, taste-bud; d and f, nerves. II., Individual taste-bud.

Man and the primates alike share in the extreme variability of the angle at which these papillæ are set; but as regards the number of circumvallate papillæ and the taste-buds associated with them, man stands easily at the head of the primates (hylobates 4, chimpanzee 4, orang 6, gorilla 5), though by no means above all the Mammalia. Tuckermann[1] gives the following figures:—

Man	has	9	circumvallate papillæ	with	6,000	taste-buds.
Fox	„	4	„	„ „	9,500	„

[1] A. Oppel, *loc. cit.*, Part III., p. 464.

Goat	has 12	circumvallate	papillæ	with 15,400	taste-buds.
Sheep	„ 24	„	„	„ 9,600	„
Calf	„ 24	„	„	„ 35,200	„

Neither is the transverse diameter of the taste-buds greatest in man, as the following table shows:—

Man	0·0396 mm.	maximum	transverse	diameter.	
Dog	0·0306 „	„	„	„	
Cat	0·0324 „	„	„	„	
Roe-deer	0·0468 „	„	„	„	
Ox	0·0480 „	„	„	„	
Pig	0·0200-0·0521 mm.	„	„	„	
Sheep	0·0360-0·0540 „	„	„	„	

A special organ of taste with very variable structure is the so-called marginal organ (Oppel), formerly known as "Mayer's organ," consisting of papillæ with taste-buds situated on the edge of the tongue. Csokor[1] describes these marginal papillæ in rabbits, horses, pigs, dogs and cats only, not in man, but Mayer himself had found them in man years previously, and has been corroborated by later observers.

On the other hand, the foramen cæcum situated at the angle of the circumvallate papillæ is not met with save in man (and then only in about 50 per cent. of individuals); this represents the common orifice of several mucous glands (the ductus excretorius of Bochdalek) and a part of the thyroglossal duct.

At the tip of the tongue occur Nuhn's glands which secrete by five ostia both mucus and saliva. Originally discovered only in man and the oran-utan,[2] they have recently been shown by Von Podwisotzky to be present also in sheep.[3]

5. Sense of Hearing.—Like the other higher senses nothing definite is known of the auditory apparatus in the lower animals.

It has been conjectured that among Cœlenterata the marginal vesicles of the medusæ which contain crystals are organs of hearing, solely, however, on the analogy of these crystalline bodies with the otoliths of higher orders; similar vesicles

[1] Ellenberger's *Histologie*, pp. 527-48.

[2] J. Hyrtl, *Anatomie des Menschen*, 6th ed., 1859, p. 556.

[3] A. Oppel, *loc. cit.*, Part III., p. 218.

sparsely ciliated in their interior and with a varying number of concretions are held to form the auditory apparatus of worms. And for this there seems better support, since these vesicles are in many cases undoubtedly connected with nerves. Tunicates and Turbellariea possess these vesicles unpaired; in the Annelids they are paired, and, as a rule, situated on each side of the brain-ganglion.

Among Echinoderms the Synapta is provided with auditory vesicles arranged in double pairs radiating from the origins of the five radial nerve-trunks. Contrary to expectation, in the higher order of Arthropoda, organs of hearing are only found in a limited number, and are not met with in Myriapods and Arachnids.

In Crustaceans the auditory vesicles lie for the most part in the basal joints of the inner antennæ. When closed they contain otoliths; if open one finds them crowded with fine grains of sand which have entered from outside; in either case nerve twigs enters the auditory hairs of the vesicles.

Ears are but rarely present in insects, at best only in Orthoptera, where they consist of a tympanic membrane whose inner aspect rests on a tracheal dilatation with a nerve-ganglion and rod-like nerve-endings similar to those which are found in the somewhat different auditory apparatus of beetles and diptera.

The actual proof of the importance of these otolith-containing vesicles as organs of hearing is furnished by the Molluscs. The highest molluscs, the Cephalopods, possess, in addition to their membranous or cartilaginous ear-labyrinth, vesicles containing nerves and concretions, as, for instance, in the Medusæ; so it may be concluded that this structure is an indispensable part of the auditory apparatus in Invertebrates.

While tracing the evolution of the organs of hearing in the Vertebrates, we find in the early embryonic stages a fold forming in the integument on either side of the hind-brain at its summit. The auditory vesicle thus formed is at first open externally and is connected with the end-apparatus of the eighth or auditory nerve; by degrees it becomes closed in and covered by the posterior part of the cartilaginous skull-cap. From the auditory vesicle is developed the membranous labyrinth, whilst the cartilaginous and bony labyrinth are derived from the cartilaginous auditory capsule. In fishes, the auditory apparatus is still quite primitive, being at its simplest in Cylostomata, where it consists of one or two semicircular canals with membranous vestibules: in higher fishes there is a differentiation of the labyrinth, from which the semicircular canals proceed into utricle and saccule.

The further the development of the ear advances the more deeply is it situated in the skull; the labyrinth even in amphibians is completely enclosed in the cranial wall; in reptiles, birds and mammals it is, as in man, deeply imbedded in bone.

The development of the internal ear is a subject of great interest. Starting from a prolongation of the vestibule (Sacculus), the cochlea grows out by degrees until it attains in mammals its characteristic form. But the final and most important metamorphosis comes from the amalgamation of portions of the visceral arches with the ear. For instance, in all orders from the amphibians upwards, the first visceral cleft goes to form the tympanic cavity, the Eustachian tube, fenestra ovalis, and fenestra rotunda: while in the Anura, a tympanic membrane appears attached to a little bony process the columella, an arrangement which gradually proceeds through higher developments in lizards, crocodiles, turtles and birds up to the mammals, including man. The human ear exhibits the highest differentiation, for in addition to the stapes which develops from the columella, two more ossicles appear, the malleus and incus, which are formed from the bone of the first arch.

Histologically, certain parallels can be traced between man and some of the mammals. The bony wall of the tympanum is compact in sheep, goats and dogs, just as in man; spongy, with tympanic cells, in horses, cattle and pigs; double, containing a hollow space, in cats.[1] The number of turns in the cochlea varies:—

In man	there are not quite	3	turns
" horses " rabbits	" " "	$2\frac{1}{2}$	"
" oxen	" " "	$3\frac{1}{2}$	"
" pigs	" " nearly	4	"
" carnivora	" " "	3	"

[1] Ellenberger, *loc. cit.*, p. 562.

In the membranous labyrinth of man and the domestic animals there are no appreciable differences, but the organ of Corti and the shape of tooth-like projections of the limbus (Huschke's teeth) vary according to the species of animal.

In oxen and horses . .	very thick.
,, cats and dogs . .	pointed ends.
,, rabbits . . .	long and thin.
,, mice	very arched.
,, man	height and arching little marked.[1]

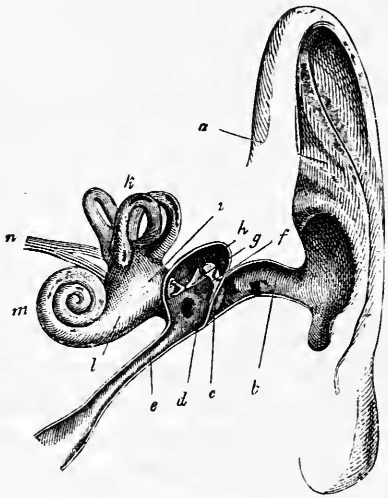


Fig. 94. Human ear. a, pinna; b, external auditory meatus; c, tympanum; d, tympanic cavity (middle ear); f, g, h, ossicles (malleus, incus, stapes); i, utricle; k, three semicircular canals; l, sacculus; m, cochlea; n, auditory nerve; e, Eustachian tube.

Waldeyer puts the number of rods of Corti in man at 20,000, the cords in the Zona pectinata at 13,400.

As regards the outer zone of the membrane of Corti in rabbits, the external margin is thickest with stout glistening marginal fibrillæ, from which a fine fibrous network (lamina reticularis) stretches over a wide span; in cats the outer margin is fairly thick, with a delicate lamina reticularis, and a mere indication of Löwenberg's lamina.

In man, on the other hand, in the lowest turn bounded by a marginal strand there is a gradual thinning of the membrane from the outer margin; in the two other turns, a free network projects terminated by fine fibrillæ. On the tympanic aspect of the membrane, Hensen's spiral band appears as a glistening streak standing out above and internal to the row of inner hair cells.[2]

The appearances which are the most characteristic of the human race are related to the structure of the external ear.

This organ, which develops as a projection from the border

[1] Ellenberger, *loc. cit.*, ii., p. 933. [2] *Ibid.*, ii., p. 938.

of the first visceral arch, is either completely absent in amphibians, reptiles and birds, or, at most, exists only as a rudiment in certain birds (night-birds), being represented by stiff "ear-feathers". The external ear is barely perceptible, or wholly lacking in the aquatic mammals (Sirenia and Cetacea). Other mammals possess membranous external ears supported by cartilage and folded into varying shapes; broadly speaking, the form of helix and antihelix can be observed.

The lower apes, like the majority of mammals, show more or less pointed ears; it is only in man and the Anthropoids that the concha is round (Figs. 95-98), but both the extent of folding and the size of the cartilage have become greatly reduced.

Fig. 95. Ape.

Fig. 96. Ape.

Fig. 97. Man.

Fig. 98. Man.

(Haeckel, *Anthropogenie*.)

A human characteristic which is by no means invariably present is the so-called Darwinian tubercle (see Fig. 99) on the free margin of the helix; this tubercle was regarded by Darwin as the analogue of the pointed tip of the ear in animals. Ludwig Meyer and Langer[1] objected that if this tubercle really represented the apex of the ear in brutes, it should not be situated somewhere on the middle of the outer border but should lie at the summit of the ear. They are therefore inclined to regard the tubercle merely as the remains of an interruption of the margin of the helix. If, however, one takes

[1] Ranke, *loc. cit.*, ii., p. 38.

the trouble to pull upwards and backwards the edge of the ear where the tubercle occurs, the shape of the brute ear is pretty accurately imitated, bearing out the suggestion of that unerring observer, Darwin.

The inability to move the ear is not characteristic of man, for there are many people who are able to move it, while chimpanzees and orang-outangs as frequently lack it as do the majority of men.

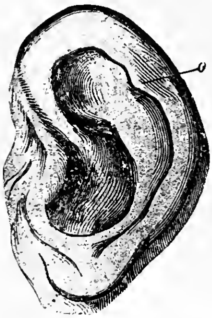


Fig. 99. Human ear. *o*, Darwin's tubercle.

A study of human phylogeny shows that the position of the pinna on the skull is a peculiarity which man has gradually acquired, for it is most probable that primitive man had an ear which projected away from the head and was freely movable.

Formerly, it was commonly stated that man was alone in possessing a lobule to the ear, but Darwin recognised, after Mivart had pointed it out, that the gorilla, whose ear most nearly approaches the human form, also possessed a lobule, and Ranke has demonstrated that it is not merely rudimentary but very often hangs quite free as in man.

There is, however, one detail in which the ear of all anthropoids differs from that of man, in that it is always placed considerably higher on the side of the head.

Ranke ascribes this position to the uniform curvature of the top of the cranium, so that the upper border of the zygomatic arch which in man is nearly parallel with the horizontal line of the head in the anthropoids shows a marked inclination downwards and forwards.

B. Comparative Physiology and Psychology.

1. Physiology.

General.

THE *elements* of which the tissues of man and the Vertebrates is composed are carbon, hydrogen, oxygen, nitrogen, sulphur, phosphorus, chlorine, sodium, calcium, magnesium, iron and minute traces of silicon and fluorine.

The average amount of *water* contained in the tissues of an adult man is 68 per cent. (Moleschott); the dry residue varies (excluding contents of stomach and intestines) from 28 to 65 per cent., of which 23 to 65 per cent. is organic matter, and 2 to 5 per cent. inorganic.

According to Dubois Reymond, plants form a fixed reducing apparatus with external roots which take from the air and the earth certain inorganic substances, and yield them up to the animal kingdom in organic form. Animals, on the other hand, constitute an oxidation apparatus not fixed to the earth with internal roots; and they take the organic compounds from plants and give back to the air and earth the inorganic material. Animals consume proteids, carbohydrates, fat and oxygen, and transform the chemical energy into vital forces, such as heat, electricity and muscle contractility; in these processes the original substances are decomposed into CO_2, H_2O, and NH_3, so that the exchange of energy and matter goes on and no atom is lost. "The weight of any new chemical compound formed by combination, or decomposition, is always exactly equal to the sum of the weights of the substances participating in the process."

Helmholtz has expressed very clearly the law of the conservation of energy: "Whenever free particles of matter move as the result of their own attracting and repelling force, whose intensity varies only with distance, the loss of potential energy is always equivalent to the gain of kinetic energy (*i.e.*, of work done) and *vice versâ*".

Moreover, the sum of the kinetic and potential energy remains absolutely constant. "Plants," says Helmholtz, "consume vital energy in so far as they store it up in the shape of a particular kind of potential energy, namely, chemical tension: animals convert the potential energy stored up in plants into vital force."

That man is no exception to this law is admitted, not merely by natural scientists, but by every thinking man, for in his whole living and being he is subject to the law of the conservation of matter and the conservation of energy. Man like other organic bodies is fated to growth and decay, to a rise and fall, and when the law that governs human growth is considered, it shows a curve with a double wave caused by the appearance of two separate periods of increased growth (E. v. Lange):[1] (1) at birth as a continuation of the very active fœtal period; (2) at puberty. Lange has shown that to each of these active periods succeeds a stage of quiescence: after the first comes a slower but still progressive development; after puberty the growth curve becomes changed to a horizontal.

The law of human growth is clearly seen if we consider the four generally accepted ages of man:—

1. Childhood, with its merry, careless life spent in eating and drinking, playing and sleeping, the stage being ended among civilised folk by the going to school with its troubles and restrictions.

2. The ripening to sexual maturity, an age full of psychical changes, marked, too, by enthusiasm for the "ideal".

3. The fertile years of married life, when the powers both of mind and body are at their height.

4. Lastly, old age, with a decline and increasing frailty of body, and a blunting of the mental activity, the memory failing, the train of thought no longer sustained.

It would be quite incorrect to suppose that the span of human life is materially different from that of animals; they,

[1] *Jahrb. f. Kinderheilkunde*, Bd. 57, 1903.

too, have their age periods, only these are sometimes infinitely shorter, and are reckoned by days instead of years.

The closest parallels are found in the life-story of the higher orders of animals, though even here there are many and important differences. The childhood free from care gives place at once to the stern battle of life, when the parents turn out of the nest or lair their offspring as self-supporting ; only among those animals that maintain the family ties do the youngsters remain longer under the family protection.

Puberty occurs, as a rule, earlier in the higher animals than in man, and forthwith the sexes seek and find each other ; they have no need, even if they could conceive such a thing, of "enthusiasm for ideals". But as in man these years represent the fulness of mental and physical vigour, and as in man the horizontal line of life gradually inclines downwards until it reaches the rapid slope of old age, till death occurs either at the hand of some more powerful beast or man, or from some physical misfortune and disease.

The strangest fables may be unearthed about the length of life attained either by man or beast in ancient times, as may be instanced from the ages of the so-called patriarchs or from such poets as Hesiod.

DE ÆTATIBUS ANIMALIUM.

Ter binos deciesque novem super exit in annos
Justa senescentum quos implet vita virorum ;
Hos novies superat vivendo garrula cornix,
At quater egreditur cornicis secula corvus.
Alipedem cervum ter vincit corvus, et illum
Multiplicat novies Phœnix, reparabilis ales,
Quam vos perpetuo decies præventitis ævo,
Nymphæ Hamadryades, quarum longissima vita est.
Hi cohibent fines vivacia fata animantum.

Reliable data can be obtained only as to the length of life in man, domestic animals and wild animals in captivity.

According to Ellenberger,[1] who seems to depend himself on Weismann's researches, the duration of life should be six times the period of growth, and he gives the following table of maximum ages :—

[1] Ellenberger, *loc. cit.*, ii., p. 585.

Man	104-110 years
Horses and bears	50 ,,
Oxen	40 ,,
Lions	35 ,,
Wild boar	25 ,,
Pigs and dogs	20 ,,
Sheep and goats	15 ,,
Cats	15 ,,
Foxes	14 ,,
Hares	10 ,,
Squirrels and mice	6 ,,

Among birds much greater ages are attained :—

Falcon	162 years
Vulture and raven	110-118 ,,

FIG. 100. How a quadruped stands.

Birds are, as a rule, longer lived than mammals (especially parrots, geese and owls), and we must not forget the turtle in the Zoological Gardens of London, which recently reached the mature age of 150 years, as well as the huge Sychellion and Aldabra forms, some of which must exceed 300 years.

The view of Metchnikoff that life might be infinitely protracted but for the bacteria in the intestines can scarcely be regarded as explaining all cases of senile decay, for the chief cause of muscular weakness, of arterio-sclerosis, of failing mental powers must still remain in man and beast the daily wear and tear of life which slowly exhausts the tissues.

I. The Skeleton and Muscles.

Physiologically, these two systems cannot be separated, and they must be dealt with in the same chapter. For without the muscles the bones are a lifeless framework, and the muscles (save, of course, the heart, the diaphragm and unstriped muscle of the entrails) cannot be considered without reference to the bones which they set in motion.

As we have seen previously, the skeleton of man and the other Vertebrates is built after the same plan: a head, vertebral column, shoulder girdle, ribs, pelvis and limbs (whose cardinal number of four is never exceeded). Both in mammals and man the pelvis is rigid, while the shoulder girdle is loosely articulated with the spine. In the standing position in quadrupeds, the centre of gravity of the body is maintained by muscular effort vertically above the supporting surface enclosed by the four outspread feet (the foot quadrilateral) (see Fig. 100). The usual attitude of the head brings the centre of gravity slightly nearer to the forequarters than to the hind; this may be proportionately represented as the weight of the fore and hind-quarters.

Horses	10 : 7
Oxen	10 : 8·6
Pigs	10 : 6·9
Dogs	10 : 4·9 or 5·9

In birds the centre of gravity falls in front of the hip-joint (Fig. 101), the ability to stand on one leg being secured by special mechanism of the joints of the leg and foot.

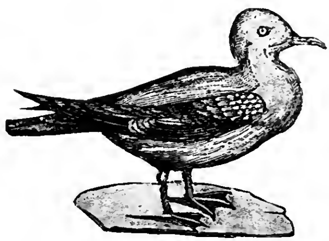


FIG. 101. How the bird stands.

Weber states that the centre of gravity of man lies in the true pelvis, close in front of the promontory of the sacrum; in standing it falls through the soles of the feet so that the fixed arches of the two feet form the only support to the body; if the toes are turned out at right angles when the heels are together, the supporting surface is greatly increased. In order to stand still more firmly, the legs are spread apart as in sailors or fencers. When a man wishes to stand on one leg, the centre of gravity has to be inclined to the supported side, either by bending the back-bone laterally, or by pushing over the opposite side of the pelvis.

The superiority of the erect position in man over that of other mammals (apes, bears) consists in his ability to completely straighten the thigh. In other animals the knee remains bent when standing upright, and a constant muscular effort is required to prevent its further flexion.

Man, however, can completely extend his knees, and his body-weight has rather the tendency to over-extend his joints, a movement which is mechanically opposed, not by constant muscular activity, but by the tendinous lateral and popliteal ligaments. When sitting, the weight of the upper part of the body rests on the tubera ischii, as a rocking-horse on its rockers.

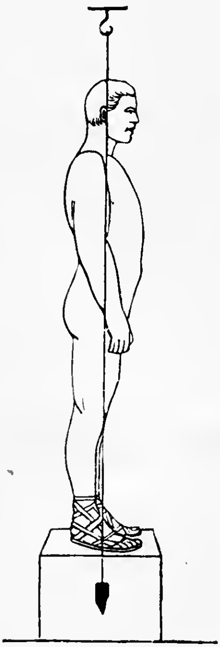


Fig. 102. Man standing naturally. (Munk-Schultz.)

The centre of gravity of the upper portion of the body lies in front of the tenth dorsal vertebra, and the body is maintained in its position of unstable equilibrium by a muscular effort which fixes the spine, so that the sitting posture becomes very fatiguing unless the back is supported. Every movement of the human or animal body is attended with a change in the centre of gravity, and an alteration in the position of the joints involved in the movement; the mechanism of the joints is controlled by the same general rules, both in man and beast. But in certain details characteristics peculiar to man can be observed.

The articulation between the trapezium and the os primi metacarpi is a saddle joint allowing movement in two planes, so that in addition to flexion and extension, not only lateral movement but even a limited degree of rotation are possible. The ankle joint between the tibia and os calcis is in man a simple hinge joint, while in animals it is a screw-ginglymus, the heel forming a segment of a screw, the articular surface of the tibia being a segment of a corresponding socket.

The human knee is a spiral joint, the antero-posterior curve of the condyles of the femur presenting in sagittal section a spiral outline. The articular surface of the lower jaw is similar in man and the other omnivora, the head is oval with its long axis placed obliquely, and it is capable of moving in the glenoid cavity either up and down, from side to side, or backwards and forwards; so, too, man shares with apes, dogs and cats the diarthrodial (lateral-ginglymus) joint between radius and ulna, with apes the amphiarthrodial articulations between the bones of the carpus, and with mammals generally the tarso-metatarsal joint.

The hip-joint in all mammals, including man, is a ball in socket (enarthrodial) articulation.[1]

But it is by his shoulder-joint that man is distinguished from all other Vertebrates, even the highest apes, for by its peculiar ball and socket form free rotation of the upper limb is possible, a movement of which no other mammal is capable.

The study of the process of locomotion must begin with the jelly-like projections (pseudopodia) in the Protozoa, thence we pass to the water-animalculæ, whose movements depend on changes in specific gravity brought about by osmosis and alterations in the air-content. When we consider movement in its strictest sense, we have to deal with all the component elements of the animal body which arise from protoplasm. They are endowed with the common property of *irritability*, that is to say, the power of contraction to certain stimuli. So that we find possessed of this capacity for independent movement leucocytes and lymph cells, mucous membrane and connective tissue cells, ciliated cells, striped and unstriped muscle fibres.

It is the contraction of the striped muscle which in animals that possess a skeletal frame, and in man, brings about changes in the position of the joints and so procures movement. The source of this muscular energy is not derived from disintegration of nitrogenous material, but from the oxidation of carbon compounds (the carbohydrate in the muscle). For the performance of work all animals require a sufficiency of carbon-containing food (carbohydrate, fat); the potential energy of any muscle is by reason of the parallel arrangement of its fibres increased in proportion to its transverse diameter, but it decreases as the muscle contracts.

Weber has estimated the amount of contraction, and has

[1] Munk-Schultz, *loc. cit.*, pp. 379-83.

found that in all muscles the maximum is about three-quarters of the natural length in muscle dissected off from its attachments, and about one-half of the natural length when the muscle is in its usual position attached to the skeleton.

Gerstner has made a comparative estimate of the load-drawing capacity of man and three domestic animals. For an eight hours' day the following figures were obtained:—

Men	with	70	kilo load	316,800	metre kilogrammes
Asses	„	180	„ „	792,600	„ „
Oxen	„	300	„ „	1,267,200	„ „
Horses	„	375	„ „	2,016,000	„ „

The mechanism of the muscles is very similar in man and

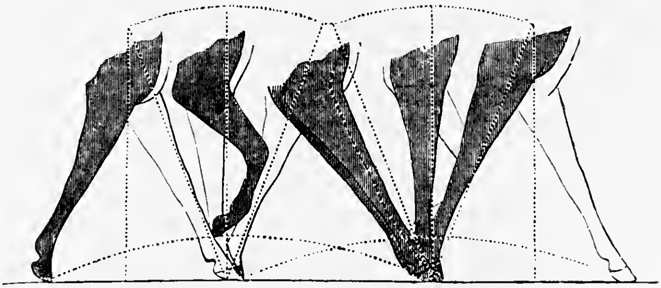


FIG. 103. Fore-legs of horse, stepping and supporting. (Munk-Schultz, *Physiologie*.)

other mammals in that the majority of bones work as one-arm levers. There are also two-arm levers to be found, as for example, in man and apes, where the triceps muscle attached to the olecranon forms the power, applied to the short arm of the lever, while the rest of the ulna represents the long arm with the weight at the hand: also the gastrocnemius and soleus in flexing the foot where the ankle-joint is the fulcrum, the heel is the short arm and the rest of the foot the long arm of the lever.[1]

Broadly considered, the gait of man, beasts and birds is similar; a pendulum movement can be seen in them all, and the greater the contraction of the leg the shorter will be the swing. But closer comparison reveals very essential differences.

[1] Munk-Schultz, *loc. cit.*, p. 387.

In birds, where the centre of gravity lies in front of the hip-joint, movements of the head, neck, wings and tail are called into play to preserve the balance. In beasts, two legs swing while the other two simultaneously support the body (Fig. 103). The propulsive force is obtained from the hind-legs, while the fore-legs merely support the hindquarters as they are thrust forward. There is a regular alternation of the pairs of legs, first a hind-leg then a fore-leg in such fashion that while the one hind-leg is swinging the fore-leg of the "pushing off" side swings too. Comparing the distance between the prints of each individual foot the track of quadrupeds is twice as long as that of men, amounting in a horse without a load to $1\frac{2}{3}$ metres, with a load only ·5-·8 metre.

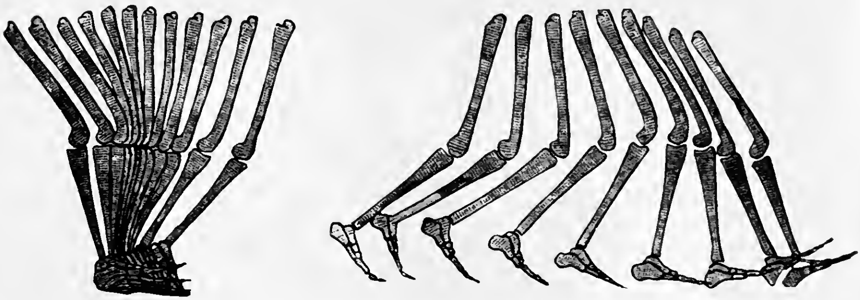
FIG. 104. Erect gait of gibbon.

FIG. 105. Erect gait of orang-utan.

The erect gait is no monopoly of man, for the anthropoid apes (Figs. 104, 105) and bears can also walk upright. But there is this all-important difference, that apes and bears can only adopt this attitude for a short time as it is too fatiguing to be long maintained, while it is man's natural position and his body is admirably adapted to movements in the erect position. The body rests on one leg (the supporting or thrusting leg) (Fig. 106), while the other (the hanging leg) (Fig. 107) swings forwards. Each leg is alternately supporting and at rest, and the centre of gravity of the body is constantly moving from one side to the other, rising, lowering or turning. A consideration of the movements in detail shows that there is a phase in which only one foot touches the ground alternating with a phase in which both feet are on the ground, the one leg becoming perpendicular just as the other foot is about to leave the ground. Moreover, when the left supporting leg is in the act of thrusting forward the left side of the pelvis, the right arm swings forward so as to re-adjust the centre of gravity.

The *trot* in animals corresponds generally with running in man, but there are certain contrasts due to differences in structure; in trotting, the legs of quadrupeds swing in diagonal pairs, while the other pair has not yet reached the ground. In man there is a moment in the act of running when both feet are simultaneously in the air, one foot having just left the ground while the other has not reached it.

The *leap* of quadrupeds, when the hind and fore-legs are



FIGS. 106 and 107. How a man walks. (Munk-Schultz.)

raised off the ground together, is only possible when the body is upright. The leap in man may either be performed on the same spot, or it may include a forward motion covering a considerable distance: in the latter case the whole body-weight is carried forwards, and the body is swung on a transverse axis.

Swimming is effected in man by rapid kicking-out with the feet backwards; animals, however, paddle with all four legs at once.[1] Most mammals can swim directly they find themselves in the water: the mole, for instance, is an excellent swimmer. Most apes, too, swim well, except a few of the baboons, and among anthropoids the orang, gibbon and gorilla. These, if by chance they fall into the water, sink and are drowned just like the camel that makes no attempt to swim.

[1] Munk-Schultz, *loc. cit.*, pp. 390-405.

There is certainly no reason why these animals should be incapable of swimming, but it seems as though the fear of the water prevented their doing so just as in the case of a man who has not learnt to swim.

II. Integumentary System.

Touch and temperature sense are excluded from this chapter on the physiology of the skin, as they have been already dealt with in the physiology of the senses. There remain to be considered certain functions of the skin which concern the secretion of sweat and sebum, the growth of hair, the shedding of the epidermis, resorption, and transpiration by the skin.

Perspiration is possible in man, as in horses and sheep, over the entire surface of the body, though certain areas sweat more freely than others; especially the face (the forehead and ridge of the nose), the axilla, and, as in apes, the palm of the hand and sole of the foot. Among animals the ox sweats much less freely; carnivora (including dogs and cats) perspire in the sole of the foot only; goats, rabbits, rats and mice do not at all.

Von Krause has reckoned the total number of sweat-glands in the human skin at approximately $2\frac{1}{3}$ millions, by no means too high an estimate probably when it is remembered that in the palm of the hand there are 310, and in the sole of the foot 300 per square centimetre.

In both man and animals the amount of sweat secreted varies considerably, being dependent partly on external conditions (temperature and moisture of the air), partly on internal stimuli (for example, hot drinks and muscular exertion). Even psychical impulses have to be included in animals as well as in man; these act through the stimulation of certain efferent nerve-fibres—so-called secretory nerves—which join the motor nerve-fibres as the anterior roots leave the spinal cord, and are connected with certain sweat-centres in the cord. That these sweat-centres do not act solely by direct stimulation but also by reflex stimulation of the skin and sensory nerves has been proved by experiment both for man and animals.

In the thoracic and abdominal sympathetic nerves, according to Luchsinger and others, there are secretory-fibres for the sweat-glands of the face, buttocks and extremities;[1] Foster, however, attributed the activity of the sweat-glands to vasomotor changes alone.

The exact amount of sweat secreted daily cannot be exactly determined on account of the numerous influences to which it is subject, especially as without the appearance of sweat a considerable amount of water is excreted by the skin in transpiration. Moreover, it must be remembered that both in man and animals a certain antagonism exists between kidney and skin excretion.

For instance, in man, after excessive muscular exertion the urine is diminished while the sweat is increased, and the urea present in the latter is relatively $\frac{1}{70}$-$\frac{1}{21}$ that of the urine (Argutinsky).[2]

In addition to a varying water-content, the sweat contains certain inorganic constituents, sodium chloride, phosphates of the alkaline earths and iron oxide; while its organic constituents besides urea are fluid fatty acids, cholesterin, neutral fat and albumin.

As specific constituents of human sweat there occur also creatinin, aromatic oxides, æthereal sulphates of phenol and skatoxyl, together with occasional variable amounts of an acid whose composition is represented by the formula $C_{10}H_{16}N_3O_{13}$. To which of these constituents is to be attributed the toxicity of human sweat described by Arloing requires further investigation.

The secretion of fat by the skin, which in many animals, especially sheep, acts as a means of lubricating the skin and fleece as well as a protection against the wet, plays in man generally a small part, and no definite estimations of its amount have been made. [Rosenfeld[3] states that the total fat excreted by the skin of a healthy European adult varies from 1 to 2·5 gm. per diem: ordinary exercise does not affect the excretion, but the amount of fat is considerably diminished if carbohydrates are withheld from the diet.] The amount varies not merely in individual but in races, being greatest in negroes whose sebaceous glands are so active that their skin is quite soft and greasy to the touch. The characteristic *odour* which

[1] Munk-Schultz, *loc. cit.*, p. 528. [2] *Ibid.*, p. 262.

[3] Rosenfeld, *Zentralbl. f. innere Med.*, 1906, xxvii., 986.

distinguishes man from animals, race from race, and even individuals of the same nationality one from another, depends upon variations in the fat and sweat secreted by the skin. It is remarkable that just as the European finds the odour of the African negro most unpleasant, so does the Japanese complain of the smell peculiar to European skins.

It has been well known for many years that the *odour of the skin* depends on altered fats, albuminates and lecithin which enter the blood in gaseous condition and are excreted again with the sweat and sebum. Gustav Jäger [1] has minutely studied this subject, and it forms the basis of his claims to have discovered the "soul," which he regards as the exhalations peculiar to every animal as well as man. The soul he believes to reside in the combined albumin molecule which is liberated upon the decomposition of the albumen, so that the exhaled substances consist of the soul itself even though the soul is in a condition of disintegration.

There are no data as to the extent of the *daily desquamation of epidermis and shedding of hair and nails* in man. [Von Noorden estimates the amount in terms of nitrogen at 1-2 decigrammes daily.] We only know that in general these keratinous structures "wear out" in animals at a varying rate —probably constant for the individual—and that they either fall off spontaneously or are rubbed off mechanically. In a dog weighing thirty kilos, Voit puts the daily waste of hair and skin at 1-2 gm. In oxen the daily loss of hair varies, according to the season of the year, between 2 and 20 gm.; in horses the daily average is 5-6 gm.

There is a difference between man and animals in that the latter usually show a double growth of hair, in spring and in autumn; while in man the hair falls out and grows again fairly evenly throughout the year. A certain seasonal influence can however be traced, for in spring and summer the rate of growth is 27 per cent. more than in autumn and winter.

The daily formation of keratin in the hair of the head is about 40 mgm. (Beneke), that of the finger and toe-nails 5-9 mgm. (Moleschott).[2]

Whether the intact skin has the power of *absorption* has

[1] Jäger, *Die Entdeckung der Seele.* [2] Munk-Schultz, *loc. cit.*, p. 264.

been keenly debated; experiments show beyond doubt that the skin of animals and man alike allows the passage of gases through its pores.

After carefully sealing up all mucous apertures it has been found that certain fluids (water and watery solutions) are scarcely or not at all absorbed by the intact skin on account of the natural fat on its surface, while other fluids readily miscible with the fat (alcohol, ether, chloroform, oil of turpentine) are easily absorbed, just as happens with ointments rubbed into the pores of the skin.

The *transpiration* of the skin whereby CO_2 and H_2O are excreted has been exactly determined by careful experiment in man and animals. The maximum is reached in those lower classes whose integument is a single layer of epithelium; it becomes less as the epidermis is thicker or a hairy coat is developed. The greater the depth of skin or hair that covers the cutaneous capillaries the less is the amount of transpired CO_2.

In horses, for instance, it is only $\frac{1}{150}$ of the respiratory CO_2 output, while in man in twenty-four hours the amount excreted through the skin is from 5-10 gm., *i.e.*, $\frac{1}{2}$ to 1 per cent. of the total CO_2 output.

The *water-loss* through the skin is, according to Henneberg:

In oxen	by respiration and perspiration	5·6 kilos	daily
,, horse (at rest)	,, ,, ,, ,,	up to 10 ,,	,,
,, ,, (at work)	,, ,, ,, ,,	twice this amount	,,
,, man (at rest)	,, ,, ,, ,,	about 600-660 gm.	,,

These quantities are nearly twice the "water-loss" by the lungs.[1]

In the sections on Anatomy it has been pointed out that man only possesses a very limited *power of moving the skin* by subcutaneous muscles. The frog possesses a number of purely cutaneous muscles, many reptiles can move their shells, scales or skin appendages, while birds are provided with many cutaneous muscles for moving their feathers or spreading their wings. In many animals unstriped muscles exist in the skin of the head, neck, shoulders and abdomen, so that in some instances (the hedgehog and porcupine) a complete cuirass of cutaneous muscle enables the body to be rolled up in the well-known fashion.

[1] M. Sussdorf in Ellenberger's *Physiologie*, ii., p. 678.

In man, and to some extent in the anthropoids, the skin muscles have undergone more or less complete retrograde metamorphosis, until in man the power of even moving the scalp backwards and forwards is an accomplishment denied to all but the few. But the development of facial muscles capable of conveying innumerable shades of expression is, like his speech perhaps, peculiar to man.

All these mimetic movements of the face are performed by striped voluntary muscles. Another kind of movement on a small scale is executed by smooth muscle-fibres which by their contraction (either from internal or external stimuli) can make the hairs move and the follicle as a whole rise up like a papilla, constituting the so-called "goose-flesh," or like the wrinkling of the scrotum which results from contraction of the dartos muscle.

III. Vascular System.

The human vascular system is an enclosed one, and like the higher Vertebrates the circulation is twofold. In reptiles the

FIG. 108. Aortic valves. (From Ranke.) a, half open; b, closed.

blood passes into the systemic circulation by both aortic arches, and in birds by the right arch, but in man and all mammals the aorta springs from the left side of the heart.

In man and horses the greater part of the systolic period is occupied by systole of the ventricle, only about one-third by auricular systole.

The corpora Aurantii, small nodules on the centre of the free border of each semilunar cusp, are peculiar to man and occur in no other animal.

An apex-beat like that of man is best seen in carnivora;

in ruminants it is hardly visible on account of the thick layer of thoracic muscles. The frequency or rate of the heart-beat varies with the size of the animal; the following figures are those of Sussdorf:—[1]

Elephant	25-28 per minute
Horse	26-40 ,, ,,
Ass	46-50 ,, ,,
Ox	40-50 ,, ,,
Sheep, Goat, Pig	70-80 ,, ,,
Dog	90-100 ,, ,,
Cat	120-140 ,, ,,
Rabbit	120-150 ,, ,,
Birds	120-180 ,, ,,

In man the rate varies, according to size and weight, from seventy to seventy-five.

The time occupied in complete circulation of the blood is, according to Vierordt:—

Dog	15-17 seconds
Goat	14 ,,
Rabbit	8 ,,
Squirrel	4½ ,,
Man	23 ,,

The average blood pressure is as follows:—

In the human aorta	about 180 mm. Hg.
,, carotid of horses	150-190 ,, ,,
,, ,, ,, dog	120-170 ,, ,,
,, ,, ,, sheep	170 ,, ,,
,, ,, ,, cat	150 ,, ,,
,, ,, ,, rabbit	90-110 ,, ,,

The radial pulse of an adult man averages seventy-two beats per minute, and of a woman a beat or two more.

The nerve-supply of the heart is derived from the vagus, or tenth cranial nerve, together with fibres from the sympathetic. Division of the vagus in man, dogs and cats causes an extraordinary increase in the heart's frequency, but if the peripheral

[1] Sussdorf in Ellenberger's *Physiologie*, ii., p. 239.

end of the divided vagus is stimulated, the heart's action is slowed down until the heart finally comes to a stop fully dilated in diastole. From this one may conclude that normally the vagus transmits inhibitive stimuli which control the heart, and that these, upon division of the vagus, no longer prevent the heart from rapid beating. The division of one vagus causes the blood pressure to fall, the division of both causes a still further fall.

The total volume of blood in man and various Vertebrates bears the following proportion to the body-weight (Collin):—

Adult man	average	one-thirteenth	of the body-weight, including contents of stomach and intestine
Horse	"	one-eighteenth	
Ox	"	one-thirtieth	
Sheep, goat	"	one-twenty-fifth	
Pig	"	one-twenty-eighth	
Dog	"	one-eighteenth	
Cat	"	one-twentieth	
Rabbit	"	one-thirty-second	
Birds	"	one-twenty-ninth	

The physical and chemical properties of the blood of man and Vertebrates generally is fully described in the text-books of physiology.

The colour of the blood in all Vertebrates is red except in the amphioxus. But apart from the difference in colour between arterial and venous blood many gradations in the brightness of the arterial blood may be met with. Among domestic animals it is brightest in the dog, darker in horses and pigs, and darkest in oxen; human arterial blood has its own particular tint.

There is something quite characteristic, although impossible to describe, in the smell of the blood in different species of animals; the taste is saltish, the reaction alkaline.

The specific gravity does not vary greatly:—

Man	= 1055
Horse, pig, dog	= 1060
Goat	= 1042
Cat	= 1054
Rabbit	= 1049

The temperature of the blood in mammals ranges between 37° and 40° C., and in birds between 41° and 43° C.

Important differences exist in the coagulation-times:—

Human	blood coagulates	in	2-3	minutes
Dogs, rabbits	,,	,,	,,	4-5	,,
Pigs, oxen	,,	,,	,,	8	,,
Horses	,,	,,	,,	15	,,

The blood of birds, reptiles, amphibians and fishes takes considerably longer to clot, *viz.*, from two to eight days.

The serum, which in all mammals contains 0·6 per cent. sodium chloride, is alkaline, and in man has a specific gravity of 1028 (average).

The hæmoglobin in man and animals is identical in almost every way. But there are differences, chiefly shown in crystallisation: the crystallisation time and the form of the crystals vary; in man they are prismatic, in oxen and dogs rhombic prisms, in horses flattened, in porpoises and rats half pyramids (tetrahedra), in squirrels flat (hexagonal system).

Quite recently Friedenthal discovered that the mixing of blood of nearly allied animals is innocuous to the animal into whom another's blood is injected, but that in non-allied animals foreign blood so injected causes disintegration of the blood corpuscles. The following interesting facts are quoted from Uhlenhuth's [1] excellent account of his biological researches.

When blood is introduced into the circulation of an animal, certain specific products appear in the blood of the subject so treated:—

i. A body which destroys the blood corpuscles—hæmolysin.

ii. A body which causes them to run together and cohere—agglutinin.

iii. A body which precipitates the albumin of the blood—precipitin.

Upon injecting a rabbit with human blood a serum is produced which will only react in this manner with human blood.

This method has been used to establish the blood-relationship of various animals. Uhlenhuth has shown that the serum from a rabbit injected with human blood will produce a pre-

[1] *Corr.-Blatt. f. Anthropol.*, etc., 1904, pp. 114-18.

cipitate in the blood of apes but in no other animal besides. Nuttall carried this point further and demonstrated the degree of blood-relationship between man and the various apes. With a similar serum he found that the blood of all the anthropoid apes gave quite as great a precipitate as that of man; the reaction was slightly less pronounced in the Cynopitheca (baboons) and cat-like long-tailed monkey, became considerably weaker in the "new world" (platyrrhine) apes, and was totally absent, or barely perceptible, in the Lemuroidea (hesperopitheca).

Uhlenhuth amplified the experiment by showing that the serum of a rabbit injected with horse's blood will produce a marked precipitate in horses, and a feebler reaction in asses, and in like manner a relationship was established between the ram, goat and ox, between the dog and fox, and so forth.

The possible application of this reaction in forensic medicine promises to be of considerable value in the examination of bloodstains with a view to determine their human or mammalian origin, and even, if need be, to identify the particular species.[1]

In the human economy there must be a constant "using up" of the blood corpuscles, and the question presents itself, where does the final destruction take place? The liver and spleen are generally recognised as the chief sites of hæmolysis. This view is supported by the fact that in the spleen of man and many animals yellowish granules of iron oxide occur, while the proofs of blood destruction in the liver are held to be—

1. The identity of the bile pigment *bilirubin* with the blood pigment *hæmatoidin*.

2. Hirt's discovery that in the blood of the hepatic vein the leucocytes are three times as numerous as in the portal vein. The red corpuscles are probably both in the liver and spleen eaten up by the white corpuscles (phagocytosis of erythrocytes).[2]

To make up for the red corpuscles destroyed new ones are formed, primarily perhaps from leucocytes and secondarily from nucleated red cells. There are many centres where this manufacture of erythrocytes may take place, *e.g.*, in the lymphatic glands, the villi of the intestines, in the solitary follicles, and Peyer's patches, in the spleen and thymus, and in

[1] *Fortschritte der Medizin*, 3, 1904. [2] Munk-Schultz, *loc. cit.*, p. 221.

the red bone-marrow where Naumann has found red blood corpuscles containing hæmoglobin and nuclei. All these conditions suggest that in man and in other mammals there exists a circulation of lymph, common also to birds, which is maintained in movement by changes in the blood pressure in the capillaries, as well as by respiratory and muscular movements: in reptiles and amphibia there are, however, definite "lymph hearts" controlling the circulation of lymph.

The total mass of lymph is difficult to ascertain, the only method available being by collection of the fluid from a lymph fistula. A medium-sized dog produces per kilogramme and hour about 2½ kilocentimetres of lymph.

A horse (Colin)	in 24 hours	16-42	kilogm.
An ox	,, ,, ,,	20-25	,,
A sheep	,, ,, ,,	3-4½	,,
A man	per hour	70-120	gm.[1]

Certain so-called vascular glands contribute to the circulation "internal secretions," specific substances which exert regulating or protective functions in the economy of the body. These glands are the thyroid, the pituitary body (hypophysis), and the adrenals.

The thyroid gland secrets a colloid containing iodine from which Baumann has isolated a proteid combined with iodine (iodothyrin); the view now generally accepted is that the function of this gland is to remove the nerve-toxines of the general metabolism and to render them innocuous. This hypothesis is based upon the observation that a man or animal whose thyroid is completely removed dies by cachexia. When, as sometimes chances, an animal survives total extirpation of the thyroid (as rodents may), the explanation is to be found in the existence of parathyroids capable of making good the loss.

The pituitary body may act in like manner, but the proof is not conclusive, for the destruction of this gland appears to produce no symptoms: injection of its extract causes an immediate fall in blood pressure, followed by a rise together with a slower and more forcible beat of the heart.

The adrenals yield from their medulla a substance soluble in water (adrenalin), of which minute quantities injected sub-

[1] Munk-Schultz, *loc. cit.*, p. 209.

cutaneously into animals cause constriction of the arterioles and a rise of blood pressure in the large arteries. As a remote effect there is observed stimulation of the heart muscle, of unstriped muscle generally, and inhibition of the movements of respiration by interference with the centre in the medulla; but it is very doubtful whether such an amount of so powerful a substance is ever obtainable at one time from the normal glands.

IV. Respiratory System.

The stages in the evolution of the organs of respiration throughout the animal kingdom have been already dealt with from the anatomical point of view: the mechanism of respiration may be considered as follows (disregarding those Protozoa in whom the respiratory exchange takes place indifferently over the whole surface of the body):—

(*a*) Animals with a *water-vascular system* where sea-water containing about 2½ per cent. of oxygen (by volume) circulates through the channels of this system to the internal organs and diffuses throughout the tissues.

(*b*) *Tracheata* with their elastic trachea branching in every direction throughout the entire organism, so that the finest subdivisions reach individual cells and, according to Cuvier, the air comes directly into contact with the tissues.

(*c*) *Branchiata* standing a step higher in development with the capillary blood vessels lying immediately under the superficial epithelium of the gill, each division of which may be regarded as a lung turned inside out.

(*d*) The highest stage is reached in the *Pulmonary system*, which is found in gradually increasing development from amphibia, birds and reptiles, up to the mammals, and finally man. These have all alike internal lungs in which the gaseous exchange is carried on, the air being sucked in and driven out by the mechanism of the diaphragm and costal muscles.

TABLE OF RESPIRATION-RATES PER MINUTE.[1]

Horse (resting)	6-10
Ox	10-15

[1] Sussdorf in Ellenberger's *Physiologie*, ii., p. 616.

Sheep and goat	12-20
Dog	15-28
Cat	20-30
Rabbit	50-60
Whale	4-5
Man	12-19

The intensity of the respiratory process, calculated on the basis O-intake per kilogramme and hour, shows the following marked variations in the different species of animal:—

Frog	O-intake per	kilogm. and	hour		0·07 gm.
Horse	"	"	"	"	0·35 "
Man	"	"	"	"	0·42 "
Sheep	"	"	"	"	0·49 "
Ox	"	"	"	"	0·55 "
Cat	"	"	"	"	1·01 "
Cockchafer	"	"	"	"	1·02 "
Dog	"	"	"	"	1·19 "
Hen	"	"	"	"	1·19 "
Small song bird	"	"	"	"	11·64 "

Pflüger gives the following table of the respiratory quotient, *i.e.*, the relative volume of expired CO_2 to inspired O:—

Herbivora	0·90-1·0
Carnivora	0·75-0·8
Man (omnivora)	0·82 (average)

When a man breathes deeply, the depth is proportionate to the increase in the transverse and antero-posterior diameters of the chest at the expense of the longitudinal.

The average circumference at the height of the ensiform cartilage, measured when resting, is in men 82 cm., in women 76 cm. (see Fig. 109); extreme inspiration increases the measurement by about 8 and 7 cm. respectively.

The inspiratory and expiratory capacity can be determined with the spirometer. The vital capacity, *i.e.*, the maximum volume of air which can be inspired and expired at a single breath, averages in men 3,700 c.c. and in women a trifle less.

The vagus (tenth) nerve serves in man and animals as the motor and sensory nerve of respiration. The laryngeal branch

[1] Munk-Schultz, *loc. cit.*, pp. 111-13, footnote.

of the vagus supplies in man apes, dogs, cats and rabbits the cricothyroid muscle which opens the vocal cords and raises the larynx (see Figs. 110 and 111). All the other muscles of the larynx are innervated by the recurrent laryngeal which sends sensory fibres to the mucous membrane of the larynx, trachea, bronchi and lungs.

The action of the vagus nerves is not to stimulate respiratory movements, only to inhibit and control them. There is a spot in the floor of the fourth ventricle in the medulla oblongata upon destruction of which respiration immediately stops.

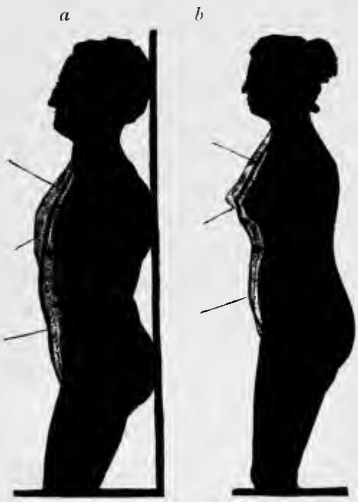


FIG. 109. Human respiratory movements. (Munk - Schultz.) *a*, in man; *b*, in woman.

Respiratory movements are excited simply by the CO_2 content of the blood; all other impulses have only a regulating effect. The respiratory centre is being constantly stimulated by the CO_2 in the blood: hence the act of inspiration. Expansion of the lung is associated with some stimulation of the pulmonary terminations of the vagus which checks inspiration; expiration then follows passively. As the lung contracts, the stimulus is withdrawn from the vagus endings, inhibition spontaneously ceases and the act of inspiration starts anew (auto-regulation of respiration by the vagus).

In forced breathing the sterno-mastoid and posterior portion of the trapezius muscles (both supplied by the eleventh, or spinal accessory, nerve) come to the aid of the breast and rib muscles.

Respiration not only provides the body tissues with the oxygen necessary to their life but by means of the oxidation processes is responsible for the vital heat. Even in cold-blooded creatures the body heat, as the result of these processes, always remains slightly higher than the surrounding air or water, if only by the tenth part of a degree. The temperature of such creatures rises and falls with the medium in which they live, but that of the warm-blooded animals (like man, *homoiothermic*) remains constant within very strict limits. This means that some mechanism exists whereby heat-production and heat-loss proceed simultaneously and exactly balance one another.

TABLE OF AVERAGE TEMPERATURES.

Horse (in stable)	37·96° C.
„ (in the open)	37·40° C.
Ass	36·95° C.
Ox	38·2-39·3° C.
Sheep	37·3-40·5° C.
Goat	39·2-40·0° C.
Dog	37·5-39·5° C.
Cat	38·3-38·9° C.
Rabbit	37·5-39·5° C.
Porpoise	38·5-39·4° C.
Man (adult)	37·2-37·5° C.

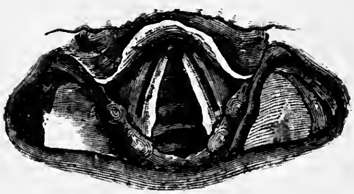


FIG. 110. Larynx in inspiration. (Munk-Schultz.)

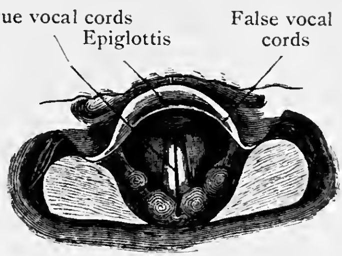


FIG. 111. Larynx during phonation. (Munk-Schultz.)

The heat-production of a man aged twenty to twenty-one years and weighing 60 kilogrammes amounts to 2,210 calories per diem.

The variations in the body temperature of man and mammals, at different times of day or night, depends on the food taken and the muscular activity. According to Munk[1] the daily fluctuations in man are as follows:—

Early morning	36·8° C.
Forenoon	37·1° C.

[1] Munk-Schultz, *loc. cit.*, p. 318.

3 p.m.	37·5° C.
8 p.m.	37·3° C.
11 p.m.	36·9° C.
During the night	36·7° C.

The effect of muscular exertion is to raise the temperature

In man by 0·5-1·0° C.
„ horse „ 1·0-1·5° C.

In old age both man and animals show a slight diminution in the average temperature.

The smaller the animal, the greater is the heat-loss per kilo body-weight and per hour,[1] thus:—

Horse	1·3	calories per kilo and hour.
Adult man	1·5	„ „ „
Dog	1·7	„ „ „
Rabbit	5·6	„ „ „
Porpoise	7·5	„ „ „
Duck	6·0	„ „ „
Pigeon	10·0	„ „ „
Rat	11·3	„ „ „
Mouse	19·0	„ „ „
Sparrow	35·0	„ „ „

Man with his hairless body is compelled to wear clothes in temperate and cold climates in order to prevent heat-loss by radiation. Despite the fact that these garments, as Schuster has shown, conduct heat a hundred times better than the air, still they accomplish their purpose because under the clothes a layer of air is kept more or less at rest in immediate contact with the skin, just as in the fur and feathers of beasts and birds.

This adaptation of clothing to the external temperature enables man to live in all climates, provided that the blood-heat does not fall below or rise above certain limits.

The lowest blood temperature compatible with life for man and mammals is 20° C. if the conditions for breathing are favourable.

Long exposure to moisture-laden air at 40° C. is fatal in 2-4 hours, after which time the body temperature, owing to absence of heat-loss, rises to 45°-46° C. At higher temperatures (49°-

[1] Munk-Schultz, *loc. cit.*, p. 322.

50° in man) death occurs rapidly from coagulation of the cell albumins.[1] The conversion of heat into capacity for work is subject to the law of conservation of energy no less in the animal organism than in non-living matter. Helmholtz has calculated that with his muscles man is able to perform an amount of mechanical work equivalent to a fifth part of the total power produced by the chemical energy in the whole body in the same period of time; in the horse the ratio of mechanical (external) work to the chemical energy is only one quarter.[2]

Finally, we have to consider the production of certain sounds by the respiratory mechanism, some of which only occur in man, some in other animals; part of them voluntary, part involuntary. (Other variations in the movements of respiration will fall under the heading of "Expression of the Emotions".)

The power of voluntarily clearing the throat of mucus, "hawking," is peculiar to man, although closely allied to it is the involuntary "coughing" of man, horses, sheep, goats and dogs; while the sound of the ape's cough is scarcely distinguishable from that of man's.

"Sneezing" occurs in sheep dogs and cats as well as in man. "Yawning" with a short deep inspiration and forcible expiration is quite as pronounced in dogs as in man.

"Snorting" is an accomplishment we share with dogs and pigs, while all animals are capable of "sniffing," a device consisting of a quick succession of short inspirations which improves the olfactory perceptions.

V. Intestinal System.

In order to maintain the equilibrium of the body, man and all animals have to replace the waste of solid and fluid constituents by eating and drinking. Animals that feed exclusively on flesh (carnivora) require very large amounts of meat to maintain the body-weight and smaller amounts of fat and carbohydrate. In herbivora, the protein consumed in

[1] Ranke, *loc. cit.*, i., p. 348.

[2] Tereg in Ellenberger's *Physiologie*, ii., p. 66.

addition to fat and carbohydrate must not fall below a certain level, according to Henneberg, $\frac{1}{4}$ gm. per kilogramme of body-weight.

Midway between the carnivora and herbivora come the omnivora, including man: in their bodily economy, they approach one or other extreme, according as flesh or vegetable food preponderates. Man's capacity for work is greatest on a mixed diet.[1] The old world apes are shown by their teeth to be adapted to a vegetable diet, but that they do not in any way despise animal food is evident from observations on baboons, who in the wild state will greedily devour small animals, birds and their eggs, reptiles and insects of all sorts. Even the anthropoids, especially the gorilla, manifest in captivity a preference for flesh food. The habits of the anthropoids in the wild state are up to the present almost unknown, and for this reason the assertion of savages that the gorilla kills and devours animals and men should be accepted with great reserve. It seems certain that the orang-utan lives exclusively on herbs and fruits.

A peculiarity which puts man on a different level from all other animals living in freedom is his predilection for condiments, a weakness shared by all races. No other animal in the natural state knows anything of these, or attempts to procure them, although it is well known that captive and domesticated animals soon acquire a taste for alcoholic beverages.

The ideal food which the young of all animals enjoy in their early days, and one which man continues to consume from infancy to advanced old age, is milk.

If food is withheld death is brought about; speaking generally, starvation proves fatal when the body-weight has fallen to about three-fifths.

This occurs in—

Adult man, Horses, Cats } after four weeks

In a full-grown dog after six weeks

Life may be prolonged, however, on water alone.[2]

[1] Munk-Schultz, *loc. cit.*, pp. 276-88. [2] *Ibid.*, p. 122.

When we come to consider the actual process of digestion we find in the first place that the alimentary canal is the longer and the act of digestion the more complex according as the diet contains more vegetable food.

LENGTH OF ALIMENTARY CANAL.

In carnivora:	lion, tiger	3	times the length of the body
" "	dog	5	" " " "
" omnivora:	chimpanzee	6	" " " "
" "	man	7	" " " "
" herbivora		11-26	" " " "

Herbivora and omnivora drink fluids by sucking, carnivora by lapping them with the tongue.

Carnivora take their solid food in great lumps which they tear off and bolt whole; omnivora and herbivora chew their food, mixing it with saliva before swallowing it.

In mastication the up and down movement is produced by the masseter, temporal and internal pterygoid muscles acting simultaneously; the side to side chewing of ruminants is produced by the alternate action of the external pterygoid of one side and the masseter of the other; in chewing backwards and forwards like rodents both external pterygoids work together.

In man the peculiar conformation of the articular head of the lower jaw allows of all three movements.

The saliva, which contains a diastase capable of converting starch into dextrine and sugar, plays an important part in digestion; this is most marked in man, apes, pigs and rodents; the saliva of horses, oxen and sheep is very feebly diastatic; that of carnivora and bears (omnivora) is practically inert. As regards the amount of salivary secretion, it is greatest in herbivora and least in carnivora. Ellenberger[1] gives the following table of amounts secreted in twenty-four hours:—

Man	200-2,000 gm.
Horse	10-40 kilogm.
Ox	50 "
Dog about	100-120 gm. per hour

[1] Ellenberger, *loc. cit.*, ii., p. 511.

Potassium sulpho-cyanide, which occurs in small varying percentage in human saliva, is not peculiar to man, for although it is not found in horses, oxen, sheep, pigs and goats, it is present in the saliva of dogs.

As regards gastric digestion, man resembles those animals that eat flesh either exclusively, or in part, in so far as he has a simple stomach as opposed to the compound stomach of ruminants. The stomach of the equidae is single but relatively of much less capacity; only the right half can be reckoned as true stomach mucosa, for the left half does not possess glandular tissue. In this respect there is a great similarity between the gastric digestion of man and the omnivora, since two stages can be distinguished, a short first stage in the left segment for the after-working of the swallowed saliva, and a second stage in which the hydrochloric acid and pepsin act.

The chemical factor of digestion plays its part in the fundus, the mechanical in the pyloric antrum.

The specific gravity of the gastric juice is:—

In man	1·0022-1·0024
„ mammals . . .	1·001-1·010

As to the amount of solid constituents of the gastric juice man ranks lowest with 1·200 per cent. as compared with the 1·385 per cent. of sheep and the 2·69 per cent. of dogs.

The detailed quantitative analysis agrees with this, for in the case of man, in addition to 994·4 of water, 2·41 inorganic material, and 0·2 HCl, there is only 3·19 of organic substances, while the herbivorous sheep yields 4·05, the horse 9·8, and the carnivorous dog 17·33 (the total amount is reckoned as 1000).[1]

The motor nerve to the stomach is the vagus; if this nerve is divided, and the peripheral end stimulated in a recently fed animal a vigorous peristalsis is induced, and this passes down the small intestine. With division of the vagus the so-called psychical secretion of gastric juice ceases ("appetitsaft"), but not the reflex secretion, which justifies the assumption that the latter depends on sympathetic-fibres running with the vagus.

[1] Ellenberger, *loc. cit.*, ii., p. 515.

In addition to the motor-fibres the vagus contains sensory-fibres which pass to the pharynx, œsophagus and stomach.

Vomiting of the contents of the stomach takes place very easily in carnivora and omnivora (man and apes), because the cardiac orifice remains open while the pylorus is firmly closed. Even in insectivora the act is easy, but it is less so in rodents and ruminants, and rare in horses except when the cardiac orifice is torn. If the vagus is divided in any animal, vomiting becomes either impossible or incomplete, because the musculature of the pylorus and cardia are cut off from the necessary stimulating source.

The duration of gastric digestion is roughly the same in man and the omnivora; this holds good of intestinal digestion too. In all mammals the amount of chyme absorbed by the stomach is very small, the bulk of it being absorbed by the intestine according to the laws of osmosis. The chyme after leaving the stomach is further exposed to the action of the bile, the pancreatic juice and the succus entericus, whereby its reaction is gradually changed from acid to the neutral condition which favours absorption.

The bile, which is formed in the liver, flows directly into the duodenum without first accumulating in a gall-bladder in Ungulates and Cetaceans, in certain Ruminants (the deer, camel and dromedary), in certain Pachyderms (the elephant and rhinoceros), and in certain Rodents (the beaver, marmot and rat). All other mammals and birds are provided, like man, with a gall-bladder.

Human bile is of a yellowish-brown colour inclining to green, similar to that of most animals. It has a characteristic musk-like odour, and a higher specific gravity in man than in any other animal, for while in other animals it ranges up to 1005, in man it is between 1026 and 1032. The quantity secreted daily is the greater in proportion to the body-weight the smaller the animal (especially herbivora). As a rule, the secretion is relatively greater in herbivora than in carnivora and omnivora; the following table gives the amount secreted by a biliary fistula in twenty-four hours per kilogramme of body-weight:—[1]

[1] Munk-Schultz, *loc. cit.*, p. 167.

Man	16-17 gm.
Dog	20 ,,
Cat	15 ,,
Sheep	25 ,,
Rabbit	137 ,,
Porpoise	175 ,,

The proportions of glycocholic and taurocholic acids vary greatly in different species; taurocholic acid is found either alone or in great excess in the bile of all carnivora, of the herbivorous sheep and goats, of birds, snakes and fishes; glycocholic acid predominates in oxen, hares, rabbits, kangaroos, pigs and men.[1]

In addition to the well-known action of bile in emulsifying fats, it possesses another very important property, namely, that of rendering inert and excreting alkaloidal and metallic poisons passing through the liver, just as the liver itself converts the poisonous ammonia salts in the portal blood to the non-poisonous urea; such are some of the powerful protective arrangements with which the body is provided.[2]

No less important than the liver is the part taken by the pancreas in the digestive processes of man and animals. In herbivora, whose digestion is never entirely at rest, the secretion of the pancreas is constant; in carnivora and omnivora the pancreatic secretion only continues during the temporary periods of digestive activity. The daily output is difficult to determine; Bidder and Schmidt give the following figures:—[3]

In man	up to	150 gm.	per diem
,, horse	,,	180 ,,	,, hour
,, ox	,,	200-270 ,,	,, ,,
,, pig	,,	12·15 ,,	,, ,,

The secretion flows from the pancreas to the small intestine by the pancreatic duct, a second accessory duct existing in man, carnivora and horses; furthermore, it has lately been demonstrated that the gland gives rise to a peculiar internal secretion which controls the carbohydrate metabolism in man and mammals. Animals after extirpation of the pancreas

[1] Munk-Schultz, *loc. cit.*, p. 164.
[2] *Ibid.*, pp. 229-32.
[3] *Ibid.*, p. 175.

die with severe diabetes, and many cases of diabetes in man are associated with degenerative changes in the pancreas.

As the chyme passes down the intestine its various constituents are absorbed by means of a series of changes in the mechanical affinity of the intestinal villi, not merely as fats converted into alkalis of the fatty acids, but as albumoses and peptones, carbohydrates, salts and water. During these processes the fat enters the lacteals of the intestinal mucosa, and as "chyle" runs in the lymphatic vessels of the intestine to be ultimately applied to the use of the body.

The excellent work of Ludwig, Zawilkski, von Mering, Munk and Rosenstein has shown that only a small fraction ($\frac{1}{12}$-$\frac{1}{8}$) of the soluble matter (water, salt, sugar and proteid) travels by way of the axial chyle vessel (lacteal radicle) of the villi, which is devoted almost exclusively to the passage of fats, the remainder being absorbed by the superficial capillary network of the villi into the portal system.

The chyle contains 7-10 per cent. of solids, some 3-4 per cent. more than lymph, the difference being made up almost entirely of fat. The chyle of dogs contains the maximum amount of fat (6-8 per cent.); that of man contains only 5 per cent.

In man and animals the intestinal digestion is associated with certain special fermentation processes which are of greater importance in herbivora than in carnivora and omnivora. They depend in all cases upon the presence of micro-organisms (organised ferments) which enter the gut with the food; they do not occur in the fœtus during intra-uterine life.

The fermentation of carbohydrates begins in carnivora and omnivora in the small intestine; the chief seat of decomposition—fermentation with formation of abundant gases (especially in herbivora)—is in the large intestine, particularly the cæcum, ascending and transverse colon. Here again we see the effect of the bile in transforming the poisonous decomposition products into harmless æthereal sulphates.

The relative proportion of useless waste material to assimilable nourishment derived from the food is always greatest in herbivora and least in carnivora, the fæcal residue in omnivora varying according to the predominance of the vegetable or flesh food taken. In meat-eaters 98 per cent. of the proteid in the food is absorbed; in man living on a mixed diet 2½-6 per cent. of proteid and 1-3 per cent. of carbohydrates (vegetables and bread) are rejected in the fæces, almost the whole of the remainder being assimilated.

VI. Urogenital System.

1. Urinary Organs.

We have already seen in the chapters on anatomy that in man and the majority of mammals the urinary organs consist of a pair of symmetrically placed, bean-shaped kidneys, each with a ureter opening into the bladder. In the urine are excreted water and inorganic substances, together with certain effete nitrogenous compounds.

The amount of urine passed in twenty-four hours is shown in the following table:—

Adult man . . .	1,500-1,700 c.cm.
Horse	3-5-10 litres
Ox	6-10-25 ,,
Sheep and goat . .	0·3-0·9 ,,
Pig	1·5-8·0 ,,
Dog (large) . . .	0·3-1·3 ,,
Cat	0·2-0·3 ,,

Human urine has certain specific characteristics. It is faintly acid in reaction, has a salt, bitter taste, and an odour like bouillon. The specific gravity averages 1015, the temperature when passed 39° C.; its organic constituents are urea, uric acid, creatin, hippuric acid, xanthin, hypoxanthin, urinary pigments, phenol and indigo sulphates The inorganic constituents are sodium and potassium chlorides, ammonium sulphate, acid potassium phosphate, calcium and magnesium phosphates, ammonium salts, iron and CO_2.

The urine of carnivora (dogs) is strongly acid, has an odour of garlic, and brown in colour; its specific gravity varies from 1025 to 1055; it contains a large amount of urea, rather less uric and hippuric acids, is rich in sulphates and poor in chlorides.

The urine of herbivora is alkaline, is muddy yellow in colour, and has a most unpleasant only faintly aromatic (benzoic acid) smell. The specific gravity ranges from 1006 in sheep and goats up to 1060 in horses. Large quantities of urea and hippuric acid (horse), aromatic sulphates and carbonates of the alkalies and alkaline earths are present, but only small amounts of phosphates. A further difference between the omnivora and the carnivora and herbivora is seen in the relative output of water by the urine and respiration upon ordinary diet.

OUTPUT OF WATER.

Carnivora	in urine	70 %	in respiration	30 %
Herbivora	,, ,,	30 ,,	,, ,,	70 ,,
Omnivora	,, ,,	60 ,,	,, ,,	40 ,,

2. Reproductive Organs.

A point in which man and all the metazoa manifest complete agreement lies in the fact that in order to maintain the species the body is equipped with special glands sexually differentiated which become functionally active when a certain period of growth has been reached.

Puberty, the period in life when the sexual glands begin to secrete their procreative products, occurs in man relatively late, in boys at fourteen to sixteen, in girls thirteen to fifteen, in tropical races a year younger. The late onset of puberty is particularly marked when contrasted with domestic animals; for instance:—

Horse	at	18 months
Cow and bull	,,	8-12 ,,
Sheep	,,	6-8 ,,
Pig	,,	5-8 ,,
Dog	,,	6-8 ,,
Camel	,,	5 years
Llama	,,	4 ,,

Whether the statement is correct that the large old-world apes are sexually mature at four years must remain undecided.[1] In wild animals observations and statements are still more scanty and unreliable upon this point.

The onset of puberty is further accompanied by secondary

[1] Darwin, *loc. cit.*, v., 11, states that the anthropoids (orang) do not reach puberty before the tenth to fifteenth year of life.

sexual external manifestations, and internally by sexual stimuli which depend in the female upon the ripening and discharge of the ovum, and in the male upon the formation and storing up of semen.

These sexual impulses appear in wild animals, both male and female, at definite seasons of the year, known as the "rut season". Among domestic animals the male obeys no rule, because the semen is secreted constantly; the female, on the contrary, observes definite "rutting seasons," each of which terminates in the ripening and discharge of an ovum. If several ova mature simultaneously, as in multiparous animals, the "rutting time" ("Brunstzeit") and the menstruation ("Brunstperiode") occur together. The "rutting season" of the mare occurs in spring or autumn, that of the cow in spring and autumn; in pigs, bitches and cats, two or three times a year.

DURATION OF EACH MENSTRUAL PERIOD.

Mare	24-48 hours
Cow	1-4 days
Sheep	1-2 ,,
Pig	1-3 ,,
Bitch	8-10 ,,

In women the ripening of one or two ova associated with discharge of blood takes place regularly as a rule every twenty-five days, so that in a year there are usually thirteen menstrual periods. These periods of three to seven days are almost identical with the "rutting periods" of animals, and terminate generally with stimulation of the sexual impulse, but in women there is nothing corresponding to the actual "rutting season". This is not absolutely peculiar to the human race, for many old-world apes, especially the anthropoids, menstruate in the same manner. Darwin refers to this relation between the periodicity of functions and the phases of the moon:—

"Man is subject, like other mammals, birds, and even insects, to that mysterious law which causes certain normal processes, such as gestation, as well as the maturation and duration of certain diseases, to follow lunar periods." "In the lunar, or weekly, recurrent periods of some of our functions we apparently still retain traces of our primordial birthplace, a shore washed by the tides."[1]

The human ovum was discovered in 1827 by K. E. v. Baer. It is essentially identical with that of any other vertebrate or invertebrate, being composed of a globule of protoplasm with nucleus, nuclear framework and nucleolus.

In microscopic details characteristic differences can be

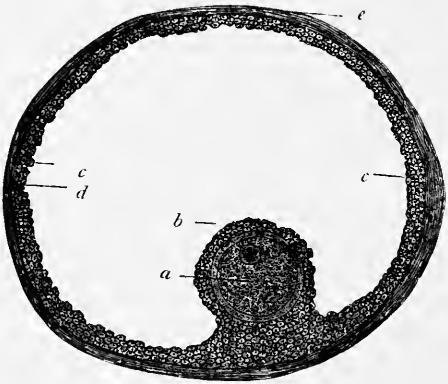


FIG. 112. A ripe human Graafian follicle. (Haeckel.) *a*, the mature ovum; *b*, the surrounding follicle-cells ("discus proligerus"); *c*, epithelial-cells of the follicle ("membrana granulosa"); *d*, the fibrous membrane of the follicle ("tunica fibrosa"); *e*, external surface.

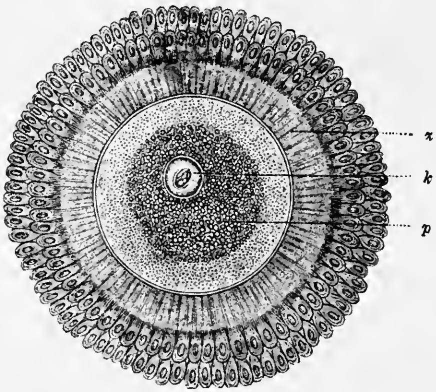


FIG. 113. The human ovum after issuing from the Graafian follicle, surrounded by the cells of the *discus proligerus* (in two radiating crowns). (Nagel.) *z*, zona pellucida ("ovolemma"); *p*, protoplasm of the cell-body ("cytosoma"); *k*, nucleus of the ovum ("embryonic vesicle").

recognised as regards the size and structure of the protoplasm, the breadth of the zona pellucida and the size of the nucleus. The diameter of the complete ovum is 0·18-0·22 mm., the nucleus (embryonic vesicle), 0·04-0·05 mm., the nucleolus (germinal spot), 0·005-0·007 mm.

[1] Darwin, *Descent of Man* (Murray, 2nd edition, 1888), vol. i., p. 10 and p. 248.

Resembling in this respect the ova of mammals (and indeed the majority of the worms, molluscs, echinoderms and polyps), the human ovum possesses in addition to the formative yolk no nutritive yolk, such as exists in birds, reptiles, amphibians and fishes.

The spermatozoa (Waldeyer's *spermia*) are the secretion of the male generative glands, and consist of minute, threadlike (caudate), flagellated cells, of which a single drop of seminal fluid contains millions (Fig. 114). The form is constant in each species, but in the various orders of animals there are distinct differences in the shape of the so-called head, and in the

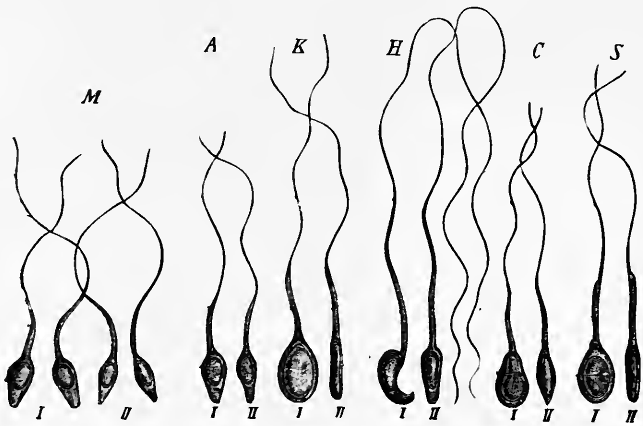


FIG. 114. Spermatozoa or spermia of various mammals. The pear-shaped flattened nucleus is seen from the front in I.; sideways in II. M, human spermatozoa; A, from the ape; K, from the rabbit; H, from the mouse; C, from the dog; S, from the pig.

length of tail. It is too great a task to discuss in detail all the variations of every class and order.

In mammals generally they conform to a single type with numerous modifications, namely, a thick almost disc-shaped head and a flagellated appendage (a threadlike tail). In the ape, man's nearest ally, the head is ovoid, the tail being attached to the blunt extremity.

In man the spermatozoa have likewise an oval head with the side from which the tail springs being thick and rounded. The head is $\frac{5}{1000}$ mm. long, $\frac{3}{1000}$ mm. broad, and $\frac{1}{1000}$ mm. thick; the tail is $\frac{50}{1000}$ mm. long.

The secretion of certain accessory generative glands has also to be considered. The prostate secretes a thin, milky fluid, consisting of so-called prostatic granules in an albuminous liquid; the flow is not continuous but momentary depending on nerve-stimuli. According to Walker, the spermatozoa of man and animals only become motile when mixed with prostatic secretion.[1]

Formerly the seminal vesicles were looked upon as mere reservoirs for the semen; but later observations have demonstrated that they are true secreting glands producing an alkaline, thin, jelly secreted continuously, which during the act of coitus is ejected in conjunction with the semen.

The physiological property ascribed to this secretion consists in stimulating the vitality and motility of the spermatozoa flagellæ.

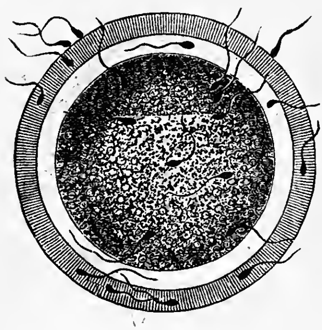


Fig. 115. Fertilisation of a mammalian ovum by the spermatozoa. (Haeckel.)

Researches on rats have proved that the extirpation of these glands does not interfere with the power of copulation but impairs fecundity, especially if the prostate also is removed.

The ampulla of the seminal ducts has, according to Disselhorst, a great bearing upon the duration of coitus; when the ampulla is absent (as in canidia, pigs, felidæ, viveridæ, hyænas) the act is greatly prolonged. Like the majority of other mammals man possesses an ampulla, and the act is soon completed.

The secretion of Cowper's glands has not been isolated in man. When, as in Monotremes, Cowper's are the only accessory glands present, they must combine the functions of the absent glands.

Reproduction of the species can only take place in man, as in all other metazoa, in one way; for the development of one single new existence the fertilisation of a female ovum by the male semen is indispensable (Fig. 115).

[1] Disselhorst in A. Oppel, *loc. cit.*, Bd. iv., p. 402.

Man belongs to that group of metazoa in which the conjunction of a male individual with a female is requisite for this fertilisation. In the mode of origin of the ovum and its early development the human species is identical with the animals immediately below it in the biological scale (Huxley).

The impregnation of the ovum commences with the extrusion of the two so-called "directive bodies" or "polar cells"; the central particle of the penetrating spermatozoon replaces the centrosome, or germinal vesicle, of the ovum, by combining with the female pro-nucleus to form the first segmentation nucleus (archicaryon); after this blending has taken place, segmentation of the ovum proceeds to the morula-stage, and subsequently the embryonic vesicle is formed (blastula-stage); by the invagination of the wall of the blastula at one point the so-called gastrula-stage is reached (Figs. 116 and 117).

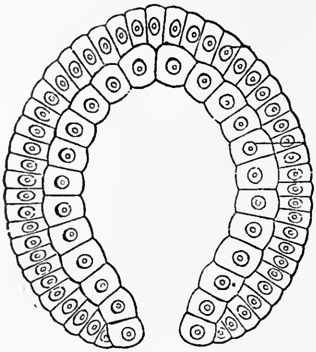


FIG. 116. Gastrula of primitive-gut animal or gastræad.

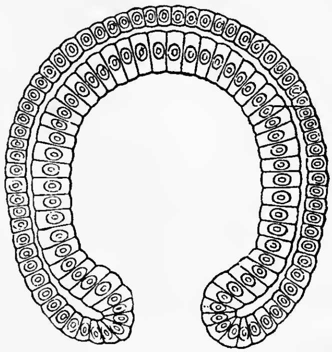


FIG. 117. Gastrula of amphioxus. (Haeckel, *Anthropogenie.*)

The two original layers of cells of the gastrula are the primary germinal-layers which contribute to the building of the whole organism; the outer stratum or skin-layer is the ectoderm from which develop the external skin, the central nervous system and the sense-organs; the inner stratum, or gut-layer, is the entoderm, from which the alimentary canal and its appendages, including the lungs and kidneys, arise. Ultimately a middle layer (mesoderm) develops between these two layers, and from this mesoderm the skeleton, muscles, fibrous and tegumentary covering of the body-wall and limbs, together with the organs of the circulatory and genito-urinary systems are derived.

It is unnecessary to describe in detail the progress of development in the embryo; one striking fact alone needs mention, that in man, as in all other Vertebrates, development proceeds to a point when the Müllerian ducts and Wolffian bodies first become differentiated into male or female generative organs. In man the differentiation can be established in the ninth week. I have pointed out, however, that not only in Vertebrates but also in all metazoa, in spite of the final determination of one sex in the individual, still the potentialities of the other sex can undoubtedly be recognised, so that all metazoa possess some features of the duality of sex even though this rarely amounts to visible hermaphrodism.[1] My views are supported by Haecker,[2] whose "double-nucleation," or the physiological importance of both the paternal and maternal sex cells, is recognisable not only in the primitive generative cells of the cyclops but also in the sexual and epithelial cells of the higher metazoa, including man. Haecker sums up the question by stating that the coalescence of the male nucleus with the female nucleus is not merely an absorption into—a surrender of independence to—a partner but "a creation of a dual personality". It is as though bi-nuclear generative cells were formed in which the two nuclei could remain widely separated, and, if possible, physiologically independent of one another.

Phylogenetically, the chief points of resemblance between the development of man and that of the Vertebrates as a whole consist in the formation of the germinal-layers, the gastrula, the chorda dorsalis, the primitive vertebra, the branchial clefts, the five cerebral vesicles (see Fig. 118), the disposition of the eyes, ears and limbs.

The three higher classes of Vertebrates (reptiles, birds and mammals) are peculiar in the envelopes which enclose the embryo, namely, the amnion and serolemma (chorion), also in the absence of gills and the appearance of the allantois, the forerunner of the urinary bladder.

[1] Tubingen, F. Pietzeker, 1904.

[2] *Jenaschen Zeitschr. f. Naturwissensch.*, xxxvii.

The human embryo is similar to all the other placentals in deriving its nourishment from the placenta, which, strictly speaking, is composed of two parts, the fœtal placenta and the maternal placenta, formed from the chorionic villi and uterine mucous membrane respectively.

Man, like the other choriata (Ungulates, etc.), shares with the indeciduata the peculiarity of originally having the villi distributed over the whole surface of the chorion, these villi, without the interposition of a decidua, penetrating into the mucosa of the uterus.

But at a later stage this becomes altered, the villi over one portion of the chorion disappear, and in the other part grow proportionately thicker and coalesce so intimately with the uterine wall that at birth a portion of this latter is torn away

Fig. 118. Central nervous system of the human embryo at the beginning of the seventh week. *v*, fore-brain (prosencephalon); *z*, between-brain (thalamencephalon); *m*, mid-brain (mesencephalon); *h*, hind-brain (epencephalon); *n*, after-brain (medulla oblongata).

and forms the so-called decidua. This occurs in beasts of prey, rodents, apes and man.

The placenta is disc-shaped in man, apes, insectivora and rodents. The naked eye and microscopic appearances of the human placenta and that of apes are very similar, for in both cases the maternal blood vessels form great sinuses into which the fœtal villi with their innumerable branches enter.

The blood relationship between man and the apes is further borne out by the survival of certain fœtal rudiments which can be found at birth, namely, the atrophied yolk-sac persisting as the umbilical vesicle, and the remains of the pedicle of the allantois; these rudiments have been shown by Selenka to be present in the anthropoids, particularly the orang.

Human embryos at the end of the first half of intra-uterine life present a general external appearance almost indistinguishable from that of any other mammal. Closer examination, however, reveals a series of peculiarities specifically human.

The smaller number of "primitive segments" constitutes an early difference between human embryos and other mammals. The jaw and the arch of the pharynx are much more delicately joined in man, and the projection of the lower jaw gives an unmistakable suggestion of a lip. The brain is much further developed both in the actual details of the fore-, mid- and hind-brains, and in the size of the whole cranium. The three sections of the brain are of fairly equal size in man, while in the embryo chick (to take an example) the mid-brain is disproportionately large.

With the exception of the monotremes and marsupials, the embryos of all other mammals, including man, are completely developed in the maternal womb.

The duration of pregnancy varies according to the body-weight of the mother and the fœtus, as the following table shows:—

Duration of Pregnancy.

Elephant	90 weeks
Giraffe	63 ,,
Mare	48 ,,
Cow	40 ,,
Sheep, goat	20-21 ,,
Pig	17-18 ,,
Bitch	8-9 ,,
Cat	7-8 ,,
Rabbit	5 ,,

In man the duration of pregnancy is very long in proportion to the body-weight. The time is about forty weeks, the same as in cattle, but the sex of the fœtus makes a slight difference, for the female develops rather more quickly and on that account is born a little sooner.

The numerical superiority of the male sex exists as a rule among domestic animals just as in man.

The percentage of males to females is as follows:—

Man	106·3 males to 100 females
Cattle, Pigs, Dogs	110 „ „ 100 „

Females preponderate among horses and sheep to the extent of 100 to 99.

The natural and all-sufficient food of the new-born of every species of mammal, from the human baby down to the young of the ornithorhynchus (duck-bills), consists of the mother's milk, which is supplied to them in variable amount over periods differing according to the species.

The human infant (according to Camerer) takes at the first day about 10 grammes at each feed, at the fifth day about 51 grammes, from eighteenth to twenty-first days about 100 grammes, and from that time onwards about 534 grammes during the twenty-four hours.

A healthy child fed regularly on breast milk should increase in weight in the first year to about 10,172 grammes, about $2\frac{3}{4}$ times the weight at birth.

The following table gives the composition of human milk compared with that of other animals:—[1]

	Water.	Solids.	Casein.	Albumen.	Fat.	Sugar.	Salts.
Human milk	90·2	9·8	1·5	1·5	3·1	5·0	0·2
Pig's „	82·4	17·6	6·1	6·1	6·4	4·0	1·1
Mare's „	90·0	10·0	1·9	1·9	1·1	6·7	0·3
Ass's „	92·5	7·5	1·7	1·7	0·4	5·0	0·4
Sheep's „	84·0	16·0	5·3	5·3	5·4	4·1	0·7
Goat's „	87·3	12·7	3·0	0·5	3·9	4·4	0·8
Cow's „	87·4	12·6	2·9	0·8	3·7	4·8	0·7

From this table it will be seen that the analysis of asses' milk comes nearest to that of human milk, both as regards water and solids generally, and as regards the particular solid components. The milk of pigs and sheep are the richest in solids.

The larger the animal the less prolific is it found to be; for instance:—[2]

[1] Munk-Schultz, *loc. cit.*, p. 271.

[2] Ellenberger, *Physiologie*, ii., p. 264.

The Elephant	bears offspring,	singly,	every	3 or 4 years	
„ Camel	„	„	„	„	2 „
„ Mare	„	„	„	„	1 year
„ Cow and deer	„	„	„	„	1 „
Sheep and goat	„	„	1 or 2	once or twice a year	
Cat	„	„	3-6	twice „	
Bitch	„	„	4-10	„ „	
Pig	„	„	6-12	„ „	
Hare	„	„	2-5	twice or thrice a year	
Rabbit	„	„	4-7	5 or 8 times „	
Mouse	„	„	4-10	4 or 6 times „	

Man ranks with the larger mammals in the infrequency of bearing young. No reliable data exist as to the fertility of the anthropoids. According to Leuckart, the proportionate weight of the offspring to the mother averages :—

In woman	about	one-fourteenth	of the mother's weight
„ pigs	„	one-half	„ „ „
„ mice	„	three times	„ „ „

The age of fertility lasts—

In the mare	till the	22nd-27th	year
„ cow	„	20th	„
„ sheep	„	8th	„
„ pig	„	6th-8th	„
„ woman	„	45th	„

In a man the procreative power seldom lasts beyond the sixtieth year.

VII. Nervous System.

The progressive evolution of the nervous system from the lower animals upwards displays from the physiological standpoint, just as from the anatomical, a gradual increase in the scope and differentiation of the functions. The primitive condition of a general sensibility of the whole body surface finding expression in a reflex contractility is succeeded by the development of definite nerve-fibres and ganglia composed of nerve-cells which in their highest perfection constitute the brain, spinal cord, peripheral-fibres and the cells of the vertebrate nervous system. In this province a very marked general resemblance can be traced between man and other Vertebrates. It is possible to distinguish in various parts nerve-fibres as the conducting apparatus and nerve-cells as the physiological centres; the latter do not consist of merely individual cells but possess a much more complex structure.

The peripheral nerves may be divided into three classes:—

1. *Centrifugal*, or efferent, fibres, running from the brain, or spinal cord, carrying motor, secretory, trophic or inhibitory impulses.

2. *Centripetal*, or afferent, fibres, nerves of sensation, or reflex nerves.

3. *Inter-central*, or commissural, fibres, linking together the ganglionic centres.

From the brain there spring direct twelve pairs of nerves, known as the cranial nerves, of which the majority are purely sensory nerves, the remainder are mixed motor and sensory nerves.

Thirty pairs of nerves arise from the spinal cord, each single nerve originating in an anterior motor and a posterior sensory root, which unite and give off posterior branches to the skin and muscles of the neck and back, whilst the anterior branches, consisting of mixed motor and sensory nerves, form four plexuses, namely, the cervical plexus supplying the skin and muscles of the neck, the brachial plexus, for the skin and muscles of the upper extremity, the lumbar plexus distributed to the pelvis and anterior surface of the thigh, and lastly, the sacral plexus which gives off various cutaneous nerves in addition to the great sciatic nerve, the motor and sensory nerve to the outer surface of the thigh and the leg as a whole.

The fibres of the sympathetic system fulfil the special function of innervating the unstriped muscles generally and the striped muscle of the heart, while its ganglia are the centres for the movements of the viscera (heart, stomach, intestines and the abdominal glands).

The spinal cord is a central organ, not a mere conducting path between the brain and peripheral nerves, for in it originate the reflexes which are constantly controlled by the brain. The communicating tracts between the brain and the spinal centres which by reflex impulses contribute to the performance of certain co-ordinate movements, exist not only in man but to a varying extent in other Vertebrates, so that muscular contractions are set up not only by mechanical, thermal and electrical stimuli but also by stimulation of the nerves which terminate in the well-known "end-plates" upon the muscles.

The medulla oblongata, in spite of its insignificant dimensions, is the seat of the most important centres governing the physical or purely animal life of the organism: in it are situated the automatic centres for the respiratory and cardiac movements, the vasomotor centre for the whole body, as well as the centres for deglutition, mastication and vomiting, and for salivary and lachrymal secretion.

But the chief central organ is the brain. Here we find man's superiority over animals most clearly expressed, for although Thudichum's researches revealed no marked differences in chemical composition, the weight of the brain as a whole is relatively very much greater in man. Fremy (quoted by Thudichum[1]) has shown clearly that the human brain is composed of the same substances as are found in the brute brain, although perhaps in different proportions. For instance, in a given quantity of fatty substance the human brain contains more cholesterin than the dog's.

Succinic acid, $C_4H_6O_4$, is found in the brain substance of man and animals, and there are a number of isomeres of the cholesterin of the human brain which are met with in animals. Thudichum[2] has demonstrated the presence of sarcolactic acid, a constant constituent of the human brain, in the brain of oxen; he has also made the following exact analysis of the white and grey matter:—

1. The white matter contains:—

Cephalin, lecithin and cholesterin (in ether extract)	11·497	per cent.
Cerebroside and myelin	6·910	"
Lactic acid	0·0456	"
Inosit	0·2171	"
Alkalies (as carbonate)	0·1717	"
Water	70·230	"
Neuroplastin	8·630	"

[1] Thudichum, *Die chemische Konstitution des Gehirns*, Tubingen, 1901, p. 24.
[2] Thudichum, *loc. cit.*, pp. 244, 276.

2. The grey matter contains:—

Cephalin, lecithin and cholesterin	1·950	per cent.
Cerebroside, cerebrinoid and myelin	0·424	"
Lecithin, cephalin and myelin	0·780	"
Inosit	0·193	"
Lactic acid	0·102	"
Alkaloids		
Sulphates (in neuroplastin)	0·06	"
Sulphates (in extract)		
Phosphates	0·017	"
Potassium	0·017	"
Sodium	0·092	"
Water extract	0·500	"
Water	85·270	"
Neuroplastin	7·608	"

A complete human brain yields 18-20 gms. of ash with 48 per cent. of phosphoric acid ($\frac{1}{5}$ free, $\frac{4}{5}$ in combination). The ash of the fresh white matter amounts to about 1·7 per cent., of the grey about 1 per cent.; the same proportions have been found in the brains of oxen.

As already mentioned in the section upon anatomy, the first feature in which man appears superior to all the other animals is the preponderance of the cerebral hemispheres over the mid-brain, and the second is the greater wealth of fibres descending from the hemispheres in the peduncles of the cerebrum. The mid-brain (corpus striatum, optic thalamus and corpora quadrigemina) contains, both in man and beast, the centres for co-ordination of movement.

The cerebral peduncles and the pons convey the motor-fibres to the anterior horn-cells, and the sensory-fibres from the periphery through the spinal cord to the brain. Each lobe of the cerebellum exercises not only a direct but probably a bilateral control over all voluntary muscles, by means of which movements are co-ordinated and adjusted so that the equilibrium of the body may be maintained. Associated movements and sensations are brought about by the central organs.[1]

The basal ganglia of the brain are the organs of mere physical control from which are given off the impulses demand-

[1] Munk-Schultz, *loc. cit.*, pp. 477-93.

ing the lowest intelligence. The grey matter of the cerebral cortex is, as Huschke expressed it, "the true brain". It is in the cortex that the "soul" rises superior to the sensations and the physical perceptions of pain and pleasure to the formation of "concepts" and "ideas". In the nerve-cells of the cortex is concentrated all the machinery of the "psychic" existence, and from them all its impulses proceed. Every nerve-fibre is connected centrally with a nerve-cell, whether afferent or efferent. The whole nervous system is composed of nerve-units (neurons). Every ganglion-cell has its protoplasmal extensions (dendrites) with delicate end-branches, and its nerve-extension (neuron) each of which ultimately ramifies among the end-branches of its collaterals.

Thus the vast multitudes of neurones are brought in contact and cohesion.

Until forty years ago it was generally held, with Flourens and Longet, that the various functions of the brain were not localised but were produced by the activity of the cerebrum as a whole. Since then, however, it has been convincingly demonstrated that both in man and animals the motor and sensory functions are situated in definite regions of the cerebral cortex. Repeated experiments have shown that the motor centres lie on the anterior portions of the cortex, the sensory centres on the posterior.

Paul Flechsig has mapped out the distribution of the four central sense-organs in the grey matter of the cerebral cortex as follows:—

Tactile	centre	in the	parietal	lobe
Olfactory	„	„	frontal	„
Visual	„	„	occipital	„
Auditory	„	„	temporal	„

Between these four perception-areas lie the four thought-centres. Upon the integrity of the cerebral cortex depends the "intelligence" in man and animals.

As to what constitutes the brain an organ of perception, thought and volition, Humboldt has spoken in his characteristic manner: "The invisible weapon of defence given to certain fishes and evoked by contact so that the shock is spread through the whole body of the disturber, the lightning's flash in the sky, the force that draws steel to steel, and directs the compass needle's point, all, like the colours in the spectrum of a light-ray, spring from a single source, all are blended together in one unquenchable, all-pervading power".

Huschke,[1] too, has likened the brain to a great electric battery. The two hemispheres are the plates which generate the cerebro-electric current, the commissures the fluid of the battery, the centre and poles are in the convolutions, and the wires of the circuit the peduncles. The chemical process set up by the electric current is the process of oxidation. In the cerebellum Huschke sees an indifferent point in the vermiform process, the fluid conductor in the pons, while the crura cerebelli are the wires.

Even the best apparatus, the most perfect machinery, wears out in time, so the animal or human brain requires certain periods of rest, *i.e.*, sleep, if it is not to be seriously and prematurely injured. The sleep of the domestic animals varies considerably. In horses it is extraordinarily light; in cattle, cats and often in dogs it is deep and sound.

This deep sleep of animals and man represents a condition comparable to that produced in animals by experimental removal of the cerebral hemispheres when neither perception of sensory impulses nor voluntary movements take place, only automatic and reflex movements, such as respiration and the heart beat, being possible. The physiological sleep of normal animals and man (averaging in adults six to seven hours) has in former times met with the most diverse explanations.

Even at the beginning of the nineteenth century one explanation given was the evaporation of the nerve-spirit from the blood, another was syncope of the vital process. Séquard regarded sleep as a daily recurring epileptic seizure. In later times sleep is considered as the result of a hyperæmia or an anæmia of the brain, of a deficiency of oxygen in the blood, and finally of certain products of fatigue in the blood, especially lactic acid (Ranke). But all these views and theories have been displaced by recent scientific research.

It has now been definitely established that sleep is a purely physical process. Formerly it was supposed that there was

[1] Huschke, *loc. cit.*, p. 168.

actual anastomosis between nerve-cells, but modern observers have shown that the branches of the neurones and the dendrites have free ends, which are not permanently attached to, but are in intermittent contact with one another, so that sleep comes on when the prickle-like dendrites of the ganglion-cells contract themselves into minute club-shaped swellings and break contact with the branches of the neurites.

The condition of hypnotism, in which there is marked cessation of excitability and dissociation either over the whole cortex or particular parts, is in many respects identical with sleep. That animals, as well as men, are susceptible to hypnotism was demonstrated in 1646 by Kircher's experiment on a hen which remained motionless with its eyes fixed on a chalk line on the ground. Czermak, who has made considerable researches upon hypnotism in animals, performed the experiment on the hen without a chalk line, "fixing" it instead with a splinter of wood on the beak. Both these cases are examples of hypnosis by fixation. The "fascination of the victim," sometimes seen among insects, is not so much an artifice as a hypnotic paralysis evoked by fear. Preyer distinguishes in this process a cataplexy (terror effect, enchantment) apart from the true hypnosis, and gives as an instance the snake and its prey.

VIII. Cranial Nerves and Sense-organs.

The physiology of the senses cannot be separated from the consideration of the nervous system, for we cannot conceive of the brain apart from the sense-organs, nor the latter without the nerve communications with the brain.

Unfortunately, the comparative physiology of the senses has not kept pace with the comparative anatomy, partly because many animals are so imperfectly organised that they do not seem to respond to such stimuli as we can devise, partly because it is exceedingly difficult to interpret the reaction which is evoked.

(a) Sense of Smell.

Here we are soon confronted by the absence of comparative physiology, for although we can trace olfactory organs from the Invertebrates up to the highest Vertebrates, nothing is known of the constitution of the olfactory perceptions.

In worms, as we have seen, there are superficial ciliated pits supplied with nerves springing from the brain ganglion. In Molluscs (pteropods, gastropods, cephalopods) certain pits, at the bottom of which is situated a papilla with a nerve, serve as olfactory organs. As to the site of the olfactory organs in insects (mouth or antennæ?) there have been innumerable conjectures. It is generally supposed that the odorous matter is wafted on the current of air by the antennæ to the olfactory surface provided with its nerves; perhaps the so-called olfactory bristles which are in communication with nerve-endings perform this function.

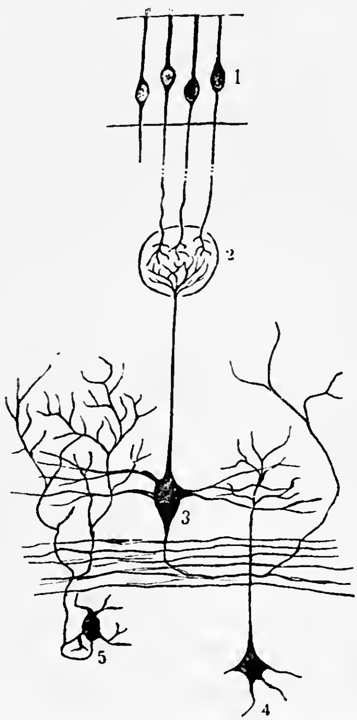


FIG. 119. Diagram of the complete olfactory tract. (Munk-Schultz.) 1, olfactory cells in the mucous membrane; 2, glomerulus in the olfactory bulb; 3, mitral cells; 4, cells of the granular layer; 5, branching cell.

Similar olfactory bristles exist in the antennæ of crustaceans; in myriapods these are developed into olfactory cylinders which may be hollow (Leydig).

It might be assumed that the physiology of smell in Vertebrates would be explained beyond all error, but the physiology of the olfactory organs lags far behind the anatomy. From the very dawn of anatomical knowledge, a "club-like" nerve running in a groove in the under-surface of the frontal lobes of the brain over the ethmoid bone has been recognised as the nerve of smell; its branches run through the ethmoid cells and end in the olfactory cells of the nasal mucosa (regio olfactoria, see

Fig. 119). This region of mucous membrane, unlike the regio respiratoria, has no ciliated epithelium, but columnar cells, longitudinally striated, alternating with spiral cells which reach to the surface of the mucous membrane as hair-like processes, and whose inner ends communicate with the end-branches of the olfactory nerves by means of fine varicose filaments. In birds, reptiles and amphibia the olfactory cells on the mucous surface bear 4-10 stout cilia, some rigid, some in wave-like motion. Mammals are similar to the other three orders (birds, reptiles and amphibia) in having olfactory cells connected with nerves. In the Vertebrates below the mammals, however, the olfactory ciliæ begin to assume the histological characters of the olfactory organs of the Invertebrates.

Man and the mammals are like the other Vertebrates in that odours are perceived not only by inspiring air from the front of the nostrils but also from behind, when the flavour of food as it is swallowed can be appreciated; according to Nagel this is a very important arrangement by which the secretion of the digestive juices in man and animals is stimulated.

Very interesting facts have been observed upon the acuteness of the sense of smell in man.[1] The following traces of various scents could be detected :—

Oil of rosemary .	$\frac{1}{1,000}$	milligramme	per litre	of air
Oil of peppermint .	$\frac{1}{10,000}$	"	"	"
Artificial musk . .	$\frac{1}{20,000}$	"	"	"
Chlorphenol . .	0·00000004	"	"	"

Jäger's researches show that some people have the power of differentiating relatively insignificant odours of individuals as well as family odours, and even the peculiar scent attaching to the inhabitants of the same village (spezifische dorfgerüche !).

Speaking generally, man, not only in a state of civilisation but also the primitive savage (*e.g.*, Papuan), has a much less acute sense of smell than that possessed by animals. Civilised man has probably lost a good deal of the "nose" that he once possessed.

The delicate and keen sense of smell in animals is astonishing, especially in wild horses, wild cattle and wild boar;

[1] Munk-Schultz, p. 556.

among domestic animals the hunting hound stands first, for he can scent the quarry at a distance of 1-2 kilometres.

(b) Vision.

In broad terms it may be said that those animals possess the most useful eyes in whom the preservation of the individual and species is most dependent on acuity of vision (Schleich). "The further an animal is wont to roam, the more perfect must be its orientation-in-space mechanism." The efficiency of the visual organs is inseparably bound up with the very existence of the animal.

As we were able to trace out step by step the development of the eye from a simple pigment-enclosing nerve-fibre up to the complicated structure of the vertebrate eye, so the visual sense itself may be traced from a simple power of distinguishing light and darkness up to the highly differentiated vision of Vertebrates and man. In medusa, echinoderms and turbellaria we see the pigment-spot with its nerve acquire a lens as a light-refracting medium. In rotifers and leeches the disc-like pigment-spot is provided with a number of crystal cones and retinal cells as light-receptors.

In the higher Mollusca (Helicid) with a cornea, lens and retina, Lubbock believes that vision amounts to no more than distinguishing light from darkness. Important differences exist between the compound and simple eyes of insects and crustaceans. The former, according to Müller, have a structure which may be likened to a mosaic picture. The simple eyes of Mollusca and the accessory eyes of insects and crustaceans on the other hand correspond to the camera-like eye of Vertebrates where the retina receives an inverted image of the object; with this difference though, that in the vertebrate eye the optic nerve pierces the retina and is distributed over its anterior aspect, so that the rods and cones are arranged on the posterior surface and the light is reflected by these after passing through the retina, while in the simple eyes of the lower animals (with the exception of certain species of onchidium) the optic nerve expands over the posterior surface of the retina and the pigment lies in front of the rods, not behind them, as in the human eye.

In man and all Vertebrates (except amphioxus and the myxinoides) a characteristic of the eye is the more or less movable globe upon the forepart of which the sclerotic coat is transformed into the transparent, refracting cornea with its varying convexity. Within the eyeball are two other refractive media, the lens and the vitreous body; accommodation is provided for in the iris and its muscles, whilst the retina lying in front of the pigmented choroid acts as the light-receptor (see Fig. 120).

Physiologically as well as anatomically the same general agreement can be seen. All mammals (including man) possess the means of adjusting the optical mechanism and the faculty of distinguishing points of varying magnitude and their relative positions. In addition to visual acuity and sense of space they have all a so-called visual field, the power of perception in the three dimensions, and of appreciating solid figures. Moreover, they are endowed with colour-perception and light-sense, *i.e.*, the distinguishing of light-intensity (quantitative) and light-waves of varying lengths (qualitative).

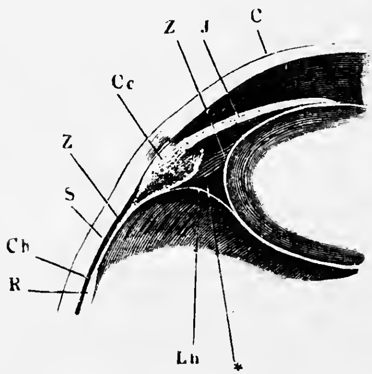


FIG. 120. Diagram of the anterior portion of the eye. (Thomé.) C, cornea; J, iris; Cc, ciliary body; ZZ, ora serrata (ciliary muscle); S, sclerotic; Ch, choroid; R, retina; Lh, suspensory ligament; *, Petit's canal.

As regards the transparency and composition of the refractive media man stands above most Vertebrates, except beasts of prey and birds, especially in the refracting power of the lens. The pupil, which is as a rule round, whether dilated or contracted, assumes in certain animals an oval or chink shape owing to a peculiar arrangement of the fibres of the iris when contracted. The less the intensity of the external light the greater must be the dilation of which the pupil is capable in order to admit as much light as possible (mice, bats).

Accommodation, the focussing of the eye to objects near at hand, is brought about in fishes by the falciform process with its bell-shaped muscular swelling (campanula), which draws the lens towards the retina; in reptiles, birds and mammals by the ciliary (Brücke's) muscle which modifies the shape of the plastic lens. This muscle is very feeble in domestic animals; in man, apes and beasts of prey it is very powerful, and in birds and reptiles actually "striped" and subject to voluntary control, so that it forms an accessory muscle to the iris.

For distant vision the ocular arrangements differ greatly in various animals according as the eye is required to see at long distances in the air, or at short distances in the water. The eye of the new-born infant, or the adult man, like the eyes of all non-aquatic Vertebrates, is hypermetropic (long-sighted), a condition dependent upon the length of the axis of the eye, the

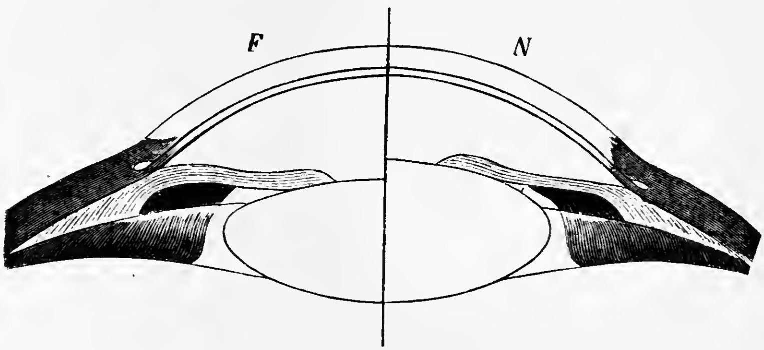


FIG. 121. Eye resting (F) and accommodating (N), magnified five times, after Helmholtz. (Munk-Schultz, *Physiologie.*)

curve of the limiting surfaces of the refractive media, and the relative positions of these surfaces. All aquatic Vertebrates have eyes which are myopic in the air, because their almost spherical lens has a high refracting power. Amphibians lie midway between the two.

The acuity of vision is not solely determined by transparency of the refracting media, but also by the sharpness of definition of the image on the retina, its size, and the perceptive sensibility of the nerve elements. The larger the eye the greater is the retinal image and the visual acuity. The apparent size of an object does not depend, however, merely upon the magnitude of the retinal image, for all objects in space will project images in a fixed ratio whatever the size of the images may be upon the individual retina; we judge the magnitude of objects and distances by the relation they bear to the size of our own body.

All travellers have been impressed by the fact that there is no very great difference in the acuity of vision between savage and civilised races; the former have the advantage, however, when it comes to seeing at a distance, or in the dark.

The retina is not equally sensitive in all parts. In all Vertebrates there is a point in the retina where visual acuity is greatest; this is known as the yellow spot, a minute depression over which the nerve-cells of the retina are specially modified (m, Fig. 122).

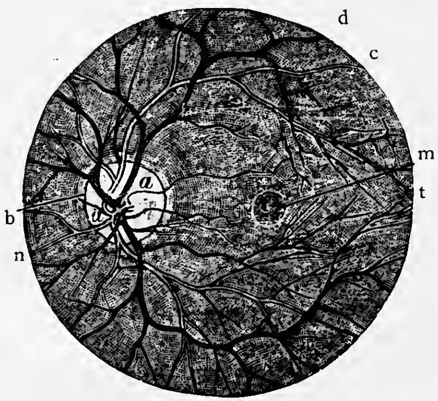


Fig. 122. Ophthalmoscopic appearance of human fundus. a, papilla of optic nerve; c, artery; d, vein; m, macula lutea (yellow spot); t, temporal side; n, nasal side; b, choroidal ring.

Apes are almost identical with men in this detail; certain birds, however, are exceptional in having two such spots instead of one (H. Müller). So that while for man and all other Vertebrates there are two points in the field of vision which are seen most distinctly, in these birds there are four such points, one for seeing with each eye separately, and two for the two eyes acting together, which coincide in binocular vision, so that actually there are three points for all practical purposes.

The position of the yellow spot enables those creatures the axes of whose eyes are directed forwards to see most distinctly what lies in front of them (birds, apes and men), but in all other Vertebrates whose eyes are set laterally on the head this does not hold good.

In contradistinction to the yellow spot where vision is most acute, there is in the eyes of all Vertebrates a "blind spot," corresponding to the optic papilla, or point of entrance of the optic nerve, whose unchanged fibres are insensitive to light, and since the membranous expansion of these fibres forms the innermost layer of the retina certain animals in whom the fibres are less transparent find them a hindrance to distinct vision.

The extent of the visual field is determined entirely by the position of the eye. In man and apes, with their eyes almost entirely enclosed in a bony orbit and the almost parallel direction of the optic axes, the visual field is so limited that it does not even include the whole of space lying in front of the eyes and extends to none of that which lies behind. In the majority of animals with their eyes directed to the front and sides there is not the same restriction of the field, which is so extensive as to include objects lying behind the observer; but this increase in the visual field is obtained at the expense of acuteness of central vision. The perception of movements, however, is chiefly appreciated at the periphery of the retina, and according to Berlin's observations the astigmatism of animals' eyes tends to increase this faculty. It is essential for certain creatures (fishes, beasts of prey, ruminants and horses, etc.) to see in the dimmest light, and the tapetum serves to assist admirably in achieving this; the tapetum (Fig. 123) consists of a variegated pigmented layer of cells covering parts of the periphery of the retina so constructed as to reflect on to the retina the feeblest rays of light.

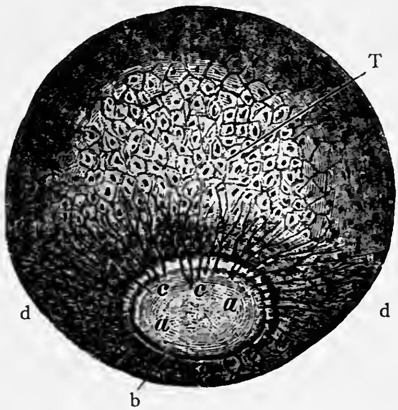


Fig. 123. Ophthalmoscopic appearance of fundus of horse. a, optic papilla; c, artery; d, vein; b, choroidal ring; T, tapetum.

As regards estimation of depth, man, and his nearest ally the ape, stand far behind the higher Vertebrates, especially the larger mammals. The wider separation of the eyes gives these animals a better equipment for judging distances. In the horse, for instance, the distance between the eyes is double that in the chamois, three times as great as in man, and only half that of the elephant.

Binocular vision is the chief factor in all space-perceptions (Schleich). Correct localisation of objects is only possible by means of stereoscopic vision with two eyes. Binocular vision gives each eye not identical but different images; with one eye alone it is easy to be deceived as to the three dimensions of the object; two eyes are necessary to appreciate solidity. "The facts of stereoscopic vision demonstrate incontestably that the two eyes perceive independently of one another, and that their perceptions are only secondarily combined in a common idea" (Wundt).[1] This fusion is a psychical process in which tactile sensibility is unconsciously aided by experience and habit. "It is evident that the estimation of distance and of solidity of objects, even using only one eye, is tolerably perfect. This is worthy of remembrance, for the discovery of Wheatstone has been found so important that it almost makes us forget what a single eye can do. Two eyes, however, can certainly do more. At least when near objects are concerned the solidity of the object can be estimated with more certainty; we cannot, in binocular vision, so easily be de-

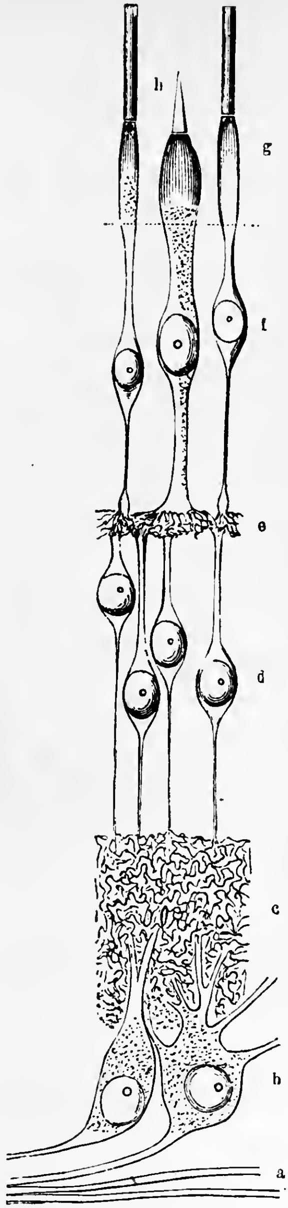


FIG. 124. Scheme of layers of the retina. (Ranke.) a, fibres of optic nerve; b, layer of ganglion cells; c, inner granular layer; d, inner nuclear layer; e, outer granular layer; f, outer nuclear layer; g, external limiting membrane; h, rods and cones.

[1] Wundt, *Beiträge zur Theorie der Sinneswahrnehmung*, 1862. *Human and Animal Psychology*, London, 1896, p. 188.

ceived by an artificial arrangement, and a peculiar sensation of the solid is developed in us, which the monocular person seems not to be acquainted with" (Donders).[1]

Light-perception, the appreciation of various intensities of illumination, has been very inadequately investigated from the physical standpoint. In the rods and cones of all vertebrate retinas (except amphioxus) is contained a peculiar pigment, the visual purple, which is acted upon by light, and in the absence of any other explanation appears to be the seat of a photo-chemical process in the retina.

There is a similar uncertainty as to the physiological explanation of colour-sense which has been provisionally attributed to the cones. In justification of this theory the occurrence of pigmented oil globules in the cones of birds is pointed out; but on the other hand many nocturnal creatures have either no cones or but an insignificant number, and yet have undoubted colour-perception.

It is well known that man and animals have colour-vision, but the perceptions cannot be identical (Schleich), for most animals can appreciate the ultra-violet rays, so that for them the spectrum not only of white but of every other colour must extend much further than in man, and result in a totally different series of colour-sensations.

Schleich divides animals into two classes, light-loving (*i.e.*, with a preference for blue rays—mammals and some birds), and dark-loving (*i.e.*, with a preference for red rays—certain birds).

Lubbock has shown experimentally that even Invertebrates (insects and crustaceans) can distinguish colours. He found, for instance, that bees evince a preference for blue and in descending order white, yellow, red, green and orange. Lubbock and Forel have attributed to ants appreciation of the ultra-violet rays; man cannot perceive them. As evidence that they can actually see these rays is the fact that varnishing the eyes makes no difference to them.

Finally, just as certain apes have special predilections for particular colours (*e.g.*, the Capuchin ape for green), so have individual men and races comparable tastes in colours. Dr.

[1] Donders, "Accommodation and Refraction of the Eye," *New Sydenham Soc.*, 1864, p. 161.

Rivers found the colour-sense very deficient in Papuans, although it was exceptionally well developed in Eskimos, who were very accurate in naming the colours.

In all Vertebrates, including man, the eye is innervated, as regards vision, from the optic nerve; sensation is supplied by the first division of the fifth nerve; the motor supply to the muscles is as follows: levator palpebræ superioris, superior-internal and inferior recti and the inferior oblique from the third (oculomotor) nerve, the superior oblique from the fourth (trochlear) nerve, and the external rectus from the sixth (abducens) nerve.

Other Vertebrates, excepting man and apes, have an additional muscle, retractor bulbi, which receives a double innervation from the oculomotor and abducens nerves.

Probably the nuclei of the second (optic) and third (oculomotor) nerves are closely associated in the corpora quadrigemina, for stimulation of the optic nerve by light entering the eye will transmit an impulse to the oculomotor nerve in the corpora quadrigemina.[1]

In those animals whose optic nerve only partially decussates at the chiasma (man, ape, dog, cat) the two oculomotor nerves must be connected in the brain by intercentral fibres, since light falling upon one eye alone causes reflex contraction of both pupils; in animals whose optic nerve decussates completely the pupil reflex is confined to the eye illuminated (ungulates, rabbits, owls).

All Vertebrates are not capable of the same perfect movements of the eyes as man and other mammals; in birds, and still more in reptiles, the movements are as a rule very feeble, movement of the head taking their place. One notable exception is found among reptiles, namely, the chameleon, whose eyes move quite independently of one another and can execute the widest excursions in opposite directions.

(c) Sense of Hearing.

The same difficulty which besets the investigation of the sense of smell in the lower animals confronts us when we try to determine whether, and how much, they hear. Frequently

[1] Munk-Schultz, *loc. cit.*, p. 497 *et seq.*

during auditory experiments it is utterly impossible to determine whether the lower animals are merely shaken by the vibrations of a tone or noise, or actually hear it. Upon the whole one must be prepared to assume that the same physical laws which govern hearing in the higher animals and man extend also to the lower species. If the intensity of a tone depends upon the extent and force of the sound waves and the pitch of the tone upon their frequency, this law must hold good for the auditory organ of insects as well as for the human ear. Whenever sounds are emitted by an animal it is reasonable to suppose that they can be heard by another animal of the same species; moreover, one is justified in assuming that not only those chafers which produce "instrumental music" but also others which cannot do so are provided with the means of hearing.

In the chapter on comparative anatomy we have already seen that in medusa three forms of auditory organs can be distinguished, namely:—

(*a*) Open pits lined with cells which either contain otoliths or terminate in auditory bristles connected with nerves.

(*b*) Auditory vesicles with one or more otoliths.

(*c*) Auditory tentacles with one or more otoliths at their extremities.

These mobile otoliths and auditory bristles connected with nerves are the prototype of the auditory apparatus of all Invertebrates, and in modified form participate in the structure of the vertebrate ear.

Lubbock was the first to investigate the mechanism of hearing in insects, not only in those that possess a tympanum with a tracheal vesicle behind, but in others also. A constant feature is the presence of auditory rods connected with nerve, which are in one way or another set in motion by the vibrations in the air playing upon them, just as one sees the hairs on the antennæ of gnats set moving by sounds.

The study of the simpler organs in Invertebrates helps to a better understanding of the complex ears of Vertebrates and man. Man has by no means the most perfect apparatus for the conduction of sound waves, since according to the laws of acoustics the more at right angles the concha of the ear can be presented to the waves the better they are picked up; the depth of the funnel aids in this process, so that the human ear, which is scarcely funnel-shaped and quite immobile, fares badly as an acoustic apparatus.

The vibrations of the tympanum are checked by the ossicles of the middle ear, which form a two-armed unequal lever and act like the damper of a piano.

The Eustachian tube serves to equalise the pressure of the air in the middle ear and pharynx.

Tones impinging on the tympanum set up vibrations which are transmitted along the chain of ossicles to the fenestra ovalis, an opening twenty times smaller than the tympanum, so that the amplitude of the vibrations is relatively increased. The orifice of the fenestra ovalis is filled by the foot-plate of the stapes, and when this vibrates the movement is imparted to the fluid in the labyrinth, any excessive vibration of the fluid being in its turn obviated by the presence of the fenestra rotunda.

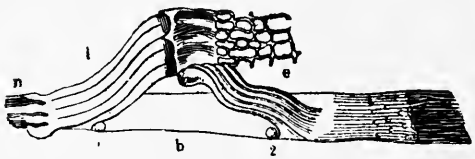


FIG. 125. Portion of Corti's organ. b, membrana basilaris with nerve-fibres (n); i, inner; e, outer rods; 1 and 2, nuclei of original tissue.

The semicircular canals containing otoliths and hair-like projections are concerned with co-ordinate movements and the balance of the body.

The cochlea with the organ of Corti is the true nervous receptor for hearing, a microscopical musical instrument, as Lubbock expresses it, upon which the sound waves play like the fingers of the musician on the keys of the piano.

To every rod-cell a fibre of the auditory nerve is attached; the appreciation of different tones is due to the stimulation of separate fibres of the auditory nerve which communicate with nerve-cells in the cerebral cortex (in man, apes, dogs and oxen in the temporal lobe).

Helmholtz's view is that in man the fibres in the organ of Corti are arranged for the seven octaves, and that $33\frac{1}{2}$ fibres correspond with every semitone and 406 with each octave; although in musical notation only twelve separate notes or intervals are reckoned in the octave, the trained musician's ear can recognise seventy, so that on Helmholtz's theory six or seven fibres represent the minimal interval of appreciation in man.

Judging from the similarity in structure in the ear of man and all other mammals it may fairly be supposed that the process of receiving and perceiving aural impressions does not materially differ. Herbivora have not such acute hearing as carnivora; but whether this acuity depends on the delicate distinguishing of tones, such as the human ear is capable of, may well be questioned.

In man individual variations in the acuteness or delicacy of hearing are partly inherited, partly acquired by practice; and in this respect savage races cannot claim anything like a general superiority over civilised man. Necessity and constant practice will develop the faculties in the roving inhabitants of wide plains and vast prairies; elsewhere the primitive peoples do not acquire the same keen ear. For instance, among the Papuans Dr. Rivers found the hearing no more acute than in Europeans.

(d) Sense of Taste.

The physiology of taste is still very little understood. It is supposed that even the lowest animals, provided they possess an oral aperture, have taste-perceptions which are probably situated in the mouth. This conjecture is supported by observations upon the selection of food in insects and crustaceans, and by the researches of Forel and Will upon ants and wasps in which it was found that ants cannot invariably recognise poisonous substances. The explanations given by these two observers do not agree. For Will surmises that the hairs or rods in the pits round the mouth must be perforated for the taste to penetrate them, while Forel denies this, and takes the view that the taste passes by osmosis through the thin chitinous covering especially when nerves participate in their structure. Wolff's cups (pits) with central hairs and a chitinous ring, and a double ganglion swelling connected with a nerve-fibre are particularly numerous in those creatures to which we have to attribute the most pronounced sense of taste, namely ants, bees and wasps. As to the gustatory organs in Vertebrates, including man, their histological structure is well enough known, but we are quite in the dark as to the real nature of the sense of taste; so far we do not even know whether different taste-cells correspond to various tastes or whether a single taste-bud can discriminate more than one sort of flavour.

Taste-papillæ are found in man on the posterior part of the tongue, on the soft palate (but not on the fauces), on the pharyngeal wall, and the hinder aspect of the epiglottis. In the larynx sweet and bitter can be distinguished, and in children the sense of taste extends to the middle of the tongue and the muceous membrane of the cheeks. The tonsils, palato-glossal fold and hard palate are debatable regions.

Man's sense of taste is limited to distinguishing salt, acid, sweet and bitter, but as in animals only when the substances in question are dissolved. It is not known whether animals have any other taste-perceptions. At any rate they are like human beings in that smell assists taste in the choice and selection of food.

If the number of taste-buds bears any direct relation to the taste capacity, man enjoys no supremacy, for the circumvallate-papillæ of the ox contain 1760 more taste-buds than those of man.

In judging of the gustatory powers of certain races great caution is necessary, for although some primitive savages have no names for this or that taste (*e.g.*, the Papuans have no word for bitter), still this does not prove that the perception is lacking.

The chief nerve of taste is the glossopharyngeal (ninth); the accessory nerves are the lingual branch of the fifth and the superior laryngeal branch of the vagus (tenth).

(e) Tactile and Temperature Sense.

The tactile sense is common to the whole animal kingdom; in fact, there are many reasons for thinking that the other senses have been developed from this one. In many of the lower species (Invertebrates) the whole body-surface is covered with fine bristles and is exceedingly sensitive; in insects and crustaceans the chitinous coat is pierced by bristles (hairs) which are connected with nerves. We have learnt to recognise as special organs of touch in Vertebrates the tactile cells in the deeper layers of the Rete Malpighii which occur in the tip of the pig's snout and the bill and tongue of birds; the touch corpuscles in the skin-papillæ of man and apes, and the Vater-Pacinian corpuscles in the sub-epithelial tissue of the palm and sole and joints of man, in the skin of the elephant, the bat and many other animals, in the mesentery of the cat, in the mucous membrane of the intestines, the genitals and the ball of the foot of carnivora, and in the hoof of the horse and sheep. Another species of tactile nerve-ending is seen in Krause's end-bulbs in the lips, tongue and palate of mammals, and here and there in the ball of the foot in carnivora. The ramifications of the nerve-plexus in the cornea form another variety of nerve-ending, and lastly many mammals possess extraordinary sensitive tactile organs in their whiskers, which are connected with nerves and can be moved by voluntary muscles. These hairs are very strong and bristly. It would be incorrect to describe such "sensory hairs" as peculiar to animals, for the hair of the head and the beard in man, as well as the downy hairs on a woman's skin, are undoubtedly keenly sensitive to the slightest touch.

Tactile sensation in man is most acute at the tip of the tongue, sixty times more so than in the upper arm, thigh and back. This sense of touch is the foundation of a cutaneous sense of space, by means of which, without the aid of the eye, the size, shape and length of an object can be determined by feeling its sides, not merely by touching the object but by feeling it all over (*e.g.*, with the hands of the ape, the elephant's trunk, the tongue of every animal, the upper lip of ungulates, the feelers of insects).

Just as the extreme tactile sensibility in the sole of the human foot is of the utmost importance to a sure gait, so all animals, in spite of their horny feet or hoofs, enjoy perfect sensation as to the nature of the ground on which they stand or move.

Pressure-sensibility as a special cutaneous perception is, according to Goldscheider, not associated with the same skin-areas or nerve-endings as the sense of touch.

In man the parts of the skin most sensitive to pressure are the forehead, temples, eyelids, back of the forearm and hand. According to Weber, upon the most sensitive areas a man can discriminate between weights in the ratio of 29 to 30. Dr. Rivers found the tactile and pressure senses better developed in the Papuans than in Europeans.

No observations have been made on the temperature sense in animals, although they must certainly be credited with perceptions of heat and cold.

In man the temperature sense is distributed over the whole external skin, in the skin of external ear, the mucous membrane of the mouth and throat, the anterior surface of the arch of the palate, in the anterior nares and the floor of the nostrils, and in the mucous membrane of the posterior nares. Physiologically, definite areas for heat and cold can be distinguished in the skin;[1] the latter are much more numerous and lie much closer together than the former; the number of heat-points is only about 30,000, while there are some 250,000 cold-points in the adult man. In consequence the sense of cold is much more extensive and intense than that of heat. The less numerous heat-points lie deeper in the skin, so that the hot stimulus must be relatively greater to evoke the sensation of warmth. Between the groups of heat- and cold-points there are gaps about the size of a square centimetre where both varieties are absent. Man calls those bodies cold which take away the heat from the cold-points in the skin, and other bodies hot which add to the heat of the heat-points. Various parts of the skin interpret different degrees of heat unequally, and the greater the difference in the thickness of the epidermis so much the more obvious are the variations in the sensibility of the part. In man the areas of extreme tactile sensibility coincide with the areas of most delicate temperature sensation.

The temperature sense is infinitely valuable to the life both of man and beast, for it serves to warn against the extremes of heat and cold.

Popular journals and natural histories, both old and new, make much of a so-called sense of direction as a most marvellous sixth sense in animals. In text-books of comparative phy-

[1] Munk-Schultz, *loc. cit.*, pp. 533-42.

siology this sense has found and will find no place. Lubbock and Romanes have investigated the problem most energetically. They have both made researches with those insects which have been most persistently credited with a sense of direction, and both came to the same conclusion that there was absolutely no proof of its existence. Experiments with bees and ants showed that when they were taken various distances from their dwelling-places only a fraction of them found their way home again provided the neighbourhood was unfamiliar. Like the homing-pigeon, these bees flew round and round at a height to obtain their direction, and those which reached home took an unconscionably long time on the journey. In consequence of these experiments the fabulous accounts of the sense of direction in other animals up to the higher mammals may come under criticism. All these animals find their way home provided that in their orienting casts they strike a point which they have seen before, otherwise they fail.

Organic (visceral) sensations and general sensations, feelings, emotions.

"That which we term emotion does not refer like perceptions and ideas to consciousness of the external world, but to the conditions of our personal existence, to sufferings and activities of the ego (material *me*). This feeling is purely subjective" (Wundt). All sensory nerves can transmit impressions of pain as well as tactile pressure and temperature sensations, thus setting up reflex movements by arousing feelings of disgust. Division of the sensory cranial nerves and the grey substance of the spinal cord inhibits the sensation of pain from the parts supplied by the corresponding sensory nerves.

There is no pain sensibility in the lungs, the brain (except in the membranes), and the parietal peritoneum. Organic sensations and the sense of movement are derived from the muscles, tendons and joints.

The emotions have been hitherto very little investigated. Erotic emotions are aroused by psychical or physical influences on the genitalia; the sense of tickling by light, unexpected touches, especially upon the delicate tactile-sense areas of the skin (lips, nostrils and soles of the feet); shivering by sudden contact of a cold object with certain parts of the skin (abdomen and back), or by shrill sounds.

The feeling of nausea is excited by the sight of loathsome objects, by foul odours, or by taking evil-smelling or tasting things into the mouth or stomach.

Hunger and thirst are experienced after abstention for a sufficient length of time from food or drink.

All these organic and general sensations exist in animals; we can conclude from observing certain signs that these feelings exist, but we have no accurate knowledge on the subject.

2. Psychology.

The physiology of the senses, although still full of dark places, has during the last fifty years been slowly divulging its secrets: from the work of Weber and Fechner we have learnt to know for each several sense the maximum capacity for stimulation, and the percentage by which the stimulus must be increased in order to produce an appreciable increase in sensation. In this province no one denies to physiology the right to scientific explanation. It is therefore all the more astonishing that psychology, which after all merely forms one branch of physiology, is strenuously claimed by the advocates of transcendentalism as their original domain.

Where is the abode of the mind? What is its real nature?

These two questions have, in all the ages, been met with the most diverse replies. The natural philosophers of ancient Greece were all at variance. Empedocles (like the Jews of old) placed the mind in the blood, Diogenes in the heart cavities, Parmenides (like van Helmont in later times) in the stomach, Strato between the eyebrows. Then Stookes looked for it in the heart, but the majority of later observers inclined to some region in the brain, Descartes in the pineal gland, Boerhaave in the spinal cord, Sömmering in the vapour in the cerebral ventricles, Lancisi and Bonnet in the medullary substance, Haller and Wrisberg in the pons, Digby the septum lucidum, Willis the corpus striatum, and Platner the corpora quadrigemina. In more material fashion Jäger (*v.s.*, p. 201) maintained that he had discovered the mind in the specific odour, or exhalations of every animal and every man, a theory which he was led to adopt by confusing the products of the mind's activity (protein-disintegration) with the mind itself.

By far the most dangerous rock upon which psychologists have been, and are still being, wrecked is the artificial invention of dualism between mind and life, the former being considered a purely immaterial force independent of the body, and only during life incorporate with the body, which at the death of the body does not perish but is immortal.

On the other hand, Huschke, at the conclusion of his work on the skull and brain, said boldly that he had nothing in common with the view of those who represent the mind as something floating over our organism too lofty to be connected in any way with the material basis of our existence. It would be as unreasonable to speak of the abode of the mind as it is impossible to understand by the mind anything else than the higher unity of body and spirit. In this broad sense the mind pervades our whole body and may be omnipresent in its every molecule. Even if one inquires for the seat of the spiritual life and means thereby the mind, still this spiritual life may pervade our whole organism as a partial manifestation of the spiritual breath immanent in all nature. In a pantheistic sense he calls each individual mind a portion of the mind of the universe. According to this theory, the seat of the mind should only be spoken of if by mind is understood not merely the feeling of the personality, the consciousness of self, but also the whole higher spiritual life. For this we may look to the mass of nerves and especially to the brain. The nerve-mass may be the body or life of our real *ego*, the brain its centre. In a pantheistic sense the mind goes through the whole corporeal world and all our organs, so there is "no thought without a body. All matter is living, and all mind-activity has an inherent accompaniment of matter."

Wundt in 1874[1] propounded a similar idea although modified in a monistic direction. He raised the objection to dualism that having exhausted every possible experiment to explain it he found none satisfactory. This he regarded as proof of its being really untenable, and he became aware of the necessity for formulating a monistic theory. Wundt calls the mind the

[1] *Grundzüge der physiol.-psychologie*, Leipzig, 1874.

inner existence of that unity whose external manifestations we are wont to regard as life. The psychic functions, like the bodily, are allotted to certain central regions, and every external process corresponds with a change in the internal conditions. A self-consciousness of this inner state first becomes possible when the alliance founded upon the external and internal organism includes the conditions necessary for the constant renewal of the processes, and for associating the present state with the past. Therefore the existence of a consciousness in the lower forms of life is excluded. In a slightly higher grade of animals the consciousness is in a rudimentary stage, in man it is perfect, having reached to a point where he can conceive of a world outside the material self. In his later years Wundt's [1] views underwent a striking change. He deserted monism and advocated the old dualism in a new garb.

"Psychical can only be adequately explained from psychical, just as motion can only be derived from motion, and never from a mental process, of whatever kind." [2]

"The connection can only be regarded as a parallelism of two causal series existing side by side, but never directly interfering with each other in virtue of the incomparability of their terms." [3]

"Psycho-physical parallelism is a principle whose application extends only to the elementary mental processes, to which definite movement processes run parallel, not to the more complicated products of our mental life." [4]

"Our mind is nothing else than the sum of our inner experiences, than our ideation, feeling and willing, collected together to a unity in consciousness and rising in a series of developmental stages to culminate in self-conscious thought and a will that is morally free." [5]

Haeckel has energetically opposed this relapse of Wundt's to the old dualism from the standpoint of the scientific conception which regards psychology merely as a branch of physiology, and the mind as having no immaterial supernatural existence but as a natural phenomenon, the sum of the phenomena of life

[1] *Vorlesungen über Menschen- und Tierseele*, 1892, p. 480.
[2] Wundt, *Human and Animal Psychology*, London, 1896, p. 442.
[3] *Ibid.*, p. 442. [4] *Ibid.*, p. 447. [5] *Ibid.*, p. 451.

which cannot be imagined without a definite material foundation. "The correct interpretation of psychic activity cannot be arrived at by introspection alone, although this is the necessary method of inquiry for the study of consciousness; exact physiological analysis based upon observation and experiment must also be employed, and from this the laws of the 'mind-life' may follow."

These contradictory views as to the nature of the mind lead to a further question: What is the relation of the human to the brute mind? The philosophers of olden times generally admitted no qualitative distinction, only a quantitative one. Christianity, on the contrary, laid down a fundamental difference between man's immortal mind and the mortal mind of the animal, and maintained it rigidly as an unassailable dogma, the more effectively since there was no lack of philosophers who brought all the weight of their dialectic to prove that dualism was self-evident. This dualism reached its zenith at the hands of Descartes, who taught that man alone had a mind, feeling and free-will, while the whole of brute creation were mere automatic machines. Even in later days and in our own times psychology as an integral section of physiology is limited to the human mind.

It is true that a start was made in the direction of comparative psychology early in the last century, but books such as Scheitlin's *Investigation of the Animal Mind* (Tierseelenkunde) possess a value only as interested attempts to discover a mind in animals; no really scientific animal psychology was the outcome of such works, for they were entirely devoid of an exact scientific basis. The first to attempt the solution of these problems was that master of comparative anatomy and physiology, Johannes Müller. He showed the way to an accurate, unbiassed estimate of the animal mind, and so to comparative psychology, although at the outset this comparison did not clearly demonstrate the general resemblance and the variation in details. It was left to Darwin to find the true balance of the harmony and discord, and to show that the difference between man and beast is one of degree not of kind.

In his book, *The Descent of Man*, which first appeared in 1871, Darwin drew attention to the important human resemblances in the psychic functions of the higher animals. "Man and the higher animals, especially the primates, have some few instincts in common. All have the same senses, intuitions and sensations,—similar passions, affections and emotions, even the more complex ones such as jealousy, suspicion, emulation, gratitude and magnanimity; they practise deceit and are revengeful; they are sometimes susceptible to ridicule and even have a sense of humour; they feel wonder and curiosity; they possess the same faculties of imitation, attention, deliberation, choice, memory, imagination, the association of ideas and reason though in very different degrees. The individuals of the same species graduate in intellect from absolute imbecility to high excellence. They are also liable to insanity, though far less often than in the case of man."[1]

Darwin alluded to the general similarity between the mind of man and animals without, however, formulating a stem-evolution, a phylogenetic development of the mind. It is a very interesting fact that one of the great opponents of Darwinism sketched out such a stem-evolution. Carus, in his *Comparative Psychology, or History of the Mind in the Animal Kingdom*, gave a schematic survey in tabular form of two natural series, of which the one dealt with the evolution of the human mind, while the other in a very similar scheme of development gave the proofs of innumerable gradations in the infinite multiplicity of animal souls without arriving at the final conclusion.

The first class of Carus includes the protists and all the lower forms without differentiated nerves. The second class consists of species which have no brain:—

(*a*) Those with a problematical or non-central nervous system (polyps, acrania, higher radiates, acraniate molluscs, and lower articulates).

(*b*) Those with a central nervous system (higher molluscs, higher articulates).

In the third class are the species with a tripartite brain (fore-, mid- and hind- brain), and more or less definite cranium, the type of perfection and the symbol of psychical development:—

(*a*) Fishes.

(*b*) Amphibia and reptiles.

[1] *Descent of Man*, vol. i. (Murray, 1888), p. 120.

(*c*) Birds, which are considered under the three divisions of their psychical activity (consciousness of an external world, feeling, will, action), and also in another classification according to their natural degrees of water-, land- and air-birds.

(*d*) Mammals also classified according to perception, feeling and will.

Carus[1] carefully traced out the gradations in the psychical functions of animals, but as he held them entirely distinct from those of man, so he left completely unobserved the natural development of the animal mind from the lower forms to the higher.

The first to formulate deliberately and logically a psychic stem-evolution identical with the phylogenetic development of all animals up to man was Haeckel. He recognised no absolute psychological boundary between animals and man, no special psychical functions as the sole prerogative of man. From the monistic standpoint he maintained a complete psychological identity for the whole organic world, extending from the protists up to man, based upon perception and movement and intimately bound up with the existence of protoplasm and a definite metabolism.

The monistic idea of a gradual psychical development which corresponds with the structural evolution from the lower to the higher forms looms large in modern natural philosophy. One of the ablest protagonists of the theory of descent, Prof. Klaatsch of Heidelberg, does not hesitate to state that precisely as we can claim a stem-history for the skeleton, so experimentally we shall find proof of the phylogeny of the mind and soul.

The triumph of man over brute creation is probably not the result of any vital difference between man and animal, but only of man's higher intelligence, because many animals have, as regards their brain-development, arrived at the third stage.

Waitz expresses the same view; man, he says, rises superior to animals by the force of his original ideas, and by his capacity for adequately giving expression to them. According to Waitz, the natural requirements of human life are more difficult to satisfy than those of animals. But this constraint to satisfy his daily needs, his erect gait and his hand, are not the

[1] Vienna, Braumüller, 1866.

prime causes which give him the command of the whole of nature. All this would not have helped him unless man had possessed a keener and more comprehensive perception of the external world, and the great fact of a memory for details and their relations to himself, which enables him to compare the present with the past, and contemplate the two as one continuous whole. It was essential for man to work so as to protect himself from destruction. The work of the individual man is not wasted but is bequeathed to posterity as the heritage of civilisation.

The opinions quoted make it evident that no serious thinker is disposed to deny that as regards psychological development man occupies the highest place; but it must be noted that natural science, and the various branches which deal with anthropology in one direction or another, guard against the assumption of any absolute difference between man and animals in this province.

Haeckel, as the champion of the gradual evolution both of the physical and the psychical organism, is on solid ground when he extends the comparison of man and apes to the mind as well as the body. Comparative psychology has established the relationship no less surely than comparative physiology.

The psychological differences between man and the anthropoid apes are less than the corresponding differences between the higher and lower classes of apes.

It was inevitable that Haeckel's protest against the anthropocentric dogma should raise the same uproar in the tents of orthodoxy as did the challenge of Copernicus and Galileo to the geocentric dogma. Many of Haeckel's opponents may be found in the ranks of science and medicine. Reinke, Professor of Botany in Kiel, is a stalwart opponent of the theory of evolution; Dr. Türkheim, irresolute as to Darwinism, has written a book in which he rejects the possibility of the human mind and intellect ever having been evolved from the animal instinct. He describes in the human mind a wholly new organ, the spirit, which creates ideas, and with their help gives the faculty of knowledge and thought. Even the bare rudiments of this are, according to Türkheim, absent in animals. But if we are to allow that organic life came into existence in the infancy of the earth after the cooling of our molten planet and the appearance of atmosphere and water; if we must admit that from primitive embryos the animal kingdom has developed from lower to higher forms and that man has sprung from the animal world; if finally we must reject as inconceivable the existence of an animal organism without a mind, matter without spirit—so we must bow to the inevitable conclusion that the human mind evolved from the animal mind, the human spirit from the animal spirit.

These theoretical considerations are amply supported by practical facts. If men of eminence like Darwin, Lubbock, Romanes and Brehm after lifelong observation of animals come to the conclusion that the psychical differences between man and animals are of degree only and not of kind, their judgment must be considered as of far greater weight than the obstinate objections of opponents who, glued to their writing-tables, build up a water-tight bulkhead between the psychical equipment of animals and man. The opposition of this tribe would be utterly silenced if they would only take the trouble to acquaint themselves with the ontogeny (development of the individual) and phylogeny (development of the race) of the mind.

The ontogeny of the mind has only been based on its true foundations by the developmental studies of the last thirty years.

If the possession of definite properties of perception and movement in the unicellular organism are to be described as a mind, the same must hold good of the ovum and spermatozoon, from which the animal body is developed. If we regard the process of fertilisation, where an attraction, a sort of selective affinity, between the ovum and spermatozoon is manifest, as the first degree of psychical activity there is no scientific objection possible. Now both parents, from one of whom is derived the ovum, from the other the spermatozoon, have their individual minds, and experience shows that the psychical qualities of the new individual are derived from both the father and the mother, so that the mind itself must be formed by blending of the two factors, a blending which, as is well known, may in the children of the same parents show every degree and variety, and may result in the transmission through many generations of psychical qualities which after lying dormant come to light again in some remote descendant.

Those animals whose embryos leave the shelter of the ovum at an early stage and pass through a metamorphosis with gradual perfection of their organism come very soon into contact with the external world, and to a certain extent experience the progressive development of their mind under external influences, while those animals which are born structurally complete and develop in the uterus protected from external influences pass through an embryonic resting stage, so far as the psychic functions are concerned, which ends at birth when the mind can only be regarded as a *tabula rasa.* How long it will remain so varies according as the most important sense-organs are receptive to the outer world or still remain dormant.

The mammals that are born blind, and even more the offspring of man and the higher apes, pass through a much longer mental babyhood than other mammalian young.[1]

Their movements show that besides organic and general feelings and cutaneous sensibility they only possess the sense of taste and smell necessary for suckling: sight and hearing are not yet in communication with the world outside. When these senses first take on their functions the foundations of a psychical apparatus are laid down.

Man's psychic activity, like that of most of the higher animals, runs through a long series of stages of development during the individual life. We may single out the five following as the most important:—

i. The mind of the new-born infant up to the birth of self-consciousness and the learning of speech.

ii. The mind of the boy, or girl, up to puberty.

iii. The mind of the youth, or maiden, up to marriage.

iv. The mind of the grown man and mature woman.

v. The period of degeneration in old age.[2]

The embryogeny of the mind alone will not crush the opponent of the theory of the gradual variation of the animal and human mind if the phylogeny does not tell an even more convincing story. Haeckel was the first to set out the

[1] W. Preyer, *Die Seele des Kindes*, 4th ed., 1895.

[2] Haeckel, *The Riddle of the Universe.*

phylogeny in a form easy to grasp, for he by logical and exact steps traced the development of the nerve-elements as channels of psychic activity. There is no need to be surprised at his representing the primitive "cell-mind" as present in the unicellular organisms. Relying as he does upon the support of Max Verworn's *Psycho-physiological Studies of the Protists*, who came to the conclusion that "the psychic phenomena of the Protista form a bridge that connects the chemical processes of the inorganic world with the psychic life of the highest animals; they represent the germ of the highest psychic phenomena of the metazoa and of man".

A higher development is found in the infusoria which are capable of movement and (above all) of unconscious sensibility; indeed the great cell-nucleus (*meganucleus*) is regarded by some scientists as a differentiated organ of psychic activity. From the unicellular organisms, the cell-mind proceeds to the cell-community (*i.e.*, the blastula-cell), in which, in addition to the cell-minds of the individual cells, there is the communal mind of the entire colony.

This finally makes way for the tissue mind in the organs of the metazoa, where each single cell has its own sensation and movement, and each tissue and each organ composed of a number of homogeneous cells has its special irritability.

Those metazoa which possess no differentiated nerves have still a very deep-seated mind-life. In their lowest forms they remind us of the two primitive embryonic layers of the higher metazoa, from the outer layer of which, the ectoderm, are developed the sense-organs and the nerves; so these lowest metazoa represent the earliest form from which the whole series of higher animals with nerves have evolved. The free swimming medusæ, unlike the stationary hydropolyps from which they are developed, possess sense-organs, nerves and ganglia which, on the one hand, are the means of communication between the sense-organs and the muscles, and on the other hand, are the seat of the perceptions and sensations. The higher we proceed in the Invertebrates the more highly developed are the psychic functions until we reach the cephalopods and brachiapods which, in spite of the small dimensions of their ganglia, possess a degree of intelligence and will-power which has been man's wonder and admiration from the earliest times.

From the description of the comparative anatomy and physiology of the nervous system, it has already been made clear that the highest development of the animal mind is reached in the Vertebrates, which, in addition to sense-organs and peripheral nerve-fibres, have a central nervous system (brain and spinal cord) completely enclosed in a bony covering. It is this great central nervous system, with its wealth of ganglion cells, that forms the basis of the unquestioned superiority of the vertebrate mind over the invertebrate. This applies in a relative, not an absolute sense to the contrast between the highest mammals and man in precisely the same manner as has been seen in the details of comparative psychology.

Special Comparative Psychology.

The fact admits of no dispute that sensibility, which we have traced from the simple irritability of protoplasm through the sense-organs right up to the centralisation of the nervous system and the conscious perception of the higher Vertebrates and man, is the original source of all knowledge; but it is equally certain that a higher phase of the mind-life can only be reached when the impressions derived from the external world are worked up in the nerve-centres.

Ideation, namely, the forming of a mental picture of an external object, is the first step in advance which the mind has to make so as to orientate itself to the outer world. But the organism only makes this advance step by step. When one considers the perfectly designed cell-structure of the Radiolaria which has adhered for thousands of years to the same fundamental plan, one is compelled to agree with Haeckel that these unicellular Protista are capable of unconscious ideation.

Unconscious ideation is found too in the common mind-life of the "cell-communities" (sponges, polyps) as well as in those numerous Invertebrates which have no enclosed central nerve-organ but only ganglia connected on either hand with sensory and motor nerve-fibres. Conscious ideation first occurs in animals with central nerve-organs, not merely in the lower and higher Vertebrates but also in some of the better developed

Invertebrates whose ganglia have practically the value of a brain (ants, bees, spiders, crabs and cephalopods).

Man's paramount powers of ideation are due to the size and development of his brain, whose cortex contains countless nerve-cells. It might be supposed that upon the question of conscious ideation in the higher animals there could be no difference of opinion. Türkheim, however, denies this faculty to animals with vehemence and every artifice of dialectic. He declares it impossible that an animal can have an "internal mirroring" of something which is not present. The entire psychical apparatus by means of which men know and think, namely, perception, observation and investigation, are completely wanting in animals. "A state of consciousness," he says, "is either ideation or it does not exist." From this point of view he will not even allow that animals have indefinite, confused ideas, for that would naturally be an admission of their consciousness. Their minds are powerless to form any after-picture of impressions conveyed by the eye, ear, nose, tongue or skin. There can be no question of their forming concepts because they have no powers of ideation, only simple sensations; still less can one attribute to them associations such as exist in man between the feelings and the groups of ideas, or between separate groups of ideas. Yet Türkheim himself admits that animals have associations, just like human beings, partly innate, partly acquired by experience.

I have quoted freely from Türkheim's book because his statements come as a real surprise to those who like myself have been engaged for many years in experiments with animals, and I have limited myself to criticising only his most striking utterances.

The truth is that comparing the human infant with the young of any of the higher mammals you please, psychologically the latter are far superior to the human infant.

And when Türkheim insists that an animal forms no idea of what is not actually before his eyes, he forgets that a dog or horse could not recognise his master at a distance from other men without some internal picture; nor could a homing-pigeon find his loft or the bee his hive without ideation. To take another instance, the wasp could not find with certainty the insignificant opening of its nest in the ground if it had not an inner presentation of it: but the most incomprehensible point to me is how Türkheim can deny that a bird has an inner presentation of its nest and young. He argues in proof of the impossibility of a dog forming a presentation of his master that the dog cannot note all the details of the head, face, etc., because he lacks the fundamental notions of light and dark, right and left. As if these were essential, for the dog only needs to recall a general impression. It is equally unfortunate to assert that pictures, or plastic representations, evoke no ideas in animals. One may see in any zoological garden how a monkey looking in a mirror will make grimaces at his supposed companion, and at last will stretch behind the glass to lay hold on him.

As to denying the faculty of association to animals I will only point to the example of the horse, that at the sight of the smithy where it is to be shod, hangs back in its paces, not on account of the smithy as such, but because it connects the sight of the smithy with the idea of the clumsy blacksmith who had previously mishandled it.

Memory.—As the result of his under-estimation of the animal-mind Türkheim even denies that animals have memory, without realising that memory is essential to the further evolution of the mind-life present in the unicellular Protista. Just as in the lowest classes of Protista unconscious presentations are to be found, so these may be reproduced by what may be called unconscious memory, which may be called into play again, for instance, in the Radiolaria and Thalamophoræ, in order to account for the retention of the fixed plan of their skeletal structure. Ewald Hering, in 1870, summed up the importance of memory to the organic world in these words: "Memory is a function of organised matter, to which we owe almost all we are and have"; and the credit belongs to Haeckel of having in 1876, in his work on the *Perigenesis of the Plastidule*, investigated the functions of the plastidule, *i.e.*, the hypothetical molecule, or groups of molecules (perhaps the cell-nuclei), which demonstrated the transmissibility of memory, and from this followed the whole existence of heredity, or as Haeckel expresses it, "Heredity is the memory of the plastidule".

Unconscious memory is not only represented by tissue presentation but also by unconscious presentation in the ganglion-cells, a function of the lower nerve-animals.

The transition from this to the conscious memory of the brain and spinal cord may be seen in those frequently repeated acts which in man have by long use become unconscious and automatic (speaking, writing and eating). The highest stage is the conscious memory of man and the higher animals.

While Türkheim denies absolutely that animals have memory because no after-images remain of impressions received through the eye, ear and other sense-organs, Wundt is just enough to allow that the lower animals have a power of recognition, at least for short periods, and that the higher animals have perfect memory. Where any particular sense is exceptionally well developed (*e.g.*, scent of hounds, or eyesight in pigeons), animal powers of recognition may far outstrip those of man.

In his ability to recall at will ideas or presentations, man stands alone and far above even the highest mammals. Association of ideas is a very important factor in the mind-life of man and animals. Appearing at first to be subconscious and leading to actions which one is accustomed to designate as instinct, the association becomes more and more conscious until at last in higher animals and man it becomes the source of conscious deliberation.

One of the highest developments of association of ideas is imagination in man, the power of inventing pictures in speech or art. "The imagination," says Darwin,[1] "is one of the highest prerogatives of man. By this faculty he unites former images and ideas, independently of the will, and thus attains brilliant and novel results."

Unconsciously, and uncontrolled by reason and logic, the association of ideas goes on in dreams, not only in man but also in the higher animals (dogs, cats, and even birds). Are we to conclude like Darwin from these vivid dreams that animals even when awake possess some power of imagination? I should not venture to call it impossible when I think of the mocking-bird that in most ingenious fashion adapts the song of some other bird to its own melody and composes an exquisite tone-picture.

[1] Darwin, *loc. cit.*, vol. i., p. 113.

Consciousness, Self-consciousness.—It is clear from the foregoing that man enjoys no monopoly of consciousness as the advocates of the anthropocentric theory aver, but that the first evidences of consciousness appear in the higher grades of animal life. On the whole, however, those physiologists and psychologists go too far who hold all psychic functions to be conscious. If one starts out with the notion of consciousness as an "internal mirroring," one sees that the theory of consciousness as a property of every organism, every cell and every atom is not compatible with this notion, for from the physiological standpoint alone it is more reasonable to assume that consciousness only exists where there are definite organs, special nerve-centres for bringing about this "internal mirroring".

Among zoologists and physiologists there is no unanimity as to where the lowest degree of consciousness is to be found, but no thinking scientist denies the consciousness of the higher mammals, man's nearest allies (apes, dogs, elephants); and there is no difference of opinion that the highest phase of "internal mirroring," self-consciousness, is found only in man.

Deliberation, Judgment, Reason.—That animals act with deliberation Türkheim [1]—in accordance with the point of view so frequently quoted—has denied. It is only given to man to deliberate; in animals there is no question of systematic design, all their actions are the outcome of a simple automatism. Yet even in Invertebrates, and still more in the higher orders of Vertebrates, designed actions can be observed. Ants finding they cannot drag their load alone, bring back other ants to the twig they had left behind so that their united efforts may move it.

Birds and beasts of prey summon one another to the spoil. Elephants carry heavy loads together without waiting for any orders. An ape that cannot reach an object because he is chained up, advances to the full extent of his tether, turns round so that he can stretch out farther and grasps the object with his feet.

These examples of deliberate actions bespeak a faculty which the more highly organised animals share with man, namely, concentration upon a limited field of associated ideas.

[1] Türkheim, *loc. cit.*, p. 110.

Reason extends further: it is not concerned with concrete, but with abstract, associations of ideas.

Both alike emanate from those parts of the cerebral cortex which lie between the four internal sensation centres: both alike are capable of forming concepts, opinions and conclusions. And it is just this difference between the concrete sphere of judgment and the abstract realms of reason that must mark the dividing line between man and beast. An educated dog grasps the idea of a "boot-jack or slipper," and will obey the command to bring the required article. But when Darwin and Haeckel attribute reason to animals (*i.e.*, the power of thinking with abstract ideas), they seem to me to have outrun the ascertained facts.

Man alone is capable of thinking of abstract subjects, though it is undeniable that individual men, and individual races, vary greatly in this respect: the faculty seems entirely wanting in certain savages (*e.g.*, Australian aborigines), who are mentally very nearly akin to the anthropoids.

According to the observations made by Dr. Thiedemann in Philadelphia on two live chimpanzees, it may be inferred that the anthropoids are capable of consciousness, thought, ideas, feelings, perception, will, design and memory, but that they have no knowledge of their knowledge, no consciousness of their consciousness, no recognition of or meditation upon the real ego.

Foremost among man's specific characteristics of mind stand the abstract thoughts of life, death, the origin of the universe, etc.

Curiosity.—Although the higher animals cannot be shown to possess reason in its strict sense, yet they have another faculty which serves to enrich their experience just as in man, namely, curiosity. Türkheim [1] will hear nothing of curiosity in animals. Why, according to his view, should they have the curiosity to obtain ideas of the relations of certain things to one another? One may reply that curiosity, although sometimes dangerous, is in the case of most animals an advantage, because they learn by the experience so acquired to avoid danger. Many animals (ungulates, deer, chamois and other

[1] Türkheim, *loc. cit.*, p. 110.

ruminants, dogs, apes, and even birds, *e.g.*, wild duck and ravens) feel an irrepressible longing to investigate more closely any unusual appearance. Apes are most inquisitive, as Darwin so delightfully demonstrated with a snake in a paper bag.[1] The old assertion that man alone has the desire to gain new experience intentionally is most convincingly disproved by these instances of curiosity in animals.

Counting, Reckoning, Measuring, Weighing.—Similarly it has long been proved incorrect to suppose that man alone is capable of counting. It is very old folk-lore that certain birds can count. I remember a story of Leroy's about the crow which he tried to outwit and did not succeed until four of the five sportsmen in the hut had come out while the fifth remained behind and shot the crow.

Leroy concluded from this that the crow could only count up to four. Lichtenberg's account of the nightingale which was only content after it had obtained its usual three meal-worms is well known, as also the old popular belief that a nest with four eggs will not be deserted if one is taken but will be if two are taken. That these statements have the support of so eminent a scientist as Sir John Lubbock (Lord Avebury) makes them the more readily acceptable. The true solitary wasps (Eumenidæ) bring slaughtered caterpillars to the nest for the larvæ. The number is very variable in different species. One species brings five, another ten, another fifteen, and a fourth twenty-four caterpillars to the nest. When the required number is complete the entrance to the nest is closed. There is indeed one special species of Eumenes which varies the number of victims according to the sex of the eggs laid, providing the males with five, the females with ten. These are very remarkable facts, and leave no doubt about the ability of these insects to count. The famous American Garner, who set himself the task of studying the language of apes, claims to have found that the capuchin ape can count up to three. He put three bullets into a box and allowed the ape to pick them out with his hand; afterwards he only put in two bullets, the ape after picking out these two searched everywhere for the third.

[1] Darwin, *loc. cit.*, vol. i., p. 109, and Sir John Lubbock, *loc. cit.*, p. 284.

The conclusiveness of this experiment is not unassailable, but it is anyhow remarkable that the Australian aborigine, according to travellers' accounts, cannot even count up to four.

The reason why primitive races have not learnt to count is explained by Kohler[1] on the grounds that there was no necessity for it, since man only learns to count when he begins to acquire property (?).

If the question is raised when man first began to count, the answer can only be based on conjecture.

Probably the numerous notches filed in a reindeer's horn may be regarded as the earliest effort to register a tally of the animals killed by the reindeer hunter. It is generally supposed that numbers were reckoned on the fingers first of one hand, then of the other, and finally on the toes, as is done to-day by savages.

Tylor believes that counting with the fingers in particular positions has led to the development of written symbols. The Roman V may represent a reduced diagram of the hand with the five fingers spread out, and the X may be simply derived from the combination of two V's. Lubbock thinks that our early forefathers could not have counted beyond ten, although still there are savages who go no further than four. Whether counting on the fingers originated in prehistoric times spontaneously in different races (Bastian's "folk-thought"), or was spread by direct transmission from one race to another, is a very difficult problem to decide. If one assumes the unity of the human race (and it cannot well be otherwise), one inclines rather to the likelihood of independent discovery.

While it appears probable that many animals besides man can count, yet the power of reckoning, or thinking, in numbers is confined to man alone, for no animal is so constituted as to be able by an independent psychical process to add up, multiply or divide figures.

Calculating horses, dogs and parrots are carefully trained by means of their good memory to perform with certain signs which are given to them. Even the intelligent Berlin horse Hans is no exception to this. Reckoning is an art acquired by man after he has emerged from his primitive state.

[1] Kohler, *Zur Urgeschichte der Ehe*, Stuttgart, 1897, p. 5.

At the Anthropological Congress at Greifswald in 1904, Professor Günther of München drew attention to the different systems of numeration extant among Asiatic, African and American races. These systems contain certain principles of addition, subtraction and multiplication, which, although they differ widely, yet present numerous features of the closest resemblance. Hence the question once more arises, whether these systems were acquired spontaneously or borrowed from one another. An instance of the latter process is the Indian zero; this extended to other races who no doubt learnt to appreciate the immense practical advantage of the cypher in reckoning.

Weighing is a faculty confined to man.

FIG. 126. Right reindeer's horn with notches.

Measuring, however, animals are certainly capable of, at least those animals which work with products of their own tissues, or employ materials of definite length and thickness, or model solid bodies to their own designs. The spider measures the length of the radiating strands of its web, and spaces the transverse strands at regular intervals. The weaver, basket and tailor birds make use only of fibres of given length; the beaver builds with logs of definite length and thickness; the woodpecker carves a hole in a tree with the entrance carefully measured; the kingfisher and sand-martin dig out their nests in the sand according to a constant size and shape, although they bring to the task nothing but their eye and unerring instinct.

In the estimation of "mass" animals are able to aid the eye by the sense of touch in the body as a whole, and especially in the extremities, while birds possess a bill whose tip is richly supplied with nerves. Man in his primitive state knows no other scale than his own limbs can provide. The use of the span from the tip of the thumb to the tip of the middle finger, the finger and its individual phalanges for measuring, is as old as the human race itself and has not yet died out. The ell and foot for greater lengths, and the pace for estimating distance, have come down from primeval ages. It is only within recent years that all these old standards, after thousands of years had established their independent value as absolute standards, have been elaborated into the decimal system of modern civilisation.

Speech.—Most modern scientists and natural philosophers, provided they are not committed to the anthropocentric doctrine, are convinced that not only men but animals also are capable of a language of some sort. Haeckel[1] attributes to many animals a language for imparting their sensations, endeavours and thoughts in the form of pantomime (gesture), touch or vocal speech.

In early times Aelian (*De Nat. Animal.*, v., 51) had with sublime naïveté placed the various languages of beasts on a line with human speech; and Lucretius, who denied that speech was a marvellous gift to man alone, voiced his opinions thus:—

> Postremo quid in hac mirabile tantoperest re,
> Si genus humanum, cui vox et lingua vigeret,
> Pro vario sensu varia res voce notaret?
> Cum pecudes mutae, cum denique saecla ferarum
> Dissimilis soleant voces variasque ciere,
> Cum metus aut dolor est et cum iam gaudia gliscunt.
> Quippe etenim licet id rebus cognoscere apertis.[2]

"But are we to believe that animals have a language although they know nothing and can therefore have nothing to say?" ask the critics. The answer is quickly given. Animals know more than proud man is aware; they always have plenty, a very great deal, to say. The old folk-lore had an inkling of the truth when in legend it was given to men to learn the language of the beasts. Aye, man must learn the language of the beasts

[1] Haeckel, *The Natural History of Creation*, 8th ed., bk. ii., p. 716.

[2] Lucretius, *De rerum Nat.*, bk. v., l. 1056 *et seq.* Munro, 4th ed., London, 1905.

if man would understand them aright. The knowledge of animals is no mean store of experiences, ideas and notions of what to them seems useful or hurtful, suitable or unsuitable, friendly or hostile. Their involuntary utterances are sounds of pleasure or disgust: what they have to say to animals of their own or other species are warnings or commands, expressions of love and affection, or anger and hate. A dog when he hears the word "cats," barks angrily, but jumps joyfully in the air barking whenever his master gets ready to go out and says "come along". A language which is not only intelligible to the same species but can be understood by other animals is the warning of some lurking or approaching enemy, like the warning note of the farmyard cock, the shrike, the swallow, the blackbird when a hawk is in the air, and the fighting cry of the raven when pursued by the kestrel or hawk. Equally characteristic are the alluring tones of the cock calling his hens to some tit-bit he has found, or the hen summoning her chicks; and the sweet song of the mother bird in the nest with her young, or the purring of the cat as she caresses her kittens. Philologists are wont to value the language of animals far below its true worth. Lazarus Geiger considers the bark of a dog as the first attempt at animal speech. Jacob Grimm in his book on the origin of speech says: "The language given to every species of animal remains always uniform and unchangeable. That which is innate has, because it is innate, an imperishable character." How far from the truth this is may be seen from the example of the dog whose bark is not merely not innate but is definitely acquired in his companionship with man; moreover, this bark is not unvarying but is capable of many shades of expression according to the different occasions (like the many different cries of the raven). How dogs learn as the result of training to communicate with men can be best instanced by the way in which a dog whose master has met with an accident on the road, or in the forest, will run home and there bark in peculiar tones until some one follows him out to the scene of the accident.

Vocal speech in animals consists as in man of a combination of tones and noises, vowels and consonants, which are partly expressed as clearly as in man, partly indistinctly, and running into one another, and are therefore, especially as regards consonants, very difficult to imitate. On this account Türkheim's assertion that no animal is capable of more than four sounds should be received with the greatest caution. But even if it were so that the particular utterances of the separate species of animals merely ring the changes on the four letters, yet animal speech ought not to be described on that account as poor, for the four letters may be compared to the primitive syllables which often do not contain even four letters and yet have formed the roots of the human language.

The voice-organ of the Vertebrates capable of vocalisation and of man is the larynx, with the cavity of the mouth as an accessory pipe. The voice is mainly produced by expiration, but in man and many animals it may be inspiratory as well. In those cases where inspiratory sounds figure in a language, as for instance among the South African negroes, these so-called "suction-tones" correspond to the noises of many animals. The vowel sounds produced in the larynx are, according to Helmholtz, not simple tones either in man or animals, but clangs, consisting of a fundamental tone and numerous accompanying overtones. The muffled vowels O and U are not so rich in overtones as the vowels A (ah), E (eh), I (ee). Every vowel sound is produced by a definite arrangement of the mouth, while the nasal cavity is shut off by contraction of the arch of the palate and raising of the soft palate. The diphthongs Ae, Ai, Ei, Au, Eu, are, according to Brücke, formed by a transition from the arrangement necessary for one vowel to the next, and during this movement the voice is emitted. For consonants the cavity of the mouth acts as a speaking-trumpet in which at particular places rubbing sounds or closed sounds are made. As regards the half-vowels (liquids) these are M, N, Ng, L, and the trilled R.[1]

Having briefly dealt with the speech of animals from a general and physiological point of view, I propose discussing at greater length the speech of apes, a theme which is of general interest to physiological psychology and of supreme importance to anthropology. Brehm[2] in his illustrated *Animal Life* describes the speech of apes as being fairly rich in modes of

[1] Munk-Schultz, *loc. cit.*, p. 415. [2] Brehm, *loc. cit.*, i., p. 9.

expressing the various feelings. Their cry of terror is quite distinct, consisting of a series of short ejaculations of a quavering discordant note which always conveys a warning to flee. That is, however, all. Long before Brehm, Bergmann and Leuckart[1] expressed their surprise that monkeys, with their well-known powers of mimicry and a mouth and larynx almost identical with that of man, cannot imitate a word of human speech, although many birds (raven, starling, magpie, parrot) learn to speak readily. Professor Marshall conjectures that this difference must be attributed to the fact that the animal has on the whole quite as sharp, but not as delicate, hearing as the bird. Whether the difference is not to be sought for in the organisation of the brain rather than in the sense of hearing remains uncertain. At any rate the surprise of these observers that monkeys cannot imitate human speech is fully justified. "But," I hear Garner say, "monkeys have absolutely no need to imitate words, for they have their own language." Mr. R. L. Garner[2] undertook the task of studying the language of apes, and sought out all over America monkeys in captivity both in zoological gardens and privately owned; he took phonographic records of the sounds they made so as to observe the effect of reproducing their voices upon other monkeys of the same or another species. He worked for the most part with the small new-world ape, but also with the old-world Javan ape, the common macacus, an anubis baboon and a chimpanzee. From these old-world apes Garner maintains that he has found a rudimentary language; for instance, from a chimpanzee he has, with the aid of the phonograph, distinguished seven tones although he is not able to explain their meaning, while from the tones of the capuchin and sapajou ape, in spite of the difficulty of apprehending them rightly, he believes he arrived at satisfactory meanings. One sound of the capuchin ape Garner interprets as "milk, food". It is an indescribable, deep guttural sound as recorded on the phonograph, which is rapidly followed by a higher-pitched clucking sound. The complete sound is something like schu-uh-uh. Another sound in the language of the capuchin ape Garner

[1] *Anatom.-physiol. Übersicht des Tierreichs*, Stuttgart, 1852, p. 433.

[2] Garner, *Die Sprache der Affen*, Leipzig, 1906.

calls "alarm attack," and he has frequently observed its exciting effect upon other apes when reproduced. A sound ejaculated after punishment accompanied with the corresponding attitude should betoken submission, a word for "danger," also a warning signal sounded something like ü-tsch-g-k, another to announce the approach of any one like (guttural) ch-i! The total resources of the language of the common capuchin ape amount to some nine words or sounds which according to their intonation have each some two or three meanings. The language of the white-faced capuchin has only three sounds (for food, alarm and friendship), that of the rhesus three also, for food, alarm and anger.

Essentially the sounds consist of vowels only in which "i" occurs but seldom. In many words traces of consonants can be detected. The fact that it is so difficult to represent the ape-language with letters does not justify, according to Garner, our doubting the existence of a real ape-language. "Why, indeed?" he asks. "They see, they hear, they love, they hate, they work with the same implements and for the same objects as men."

So he concludes that the sounds which the apes utter are voluntary, premeditated and articulate (!) They are always addressed to a particular individual with the view of being understood. The apes are conscious of their purpose, they make a pause after they have spoken and wait for an answer; if none follows they repeat their words. They usually look at those to whom they speak, and do not talk if they are alone or busy. They understand the sounds of other apes of their own species and answer them, but they also understand the ape-language when imitated by a man either orally or by means of the phonograph. The same sound has the same meaning, different sounds are accompanied by different words and produce different effects.

Except for the assertion that the speech of apes is articulate one may agree on the whole with Garner's views, for there is nothing in them which does not occur in the intercourse of the higher Vertebrates with each other. It is by no means inconceivable that the apes understand when they hear the sound of their own species reproduced by the phonograph, and that they come nearer to the phonograph, hearing a voice and being puzzled as to where the other ape can be. But Garner allows his imagination to tempt him to conclusions which are inconsistent with the well-recognised position of the capuchin ape in the order of primates when he describes a small capuchin feeling cold and talking with a worried look about the weather (!), or another making a speech defending itself against an accusation, and finally receiving humbly a box on the ear.

Garner's account, too, of the expression of negation (shaking the head with a clucking sound), and of affirmation (nodding the head) in these small apes sounds so suspiciously fantastic that it is only fair not to suppress our doubts. On the other hand, we can readily agree with Garner's further conclusion that as a rule every action of an ape is accompanied by a sound, and the sound has an accompanying action which conveys a constant and fixed meaning to another ape of the same species. Their speech consists simply of certain sounds, and since these sounds are as a rule associated with corresponding signs, I expect that it would be easier for them in the course of time to understand the sounds without the signs, rather than the signs without the sounds.

From the beginning to the end of Garner's book, there is not a single proof of the existence of articulate speech among apes nor of any difference between their language and that of the other higher Vertebrates. Both are mere rudiments of a true language in which there are sounds representing certain moods and wishes, or orders, warnings, cries for help, etc., but nothing approaching the higher phase of articulate speech.

Man alone has attained to these higher planes of speech depending on the development of ideas, judgment and reason, and corresponding with a more highly developed brain. According to Wright [1] a psychological analysis of the faculty of language shows that even the smallest proficiency in it might require more brain-power than the greatest proficiency in any other direction.

The process of apperception in man when once it has been acquired is much fuller and more intensive than in animals in whom ideas are very indistinctly defined in consciousness (Wundt). So the much-debated question presents itself, When

[1] Darwin, *loc. cit.*, i., 72.

and how did man first come by his speech? for the myth of its being a gift implanted by Divine Grace at birth has been long ago disproved by physiology. The child comes into the world devoid of consciousness, and, after this has been acquired, has to learn the language of its parents and brothers and sisters; moreover, not only is there this ontogenetic development of speech repeated in each individual but there is a phylogenetic development for the whole race. The French authority Bordier holds that the palæolithic reindeer hunter had no speech, and thinks that it must be concluded from the numerous bone-flutes discovered that he communicated by whistling. But these palæolithic men had a relatively large cranial capacity which would admit of a very well-developed brain, and this fact completely disposes of Bordier's view. Darwin[1] rightly says that "the largeness of the brain in man relatively to his body compared with the lower animals may be attributed in chief part to the early use of some simple form of language". This is not the place to recapitulate a historical synopsis of all the theories as to the origin of language. That the human language did not arise from a single stem was clearly held by the thoughtful poet-philosopher Lucretius (*De rerum Nat.*, v., 1050):—

> Cogere item pluris unus victosque domare
> Non poterat, rerum ut perdiscere nomina vellent.
> Nec ratione docere ulla suadereque surdis,
> Quid sit opus facto, facilest; neque enim paterentur
> Nec ratione ulla sibi ferrent amplius auris
> Vocis inauditos sonitus obtundere frustra.

Necessity, Lucretius means, has given to language its form. It must seem far more natural to attribute the origin of language, not to a conscious design but to unconscious cerebral activity, an instructive impulse shall we call it? It may be that animals only make imitative sounds, or that the uttering of noises is excited mentally by other sense-impressions which form the basis of those roots from which the human language has developed in every race.

The history of civilisation for thousands of years proves that language as a natural phenomenon has not only under-

[1] Darwin, *loc. cit.*, ii., p. 426.

gone, and is still undergoing, a progressive development, but is also subject to the same struggle for existence between the weak and the strong (*i.e.*, between different words) as governs organic life. Many words must have lost ground in the struggle even after surviving for countless years; many others must have passed later into new forms, or disappeared entirely. Philologists have actually shown that conjugation and declension are originally derived from separate words which have ultimately become fused together.

Emotions and their Expression.

By emotions we understand the complex idea of the various feelings of the human, or animal, mind, which may be manifested as sensations of pleasure or disgust, as volitions of negation and assent, or love and hate. An animal experiences all these feelings no less than man. The peculiar individual disposition known as temperament is present in both. Men equally with animals are, according to Kant, "light and heavy blooded" on the one hand, and "warm and cold blooded" on the other. At the highest rung of the ladder stands civilised man with his infinite shades of emotional life, his varying emotions being manifested in his speech, his movements of expression and his actions.

For a state of mind free from all unpleasant feelings, a state of complete contentment, we have the good German word "gemütlich". Human contentment is represented by the man who has finished his day's work, and is sitting enjoying himself in the circle of his family or friends; in animals by the siesta after a full meal. Both in man and animals, the look of the eye is peaceful, the muscles of facial expression, so far as they exist in animals, are relaxed. Among cats, not only the ordinary domestic cat but the larger cats, the lynx, leopard and the Indian leopard, there is a peculiar way of expressing contentment by purring. When this feeling of pleasure increases to actual delight and joy the eyes flash with admiration in both men and those animals who possess higher psychic capacities; at the same time the voice utters sounds full of vivacity accompanied by movements of the head, limbs and tail. The shout of joy and "hurrah!" of man have their counterpart among animals in the loud, joyous bark of the dog, the whinny of the horse, the screech of the parrot and other birds.

Another characteristic expression of delight is "laughter," consisting of forcible expiratory shocks of sound with shaking of the thorax and abdomen. The mouth is pulled upwards and backwards so that its opening is transversely widened, while the lower eyelids are wrinkled up (Figs. 127 and 128). Haller made the observation that the note on which an adult man laughs has the character of the vowel A or O, women and children sound an E or I. The latter is always the case in apes when laughing or chuckling, even as the result of tickling. The chimpanzee makes a half-barking, half-chuckling noise; the small capuchin ape Nellie, the subject of Garner's observations,

FIG. 127. Girl laughing.

FIG. 128. Black baboon grinning.

was so amused by the sudden appearances of a boy who played hide-and-seek with her that she burst into loud laughter which could be heard all over the house. The rhesus ape Dolly had an almost human, but somewhat softer laugh. Dogs and horses, although they do not laugh, certainly grin with delight, the former sniffing with retracted upper lip, the latter drawing back the upper lip and exposing the upper teeth. Laughter is then no specific human characteristic of expression.

Dancing too is not peculiar to man. Mankind, especially during youth, dances round in a circle in ecstasies of joy, and takes great delight in the social dance. When the dog is told to come out with his master he rushes round and round madly, and there are birds which give expression to their joy by dancing,[1] especially all species of cranes, grouse (Pediocaetes phasianellus), a heron (Ardea herodias), the vulture of South America and the bower-bird of Australia. The shouts of children at play, their action-plays, hunting and fighting games can be paralleled in modified form by many classes of animals and birds.

"Our own play," as Wundt says,[2] "is merely an imitation of the actions of everyday life stripped of its original purpose, and resulting in pleasurable emotion. The play of animals bears the same relation to the play of man as animal life does to human life. . . . Though it is true that play is an indication of high mental development and brings the animal nearer to

FIG. 129. Chimpanzee undeceived and annoyed. (Darwin, *Expression of the Emotions.*)

FIG. 130. Expression of grief. (Darwin, *Expression of the Emotions.*)

ourselves than any other activity, it is rather the fact that it plays than the nature of the play itself which is the important point."

Expressions of displeasure, like those of pleasure, are often conveyed in surprisingly similar fashion by man and the higher animals. Dejection is shown in man by dropping the jaw, making a long face and pulling down the mouth. Young orangs and chimpanzees during illness express their wretchedness by apathetic movements, a limp appearance and dull eyes, very similar to the manner of dogs and horses.

Orangs and chimpanzees in a bad temper push out the lower

[1] Darwin, *loc. cit.*, ii., p. 74.

[2] Wundt, *Lectures on Human and Animal Psychology*, London, 1896, p. 358.

lip just like children and adults and look on the ground with knit eyebrows. Ill-tempered dogs lie curled up and betray their temper by snarling when any one comes near to disturb them.

A human peculiarity, not so far observed in any animal, is the expression of sorrow, or grief, which consists in wrinkling up the forehead by contraction of the central portion of the frontalis muscle with a sad heavy look in the eyes (Fig. 130).

Fright and dread are evinced in almost identical ways in man and beast, by a rapid action of the heart, trembling of the muscles, an open mouth with quivering lips and dilated pupils. If the fear increases to terror the eyes stare, the brows contract, the hair stands on end and the sphincters of the bladder and rectum are relaxed (children, dogs, cats and apes).

Physical pain causes men and animals to cry out in anguish with widely opened mouth, and often also doubling up of the body, the skin of the head and face grows red, the eyes suffuse and fill with tears which roll down the cheeks if the pain continues (Fig. 131).

FIG. 131. Boy crying. (Darwin, *Expression of the Emotions.*)

Lachrymal glands secreting a fluid to moisten the cornea and conjunctiva do not really exist in the crocodile whose tears have made him notorious, but they are present in all mammals except the whale. Tereg[1] is mistaken in describing increased lachrymation as confined to man. Wounded dolphins raise their voices in the death-struggle, making dreadful groans in their agony, and sometimes great tear-drops roll from their eyes.[2] Surely these tears must be a psychical manifestation. Tennent too puts this beyond all doubt in his description of the conduct of captive, but otherwise unwounded, elephants in Ceylon: "Many of them after a few strenuous efforts to release themselves lie motionless on the ground, and their tears alone which spring unbidden to their eyes tell us what they are suffering". That

[1] Ellenberger, *loc. cit.*, ii., p. 478. [2] Brehm, *loc. cit.*, ii., p. 835.

apes weep from emotion was proved by Humboldt's instance of the Callithrix. In the London Zoological Gardens there was a macacus that wept so bitterly from grief that his cheeks streamed with tears; and Garner[1] states, "At the departure of a little boy of whom a female capuchin ape had been very fond she wept so bitterly that she was inconsolable". "This little creature," he says, "shed true tears which no doubt came from the same source in the heart from which human tears flow." The absence of tears when the new-born infant expresses its feelings of displeasure is not explained by inability of the lachrymal gland to secrete freely, but is due to the incomplete development of the central nerve-organ. A child has to learn not only to appreciate sensory impressions, and to talk, but also it must acquire the art of weeping. It is evident from the foregoing that weeping is not a human speciality.

Sobbing, the series of expiratory gasps that accompanies weeping, and is caused by deep mental depression, has never been observed in animals, not even in the higher apes.

Those expressions of feeling which belong to the sphere of the will, and appear as inclination and disinclination towards other people, play the same part in the lives of animals as in those of men. Inclination and love have no very distinct expression in man, beyond perhaps smiling, brightness of the eyes, and a desire to touch the beloved person. This desire is seen also in the higher mammals and birds, especially in parrots. Dogs press closely against one and wag their tails vigorously; cats rub against the legs of people of whom they are fond, and erect their tails and purr loudly; horses lay their heads on the shoulder of their master, or groom, and whinny gently; parrots are delighted at having their outstretched heads scratched.

Kissing is a sign of affection not entirely peculiar to man. Many animals appear to kiss one another. Dogs, and less often cats, lick with their tongues other dogs and men upon whom they have bestowed their affection, and Darwin describes how two chimpanzees brought together touched each other with outstretched lips and then embraced. Yet kissing is not universal among all the races of mankind; it is unknown through-

[1] Garner, *loc. cit.*, pp. 40, 51.

out the whole Malay peninsula, among the New Zealanders, Australians, Papuans, Tahitians, Somalis and Eskimos.

It is incomprehensible, according to Türkheim, who denies this power to them, that animals separated from their companions, or their master, should mope and refuse their food. Still there is overwhelming evidence of the fact they do show their grief in this manner. Any one who owns animals knows how dogs and horses when they change owners will fret for days over the separation; it is well known too that if one of a pair of love-birds dies the other will almost invariably follow suit in a short time. I myself can vouch for the fact that a crested cockatoo who was sold by its mistress touched no food from that hour and was dead in two days.

Türkheim's repudiation of these well-authenticated facts is part and parcel of his belittling of the animal mind which allows him to deny also their powers of expressing dislike. He denies that animals possess any self-consciousness because they must lack those characteristic attributes with which it is associated, namely, envy, jealousy, malice and hate. As it can be proved, however, that these qualities are not wanting in the higher animals, especially those that are trained, so he must logically allow that they have a consciousness of self.

Envy and jealousy, although men rarely betray these feelings outwardly, may be vividly expressed by domestic animals (dogs and horses) and by apes and parrots when some other animal is caressed in their presence, or given some dainty morsel. Instances can be seen any day of this where the favoured animal is attacked with fierce yelps. Dogs can express pleasure at the misfortunes of others, as for instance when another dog is beaten or when they bark scornfully at some beggar man. The chastisement of others seems often to afford them keen pleasure and they accompany the spectacle with loud barking.

Anger can be expressed not only by the higher animals but even by many of the lower classes. Amphibians and reptiles when angry inflate their bodies, birds ruffle up their feathers, mammals bristle up their hair, horses and cats lay back their ears: but all animals capable of producing noises make use of them when roused to anger: snakes hiss, jar and rattle, storks clatter their beaks, rabbits stamp on the ground, and all animals make use of such vocal powers as they possess and show their teeth (Fig. 132). The ape's face visibly reddens when angry, he stares fiercely, and with outstretched lips utters loud cries and beats with open hand on the ground or with clenched fist on breast. The angry man behaves in much the same way, his face flushes, his eyes stare, his lips are firmly set, his voice gets shrill, and if he does not stamp he bangs his hand or fist on the table, or on anything lying near, while often enough his anger carries him, like an angry animal, to express his feelings by aggressive action. Persistent anger or hate is not unknown in animals; there is the familiar spectacle of a dog who catches sight of another dog in the distance, stopping with

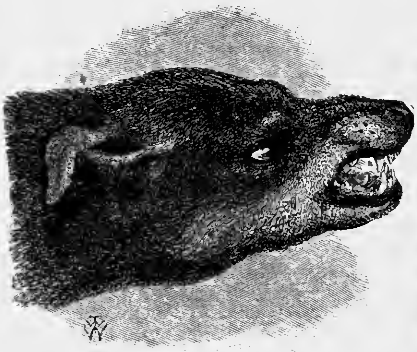


Fig. 132. Angry dog. (Darwin.)

Fig. 133. Angry man. (Darwin.)

the hair erect along his spine, first growling and then barking furiously. Many anecdotes have been published of the long-delayed and unexpected revenge of horses, camels and other domestic animals on men who have previously ill-treated them.

There remains only a few other modes of expressing antipathy and they are certainly confined to man: namely, scorn, disdain, contempt and loathing.

Curling up one side of the nose and displaying the eye-tooth, which is in many men the expression of scorn, may be compared to the retraction of the upper lip and baring the teeth in bad-tempered dogs, but not even the highest animals can feel real contempt. Neither can the disregard of small animals for the large beasts of prey be likened to the moral contempt of man, nor the physical horror which many animals show for certain unpleasant odours be set on the same plane as moral loathing.

Wundt,[1] who held that emotional expressions arose from the action of the feelings upon the progression of ideas, distinguished two classes of movements for the expression of the emotions. Affective (reflex or purely expressive) movements, arising from the direct stimulation of the mind by an impression, and impulsive (impulse) movements, the result of internal or external stimuli, which excite a succession of ideas whose outcome is the production of definite feelings. Impulsive movements will be discussed later on; at present we may confine our attention to the affective movements, or those expressions of emotion which manifest by expressive movement certain psychical affective states. Although the number of mimetic movements is very small in comparison with the multitude of emotions and moods, it is very difficult to give an adequate psycho-physiological explanation of them. According to Herbert Spencer,[2] there is a general law that feeling passing a certain pitch, habitually vents itself in bodily action, and that an overflow of nerve-force undirected by any motive, will manifestly take first the most habitual routes; and if these do not suffice will next overflow into the less habitual ones.

Already physiology had independently tried to arrive at a scientific instead of a philosophical explanation of the movements of expression; but Johannes Müller, the greatest of the older physiologists, declared in his *Text-book of Human Physiology* that it was utterly impossible to find an explanation why various groups of fibres of the facial nerve are stimulated according to the mental mood.

Darwin[3] did not allow this statement to deter him from making further research. He adopted three principles applicable to the influence of mental emotions, or involuntary feelings, upon men or animals. The first is the principle of serviceable associated habits, as for instance a hungry horse pawing the ground, or the huddling together of frightened animals and men. The second is the principle of antithesis, and this seems

[1] Wundt, *loc. cit.*, p. 381.

[2] Spencer, *Essays: Scientific, Political and Speculative.* Second series, 1863, p. 111.

[3] Darwin, *The Expression of the Emotions*, London, John Murray, p. 28 *et seq.*

to me to be the most important. Darwin explains this by saying that if a mental state is produced which is opposed by certain purposeful associated movements, the inclination is excited to exhibit movements of a directly opposing nature. He quotes as striking examples an angry or peaceful man, an angry and a friendly dog or cat. (In an angry dog the ears point forwards, in a peaceful dog backwards, and *vice versâ* in cats.)

The third principle he terms direct action of the nervous system, independent of the will, and to a certain extent independent of habit. In man and animals, this includes the muscle-tremor of fear, of great anger or extreme joy, the beating heart of terror or surprise, the staring eyes of horror. The great anthropoids display very similar mimetic movements to men, because their facial muscles are practically the same (Owen, *Proc. Zool. Soc.*, 1830).

Will.—A gradual evolutionary scale can be traced out as regards the will. The simplest manifestations of the will are the reflexes, *i.e.*, the elementary expressions of unconscious psychical activity which result from the connection of sensation and movement. The response of the whole protoplasm of a unicellular protist to an external stimulus is a reflex movement. Higher in the scale come those simple metazoa in which there is direct reflex connection between a sensory-cell and a motor-cell. Advancing a step higher we find joined to these two cells a third "ganglion-" cell which is the seat of unconscious reasoning processes, as seen in most of the Invertebrates. In the highest evolutionary forms, and among the Vertebrates generally, the reflex organs consist of the sensory and motor-nerve fibres with two ganglion-cells intervening, one sensory and the other motor; by these means not only reflex, but also conscious, movements are performed. Haeckel and the other supporters of the monistic theory regard the conscious will of the higher Vertebrates and man as a gradual development from the psychic reflex activity; they distinguish, however, two processes: (*a*) primary reflex actions, or those which have never reached the stage of consciousness in phyletic development, and thus preserve the primitive character in the higher animals by transmission from the lower forms; (*b*) secondary reflex actions, *i.e.*, those which were conscious voluntary actions in our ancestors but which afterwards became unconscious from habit or the lapse of consciousness. Even Wundt[1] recognises in man and animals certain purposive reflexes which have acquired this character as the result of voluntary acts transmitted through many preceding generations until they have become a constant attribute. But of primary reflexes Wundt will hear nothing, and opposes most determinedly the views of those who suggest that reflex actions may be the source from which the will has developed; he does not in fact hesitate to say that the protozoa are not merely reflex machines but give plain evidence of voluntary movement.[2] In this respect he is in favour of the fundamental similarity between the human and the animal mind, and directly contradicts the Cartesian and "orthodox" view of the absolute automatism of animals and the free will of man. The truth probably lies somewhere midway between these two views, and at any rate warrants the assumption of a gradual progressive evolution of the will.

We have previously learnt to regard "impulses" as actions which represent the endeavour to give effect to the feelings. The simpler impulses have little more than the character of reflexes. The inborn, or connate impulses, the "instincts," are originally blind actions without definite ideas, being purely reflex movements, as, for instance, the hungry infant feeling for the mother's breast, or a kitten whose eyes are just open clawing at anything that moves. Wundt distinguishes sharply between impulses and instincts, the former word is used to denote the simpler purposive movements, the latter to denote the more complex impulsive actions which presuppose a long course of individual or generic practice. Instinctive action, therefore, stands midway between reflex movement and pure voluntary action.[3] The definition of "instinct" has been constantly more sharply limited since Kant's day. Kant regarded "instinct" as a feeling of the necessity to do something, or to enjoy something of which one has as yet formed no concept; Herbert Spencer defined it as the complex reflex movement dependent on the physical complexity of the organism; Hartmann as a purposive action without consciousness of the purpose. Darwin and his school see in the instincts purposive actions which are not the outcome of deliberation but rather of indistinct ideas of the

[1] Wundt, *loc. cit.*, p. 398 *et seq.* [2] *Ibid.*, p. 226. [3] *Ibid.*, p. 388.

needs of the individual representing the sum of ancestral experiences in the struggle for existence. The knowledge of what is harmful or harmless is transmitted hereditarily to succeeding generations until the corresponding movements become purely reflex. Even Wundt admits instinctive actions to be movements which were originally simple, or complex, voluntary acts ultimately transformed by habit during the individual life, or in the course of a general evolution, into acts which are wholly or partly mechanical. In this he agrees with Haeckel, who divides instincts into two fundamental classes, primary instincts or the impulses to self-preservation and the preservation of the species, and secondary instincts manifested by acts originally conscious and deliberate but which by habit have acquired an automatic character. Physiological psychology has long ago ceased to waste time in discussing the old theory according to which the animal instincts are of a nature apart from the human while the intelligence is to some extent similarly innate.

Man too has his instincts if thereby we understand purposive involuntary actions, partly impulsive, partly reflex. Walking, for instance, is an instinctive impulse learnt with great difficulty, but its movements eventually become mechanical just in the same way as writing, pianoforte playing, etc. Wundt [1] goes so far as to allow that mankind may be regarded as the richest of all creatures in instincts. "Man shares with the birds the instinct to live in wedlock; like the fox he educates his children; he has the beaver's impulse to build houses and the bee's custom of founding states and sending forth colonies; while he has in common with the ant a pleasure in war, in slave-making, and in the domesticating of useful animals." The last examples are, however, not striking, for primitive man does not instinctively resort to warfare, slave-making and domestication of animals, but arrives at these and many other equally instinctive actions by reasoning and deliberation. Wundt is perfectly correct in regarding the original sources of acquired human instincts as being mimetic impulses, although I cannot agree with the distinction he draws between human and animal instincts which makes the former "the fruits of a continuous intellectual development not a trace of which is demonstrable

[1] Wundt, *loc. cit.*, p. 396.

among the animals," nor can I comprchend why he will allow to man alone "volition" in the individual accomplishment of instinctive actions, and denies it entirely to animals. For even animals modify their instinctive actions (*e.g.*, nest-building) if natural circumstances, or experimental conditions devised by man, compel them so to do.

It is obvious that many erroneous hypotheses have passed current from lack of opportunity to carry out experiments with animals. Türkheim and many others limit the power of deliberation to man, as if the higher animals were utterly incapable of this process. The crow in the tree does not fly away when the tree is struck with a stick, but makes an immediate flight when it catches sight of a gun. The elephant which at first cannot succeed in dragging a balk of timber will carry it perfectly as soon as it has balanced the timber on its tusks. Apes if they cannot open hard nuts with their teeth will crack them on a stone. Wundt[1] regards very sceptically these instances of reasoned action on the part of animals; he considers that animals like men are capable of "similarity associations" in time and space, and so perform acts which in their results are equivalent to the products of intellectual functions. He draws a line, however, between apparently intelligent associative action and intelligent action proper, in that the effect of association does not go beyond the connection of particular ideas, no matter whether these ideas are directly excited by sense-impressions, or are only reproduced by them. Intellectual activity, in the narrower sense of the word, presupposes a demonstrable formation of concepts, judgments and inferences, or an activity of the constructive imagination. But just as we cannot deny the formation of concepts, judgments and inferences by the higher animals, although they are undoubtedly less clearly defined than in man, we must admit the possibility of the deliberate action by animals. This power of selective action, which the majority of the older psychologists did not confine to man, is in no way identical with "free-will," and the two ideas must be clearly differentiated.

Wundt devotes a whole chapter in his book to the problem of free-will and describes many motives, some conscious, others

[1] Wundt, *loc. cit.*, p. 359.

unconscious, as contributing to the causality of free-will. From these is evolved a feeling of independence stronger than anything derived from impulsive actions, and this constitutes the sense of freedom. Yet in this consciousness of freedom lies the error into which the supporters of indeterminism have fallen. The will is free, they say, because the conscience perceives as constraint every opposition which the action excited by the will encounters. This opposition is the collective will of the community conflicting with the individual. These ideas of an opposing community-will are always present in considerations of a moral character; as a matter of fact, in the vast majority of human actions the community-will does not come into account at all and makes absolutely no difference in those numerous actions which are purely individual. Even if the individual will should come into conflict with the collective will of the community, the man who deliberates as to whether he shall give offence or not, is after all only in the same position as a setter deliberating when a hare gets up as to whether he shall give chase. The decision is not free in either case, but is the necessary result of the predominance of one or other of conflicting motives.

If the setter were in the field alone the lust of the chase would so far gain the victory that he would start off at once in pursuit, but in his master's presence the fear of punishment is overwhelming, and, trembling all over, he simply gazes at the hare.

A man is in precisely the same predicament when faced by the choice of performing, or neglecting, some moral action; on the one hand, he is influenced by conditions in the external world, and on the other hand by the dictates of his individual organisation, his inherited character. In every action the strongest motive turns the scale without its being always possible to recognise the motive in question.

From the point of view of monistic philosophy no absolute difference—but only one of degree—can be established between the human and animal will, for both are expressions of the psychical elements entering into the organisation of the body, and so are subject to the laws of nature. Every apparently free action is, even in man, a necessary inevitable occurrence for the performer.

Social Impulses and Observances.

Social conditions can be observed to occur among the lower animals (medusae, molluscs, insects). It seems natural to conclude when one sees the individuals of these orders forming compact congregations that if they are not actuated by individual reciprocal affection there is some unconscious bond uniting the species. In many instances birth-affinities may have conduced to this community-life. No gain whatever to the individual results from this form of socialism; mutualism, on the other hand, is always associated with some advantage to one or both the contracting parties, who may or may not be physically affected by their mutual relationship. The relation of the peacock to the tiger and the hen curassow to the puma is an offensive and defensive alliance. The strong protects the weak in consideration of the latter's usefulness in warning him of danger. This is the case with the shark and the pilot fish; in return for definite protection the pilot fish reconnoitres for the shark. What is the alliance between the hermit crab and the sea anemone on his shell but a mutual compact that the crab will protect the actinia with his claws in return for the protection of the other's stinging powers? Still it is somewhat inexplicable why the ants, which are otherwise so pugnacious, should tolerate in their nests a large number of larval, or mature, chafers (Scarabaeidae); possibly the ants are fond of some excretion or exudation of these myrmecophilæ; for it is inconceivable to suppose the ant acts disinterestedly. It is quite easy to explain the friendship between the starling and the sheep, between the maggot-pecker and the great African mammals; both parties confide in one another because the advantage is mutual, the insectivorous birds finding an abundance of food on the skin of the animal who is relieved of his parasites by the extraordinary vigilance of the birds.

A sort of travelling companionship is set up when one species uses the strength of another as a vehicle, *e.g.*, the turtle and the sea-urchin (Echinus) clinging to it, or the aplysia riding on the larger crabs. This travelling at some one else's expense may be regarded as a sort of parasitism; it may extend further to a table companionship (commensalism), when one party shares its food with the other, or finally to vital-companionship, where the parasite either lives in the skin, or in the viscera of its host. As a rule, the parasite is a lower species than the host, but there are exceptions to this, for not only do animals of the same rank act as host and parasite (namely, insects on insects, or crabs on crabs), but sometimes actually a higher animal lives on a lower (crabs on molluscs and fish on echinoderms). The most remarkable instances are however those of the male, the smaller sex of the species, living a parasitic life in the larger female, as sometimes occurs among the bonellia, and certain crustaceans (wood lice and centipedes).

Man does not make a very notable exception to this custom, for have we not always with us the professional beggar, the gipsy, and other tramps, the usurer, the thief and burglar who without troubling to work for a living exist at the expense of the community? If we turn, however, from parasitism—this dark side of the social instinct—to the better aspect of the mutual affection, we find that the expression of this impulse by the individual which we call friendship is only found among the higher animals (birds and mammals).

Examples of friendship amongst birds, between birds and animals, and between different species of animals, are well enough known to make it unnecessary to quote them here. It is a fallacy, however, to suppose that a friendship between a dog and cat is quite impossible; if the pair have been brought up together the friendship between the two may subsequently become even more firmly cemented than many human friendships.

The highest phases of individual affection are reached among animals. Wundt[1] is of the opinion that these exist only among the higher Vertebrates (birds and mammals), and not among Invertebrates, or the lower Vertebrates. He does not seem to be aware that among the chafers of which the well-known Ateuchus sacer may be taken as the type, the males and females care for their progeny so much that they form for each egg a dung-ball; finally when the number is complete they may end their life. Close investigation reveals, moreover, among the lower Vertebrates a pairing between the male and

[1] Wundt, *loc. cit.*, pp. 411-22.

female obstetric toad, and this monogamous union is maintained until the strings of eggs which the male carries about twisted round his hind legs are gone, and the larvæ are hatched.

Wundt's further statement that the majority of higher birds and mammals live in monogamy only holds good of birds, for most mammals prefer polygamy, the male not being satisfied with wooing a single female; afterwards he may not concern himself with the offspring, or he may act as the leader and protector of a herd of females and young. The majority of apes up to the baboons have never risen above this social condition, and it is only the anthropoids (except perhaps the gorilla) who pair monogamously.

Polyandry is not, at least as a temporary condition, by any means so unusual as Wundt supposes, for many female animals whose rutting season is protracted incline to the approaches not merely of one, but of many males, if she succeeds in evading the attentions of her first choice. Polyandry has been demonstrated in insects (the Elateridæ) and in fishes (carp and minnows).

The probable marital observances of our palæolithic ancestors may be deduced with some degree of certainty from those now extant among the primitive savages of to-day.

It may be broadly assumed that the primitive conditions of marriage and property of the modern savage correspond with those of primeval man.

Darwin[1] regards as one of the chief causes which prevent or check the action of sexual selection the so-called communal marriages or promiscuous intercourse. The authorities whom he quotes as vouching for the existence of present-day tribes who practise this custom are Lord Avebury, McLennan, Morgan and Bachofen. All these observers believe that communal marriage was the original and universal form throughout the world. Even Kohler[2] thinks it not at all improbable that before the existence of any form of marriage tie in prehistoric times a condition of general promiscuous intercourse prevailed. The customs described by trustworthy travellers as surviving to the present day amongst red-skins, Eskimos, and Australian blacks probably resemble the old-time conditions.

[1] Darwin, *Descent of Man*, ii., p. 390. [2] Kohler, *loc. cit.*, p. 164.

Darwin[1] states that the indirect evidence in favour of the belief of the former prevalence of communal marriages rests chiefly on the terms of relationship which are employed between members of the same tribe implying a connection with the tribe and not with either parent.

Mucke draws a totally different picture of the origin of marriage in his book, *Horde und Familie* (Stuttgart, 1895): according to him the tribe was the first to appear and immediately afterwards came the family. He thinks the grouping of the sexes was very peculiar; for just as on board ship the various details of cargo are stowed on one or the other side, so the women and girls had their dwelling-place on the one side of the tribe, the men and boys on the other, while a special place was set apart for the old men and women. Then at a given season, probably in the spring, the union of the adults of either sex took place and, no doubt, *coram publico*. That the marriage was monogamous and that the family tie between brothers and sisters followed naturally seems to him an obvious conclusion, though he does not explain the reason why. Later disturbances would arise in the tribe over women stolen primarily that they might work, and secondarily be enjoyed sexually, and so Mucke goes on to elaborate the fanciful scene. Throughout he makes the mistake of concluding that because certain anthropoids live monogamously, this must also have been the rule with primitive man.

The brothers Sarasin have fallen into the same error in supposing that the Veddahs represent the original conditions of mankind living *à la* Adam and Eve because these miserable savages observe monogamy. Disregarding the fact that these inhabitants of the Ceylon mountains intermarrying with their own sisters and daughters cannot be looked upon as enjoying the very highest ideal of matrimony, Kohler,[2] in his able criticism of the Sarasins' book, shows that the wretched economic conditions of the Veddahs do not represent the circumstances of early mankind, but rather a stage of degeneration from the original happier conditions: primitive humanity must have lived a far more sociable life.

Kohler takes communal promiscuous marriage to have

[1] Darwin, *loc. cit.*, ii., p. 389. [2] Kohler, *loc. cit.*, p. 11.

been the earliest and most widely prevalent mode of union. Judging from the fact that community-life has always been so characteristic of man, and in its development has proved so beneficial, Kohler[1] comes to the conclusion that an element so intimately connected with the society as communal marriage may have been one of the chief factors in the evolution of culture in the dawn of the world's history. For "the race destined to rule the world is not that which originally lived in strictest monogamy".

Communal marriage is closely bound up with totemism, that primitive form of religion which may well be considered now before we proceed to the comparative consideration of the other early forms of religion, for totemism contains the germs of the family, or national, idea.

It is well known that the North American Indians, the Dravidas of India, and the Australian blacks trace the descent of each tribe from some animal which is on that account held sacred and inviolate by them, whilst its characteristics and various attributes are used as personal names in the particular tribe. The influences affecting marriage and prosperity are derived from the same superstition. Because a man is forbidden to marry a wife belonging to the same totem he is compelled to find his consort in a tribe with a different totem; the result of further marriages between members of totems A and B is that, as happens, for example, among the Indians, the union of brothers and sisters can take place, of a man with the sister, aunt or niece of his wife, or of a woman with the uncle and nephew of her husband.[2] Furthermore, according to the views of these savage races, no one can be descended from two totems (two animals as a combined form), so that the relationship must be derived from the father or the mother, and naturally it tends to the maternal side; thus "mother-right" is established by which the mother's brother has more authority over the children than the father.

Out of totemism springs blood-affinity, the fundamental human bond which finds direct expression in the family and the family confederation, including the whole totem in one body politic. Totemism has always led to mother-right, and the latter is universally older than father-right.

[1] Kohler, *loc. cit.*, p. 6. [2] *Ibid.*, p. 66.

The necessity for setting up sub-totems first arose from the great extension of the totem in a single tribe, and it was convenient to take the sub-totem from the father who transferred his totem-name to his son. So the sub-gens changed to father-right and gradually abandoned mother-right, especially among such tribes as divided the means of subsistence in each family into halves (*e.g.*, Australians). Among the Australians mother-right as well as communal marriage is becoming obsolete: in other tribes it still persists, and long families and tribal constitutions have developed.

Communal marriage is rapidly decaying among the Dravidas, although it is still customary among a few southern tribes. In its stead polyandry frequently obtains. Among the Todas and Himalayan tribes several brothers share one wife who is bought by one of the brothers, the others contributing their share to the purchase-price. In addition to this there are communal marriages, where several brothers marry several sisters, and every child of these women is regarded and treated by each man as his own.

Temporary marriages exist among the Nairs, according to which the woman does not have several husbands simultaneously but changes from one husband to another after varying lengths of time. Actual polyandry goes further among the Bhils of Panchmahal, the Cingalese and the Tottyar of Madura, where brother, uncle and nephew take the same wife.[1]

Polygamy is not by any means confined to the animal kingdom. It existed more extensively among many races of olden times, being regarded as an institution in a measure self-evident. The literature of folk-lore shows how large a part of Africa, Asia and even Eastern Europe is occupied by nations practising polygamy. Polygamy is in direct contrast to polyandry, and owes its existence to exactly opposite motives: for while polyandry is the outcome of poverty-stricken conditions, where no single individual can permit himself the expensive luxury of a wife, but three or more brothers must share the cost, polygamy, with its harem of secondary wives and concubines, originates in an ostentatious superfluity of riches applied

[1] Kohler, *loc. cit.*, p. 143 *et seq.*

to the gratification of lustful appetites, and the maintenance of the household of wives and their children.

If monogamous birds and mammals live together in societies (*e.g.*, crows, herons, martins, finches, beavers), they form settlements, or colonies, which often last for years, and by gradually enlarging may in time grow to a great size. Polygamous animals (ruminants, ungulates and apes) form flocks, herds or troops under the leadership of the oldest and most experienced of their males, from which, as their membership increases, offshoots break away under some younger leader and in turn grow into larger flocks or herds.

The community-life of certain species of insects is remarkable. Their so-called states prove on closer observation not to be states in the human sense of the word, but only overgrown families formed by the gradual development of a large nest from a small one by increase of the brood.[1] In all honeybees, wasps and hornets there exists, in addition to the males and females, a sexless class of workers, in reality undeveloped females. The industry in such hives is, generally speaking, the same, but the division of labour is much stricter in a bee-hive.

In ant-states there are similarly fertile (winged) males and females and wingless workers (undeveloped females). The differentiation goes even further among the termites, for they have, in addition to workers, soldiers with exceptionally developed jaws.

The communal life and the separate household of the social hymenoptera may be explained as the result of a gradually acquired habit reproduced in every succeeding colony by hereditary transmission. The government of these hives has reached to such a pitch of social instinct that they have been given the name of states, and a monarchical constitution has been attributed to the bees, while the ants are held to be republicans; nevertheless, these instinctive, unvarying arrangements, although resembling the constitutions of human-states, are not really comparable to them.

Turning to the primitive social arrangements amongst men, we start from the family, or confederation of families, who in part thrust out their offspring and in part live in union under

[1] Wundt, *loc. cit.*, pp. 411-22.

a chieftain, he having undertaken the duty of directing their internal affairs and leading them to battle with other tribes. The combination of one or more of these tribes, whose regulations are more or less lax, produces the state with its rules: and while the so-called insect-states always reproduce in subsequent generation the old arrangements instinctively acquired, human-states constantly change their regulations and their constitution according to external conditions and the internal motives of state policy, varying between oligarchy, monarchy and republic. It is also well to remember that the differences between the rights and duties of the individuals in human-states are based upon inherited, or acquired possessions, and upon the standard of intelligence. In animal-states the differences depend upon sexual distinctions and secondary sexual characteristics.

A characteristic wholly confined to the human race has been commented on by Hörnes,[1] namely, the deep attachment to the fatherland and nation. This attachment is dependent on the language or mother-tongue, which is the chief bond which unites men together or serves as a barrier to keep them apart, and so becomes the mother of the nation.

There are many more points of resemblance between the social lives of animals and men. A striking instance is the migration-impulse (Wandertrieb) which comes upon many Vertebrates and Invertebrates at definite seasons. The most familiar example of emigration and colonisation is that of the bees swarming under the leadership of a queen; many other insects (butterflies, Orthoptera, Diptera and Neuroptera) collect, in millions perhaps, to migrate over lands, rivers and arms of the sea, partly in voluntary flights, partly driven by the wind. Compact shoals of fish approach at spawning time to the river or sea-shores; the young of many birds wander in great flocks from place to place until the breeding season is over, when in company with their parents and kindred they turn south again. Lemmings and rats are from time to time seized by an irresistible impulse to unite and travel in some definite direction over land and water. In South Africa herds of springbok, followed by beasts of prey, join by thousands in a general

[1] Hörnes, *Urgesch. der Menschheit*, Wien, 1892, p. 105.

migration. The American bison, too, lived in great herds, and the ground often thundered under their countless hoofs as they stampeded from the northern feeding-grounds to the south.

The causes of these animal migrations are, and always have been, the old incentives, hunger and love; and when human tribes and peoples migrate it is the same want of sustenance that drives them either to travel *en masse*, or to send off a part of their surplus population, as Uhland has so magnificently described in his *Ver Sacrum*. Yet there are other motives as well, such as covetousness of the movable property of other tribes and the appropriation of men themselves as labour material. Thus arises war, the violent armed attack, which even to-day occasionally initiates fighting amongst nations, and in former days played a constant part in human affairs. "It is no argument," says Darwin,[1] "against savage man being a social animal, that the tribes inhabiting adjacent districts are almost always at war with each other; for the social instincts never extend to all the individuals of the same species." Ancient history describes whole nations conquered and taken captive into slavery; we know that up to Montezuma's reign in Mexico, thousands were taken captive in war, some to be made slaves, and some to be sacrificed. Many slave-dealers in Central Africa used to organise regular men-hunts. We own, therefore, with shame, that side by side with social instincts, the brute lies dormant in man, and we scorn to console ourselves with the thought that there are animals too that wage war and make slave raids, namely, certain species of robber-ants: Polyergus rufescens, Strongylognathus testaceus and Formica sanguinea.

The workers of these robber-ants are not the progeny of the common ancestress of the nest, but are stolen as larvæ or pupæ from the nests of entirely different species, so that the colony is a mixed one. Polyergus rufescens and Strongylognathus testaceus are distinguished by toothless jaws not adapted to work; the former steals the worker-brood of Formica fusca and Auricularia, while Strongylognathus takes the Tetramorium cæspitum. The Formica rufescens, however, takes the eggs and pupæ of its two species of formica and allows itself to share in the labours of the workers when they

[1] Darwin, *loc. cit.*, i., p. 166.

are hatched, while the other robber-ants do nothing but permit themselves to be fed. As may readily be imagined these slave raids are not effected without serious bloodshed and loss of life, for the ants are a fierce race. So we see that slave-owning is not merely a human social contrivance.

A characteristic which must be described as peculiar to man is the slavery which exists in times of peace as the result of industrial subordination: it is caused by the unequal distribution of property and the accumulation of wealth into a few hands at the expense of the remaining surplus population.

Community of possessions and right to such sustenance as there is, and to defence from all outside oppression even at the hands of their own species, is the feature of every hymenoptera state; among the honey-bees, however, the lazy, non-working drones after they have done their duty, are, at the end of July, or the beginning of August, either closed in and abandoned to death by starvation, or driven out of the hive, or else simply stung to death in a so-called "drone fight".

Communism in its broadest sense is based on blood kinship, and may be assumed with almost absolute certainty to have been the rule among the primitive family, communities and tribes. Indirectly we may arrive at this conclusion from the customs of the simple savages as described to us by trustworthy travellers.

Among the red-skins, for instance, so long as they were masters of their own land, there prevailed not only common possession of land, food-material and the necessary implements for hunting and fishing, but even common hearths and homes, and a most lavish hospitality, at least towards members of friendly tribes.[1]

The rudiments of other social qualities, such as sympathy and pity, we should not look for only among the higher animals and man, but also among those social animals which though low down in the scale of structure yet must be classed high in the psychical scale. At any rate, scientists like Forel, Huber and Lubbock have observed that ants lick one of their own species when injured or wounded in a fight, take hold of it carefully and drag it to the nest, but only if they have

[1] Kohler, *loc. cit.*, p. 146.

recognised by the smell that it belongs to their own nest. There are many instances of the higher birds and mammals exhibiting sympathy and pity not only towards their own kindred but also to animals of other species and even different orders. Darwin[1] quotes many cases of blind birds fed by their companions, also that of a dog who never passed a cat who lay sick in a basket, and was a great friend of his, without licking it. He also tells of a little American monkey in the London Zoological Gardens who rescued his keeper, to whom he was warmly attached, from the savage and dangerous attack of a baboon, by distracting the attention of the baboon by screams and bites. Buchner has published many equally trustworthy instances in his *Liebesleben der Tiere.* Dr. Bouchinet[2] does not hesitate to regard such examples of sympathy of animals with the sufferings of others as forming the first beginnings of the healing art.

Just as the sympathy of animals outstripping that of man may morally be ranked so high, their love for their offspring may, from a biological standpoint, be ranked even higher, because it contributes far more to the preservation of the species. This parental affection, especially the mother's love for her young, is first seen in a very humble order of Invertebrates, the starfish; it is even more marked among the articulates where the spiders carry about their ova until the young are hatched. Field-crickets and earwigs actually cover their hatched larvæ with their bodies. Exceptionally strong is the parental affection of Vertebrates, and it increases as we ascend the animal scale; the male stickleback strives his hardest to keep the brood together in the nest until they have grown to a certain size. There are, however, frequent breaks in the chain through the animal kingdom, for many lay their eggs or bear their young and trouble themselves no further about them. But the solicitude of birds for the welfare of their young has always been proverbial; it is found among the mammals in no less degree, reaching its highest expression among apes and men.

The question, whether man is alone capable of moral feelings, or whether they are present in the higher animals also, has

[1] Darwin, *loc. cit.*, i., p. 157.

[2] Bouchinet, *Des États Primitifs de la Médecine*, Paris, 1891.

been summarily decided in favour of man by the advocates of the anthropocentric doctrine, although their decision by no means agrees with the evidence.

In the first place it is common knowledge that gratitude is a quality widely distributed among birds and mammals, and is shown by animated looks and joyful movements when they receive any kindness. Unbounded fidelity and trust are exhibited also by otherwise savage and ill-natured creatures. It detracts but little from the value of the gratitude that in man, as well as in animals, it is based on selfish motives; for on this foundation rests every moral motive to those well-recognised social instincts that have led to and maintained the position of the family and racial kinship.

According to the view of Darwin and many other observers, morality is a purely practical outcome of the social instincts.

The post of leader among animals, of commander and defender, of keeping guard and giving signals, is a post of honour acquired by merit, and the trust is loyally discharged just as a soldier would rather lose his life than betray his trust.

"With those animals which live permanently in a body," says Darwin, "the social instincts are ever present and persistent;" even among them there is often a conflict between opposing instincts, and those offending against the common good are crushed (*e.g.*, apes who by making expeditions into the fields have jeopardised the safety of the troop). Darwin further suggests that a moral feeling, a sort of conscience, must have been acquired by every social animal if it had developed its intellectual powers as highly, or nearly as highly, as man, and naturally there would have been room for an infinity of variations. The highest limit to which an animal can rise, and the nearest to man intellectually, is the feeling of duty, or responsibility, such as is seen in the trained elephant and some dogs (sheep dogs and watch dogs), especially in the true St. Bernard.

Such dogs as "Barry" of the poem, that set out unbidden at the risk of their lives in spite of snow-drifts and avalanches to save the unfortunate traveller, are enough by themselves to dissipate the old idea that animals have no moral sense.

Finally, the widely accepted view that the sense of shame is an innate characteristic human attribute is one which may henceforth be rejected as entirely erroneous. Modesty is not inborn in man but has been acquired in the process of culture-development, and actually varies greatly in regard to different parts of the body. From the fact that prehistoric hunters have depicted man absolutely naked (the wife with the reindeer, the husband with the bison), we ought to conclude that at that period he saw nothing improper in being naked, any more than our own children, who as their intelligence grows absorb the teaching of their parents and teachers. And are there not still savage tribes who without a trace of shame go about in Eden-like nudity? The races among whom both sexes go naked were, in 1875, when Oskar Peschel wrote his *Völkerkunde*, the Australian blacks, Andaman Islanders, sundry tribes of the White Nile, the red negroes of the Soudan, and the Bushmen. It would be totally untrue to suppose that the sense of shame was developed earlier among women than men. Humboldt found that on the Orinoco the women were much less modest than the men; among the Obbo negroes (to the east of the outlet of Baker's great lakes of the Nile) the covering of the women consisted of a bunch of leaves while the men wore an apron of skins; similarly, among the Monbutton negroes, where the men are clad in an ox-hide garment reaching to the knees, the women only wear a piece of banana leaf, the size of a hand, attached to a waist-girdle.

Moreover, it is by no means always the genital organs which are covered; on the contrary, the ideas of what constitutes decency are widely different among races of lower, or middle, civilisation. Among certain negro tribes propriety requires the buttocks to be covered rather than the genitalia. The Philippine Islanders and Samoans regard it as most indecent for the navel to be exposed: every other part may go uncovered. So, too, the Mohammedan women universally endeavour to cover their faces; the Arab women allow their feet, legs and breast to be seen quite indifferently provided only the back of the head is covered; and in China a woman is considered extraordinarily immodest who exposes her artificially deformed feet to a strange man.

These instances clearly prove that the sense of shame, in its various manifestations, is not an aboriginal inborn characteristic of man, but in the course of the history of man has been produced by customs and manners, or, as one may say, represents the effect of fashion. Only a few savage tribes now preserve their old untrammelled *naïveté* which they share with the animals; the majority of tribes and races have lost this freedom from restraint.

This almost universal development of the sense of shame among men must be considered another specific characteristic of the human species.

Religion.

Moral sense must be attributed to the higher animals as well as to man. But there is one undisputed possession which man alone enjoys, namely, religion, a feeling of reverence combined with fear and gratitude towards some transcendental, higher being that rules the world and human destinies.

Only man looks up to heaven, where he believes the transcendent power to dwell: for Professor Braubach's assertion that a dog looks up to his master as a god is no more than an ingenious figure of speech, not intended to endow dogs with the capacity of transcendental thought. Since we have to look upon this faculty as exclusively human, we must consequently endeavour to find the primitive manifestations of this characteristic in the known beginnings of mankind, and if we get no evidence from this source it must be sought for among the primitive savages of our own times.

Hörnes is partly right in calling totemism the first and oldest indication of religious feeling. Darwin[1] suspected "that there is a still earlier and ruder stage, when anything which manifests power or movement is thought to be endowed with some form of life and with mental faculties analogous to our own". The plants and animals were, as primitive man fully divined, before him on the earth; upon them, especially the animals, he looked with a feeling of reverent awe which grew upon him until he saw in one or other of them the progenitors of his tribe. The result was that such animals were held sacred

[1] Darwin, *loc. cit.*, i., p. 144 footnote.

and inviolate, and were worshipped in the shape of an image carved out of wood. There are hunter-tribes in North America and Australia where totemism holds its own to this day; and it is from this that we conclude that the palæolithic hunters of Europe observed totemism; but we have no proof to this effect, for even if totems were erected in front of the cave-dwellings and huts of these hunters, and we can readily credit them with the requisite skill, they must long ago have mouldered into dust. Perhaps these palæolithic men, like the North Americans, had their individual totems, selected at will from the animal kingdom in addition to their chief totem, and carried them about in medicine-bags, parts of these animals, as fetishes. This, however, is only conjecture, for the pierced teeth of wolves and bears worn round the neck may be explained in another way as mere trophies of the chase and evidences of prowess in hunting.

There is much better foundation for the view that in the dawn of mankind, animism, belief in and cult of the soul, held sway, emanating from an uneasy presentiment, or conviction, of the survival of the soul after the body has perished. The departed soul was pictured as the phantom likeness of the body (the ghost), or as transformed into the shape of an animal (usually a bird or snake). This belief in immortality, this world-wide faith in the existence of the ghosts of the dead among the living, has been combined in the form of respect of death on the one hand, with a selfish hope of assistance from the departed, and on the other, with a secret dread of injury from them. If the departed were prominent men during life (warriors, hunters or pioneers of culture), they were in the course of time raised to the rank of heroes or demigods. Did this belief in the soul and immortality exist in palæolithic ages? Gabriel de Mortillet answers with a definite "No," and supports his opinion with the fact that among the ornaments of the reindeer hunters in the caves of France, no symbolic signs have been found (circles, triangles or crosses), and that among palæolithic races neither burial nor the cult of the dead was known. Cartailhac, on the contrary, rightly points to the red-coloured skeletons in the grotto of Mentone (Barma grande), and Mas d'Azil, as well as other burial-caves in France and

Belgium, and raises the further objection that we are quite ignorant whether besides cave-burials there were other methods of which no trace remains. At any rate, the question requires other and more enlightening facts for its final solution.

Certainly animism is proved to have existed in the neolithic age, in the first place by the discovery of trepanned skulls in the caves and dolmens of France and other countries (Fig. 134). From the condition of the edges of the bone it can be settled that the trepanning was performed during life, probably to allow of the escape of the evil spirit from the brain of those who were mentally afflicted, as was quite recently the practice in the Tonga Islands. The dolmens of Brittany and Central France (Fig. 135), in the Pyrenees, Corsica, and Northern Europe serve as proofs of worship of the dead and the cult of the soul, as also do the menhirs of Western Europe and the cromlechs in England (Stonehenge).

Fig. 134. Trepanned neolithic skull. (Hörnes, *Urgeschichte des Menschen*.)

Among the gifts with which the dead were provided on their journey to the world beyond (Hissarlik, Tiryns, Mycenæ, Laibacher Moor) are found idols, *i.e.*, anthropomorphic representations of a godhead which should protect the soul.

In contradistinction to Hörnes, who ascribed the possession of religion to all races even in primitive ages, Darwin believed that many races have existed, and still exist, who have no idea of a god, nor any religious customs. However, it is certain that other savages believe in invisible, or spiritual agencies, based on the resemblance of their own powers and faculties to the phenomena of nature. Thus savages have arrived, and still continue to arrive, at the idea of endowing natural and terrestrial objects with a spirit and divinity which their simple human mind can only imagine in human shape and therefore so portrays their god.

As compared to the worship of the fetish, the worship of idols stands on an obviously higher plane; although in the former the objects of adoration are regarded as alive they are not represented by any tangible articles; the latter system, on the other hand, has reached the point at which the gods or spirits are endowed with human form. The worship of idols is found at the present time among many savage races, the notable exceptions being the Australian and Tasmanian hunter-tribes, the Veddahs and Mintopis.

It was long thought that no idols could be ascribed to the palæolithic age, but in 1891 a rough ivory idol having a human form was dug up in the town of Brünn (Figs. 136 and 137), close to a skeleton and some bones of animals which undoubtedly belonged to the quaternary period. The idols of the neolithic

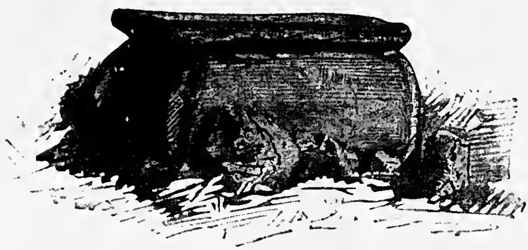


FIG. 135. Grave in South Bulgaria.

age are much more numerous, but they are only small, rough figures of a conventional character. They are usually naked or stiffly draped female forms (Fig. 138); animals such as cattle or birds are less common. According to Waitz, savage races at the present day do not regard their idols as images of the gods, but as objects in which the gods prefer to dwell, and by which they manifest their presence to man in a sensible form. It is certain, however, that the older idols were not merely used for this purpose, but were also regarded as the means of exorcising spirits, for the most certain protection against the spirits or souls of the dead was secured by making the image of wood or stone the actual god into which those souls had been received. Later on, therefore, they were placed not only on the graves but also in the houses, and were more reverenced than any other spirits.

We must now pass on to consider the ancient representations of the sun and moon, which point to a worship of the stars, and thus to a higher plane of religious thought. For this

Fig. 136. Ivory figure from the side. (Hörnes, *Urgeschichte der Kunst.*)

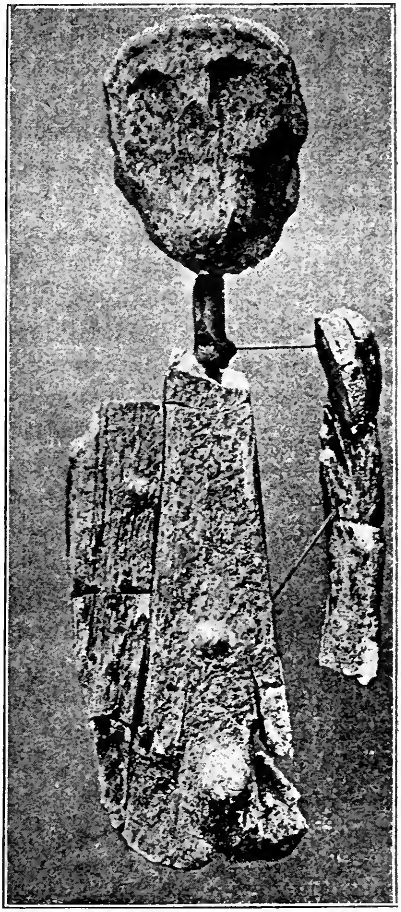


Fig. 137. Ivory figure, excavated at Brünn, ½ natural size. (Hörnes, *Urgeschichte der Kunst.*)

worship assumed for the first time the existence of higher beings, by which the stars themselves were governed. Coloured pictures of the moon from the lake-villages of the Lake of Constance, and other Swiss lakes, are to be seen in large numbers in the museums in Constance and Zürich; others adorned with suns and spirals have been obtained even from the neolithic necropolis of Lengyel in Hungary, and from the graves of Ödenburg of the Hallstatt period (Fig. 139).

Pictures of the sun can be traced back as far as the palæolithic period. In the cave of Gourdan, one of the so-called sceptres was found, with a circle carved upon it, the rays of which turned inwards and outwards. In this cave, and in the lower Laugerie, were found circular bone discs pierced in the centre and with rays carved on them. At Mas d'Azil (the transitional locality) are some red-painted flints, the rings on which were explained some time ago by Piette as representations of the sun. The circles either with or without rays on the neolithic dolmen stones are also pictures of the sun, as are the rings on the civic monument in Skåne (Scandinavia) belonging to the Bronze Age (Figs. 140-142). Montelins also considers that in the pictures of ships belonging to the latter epoch we may recognise very widespread and ancient symbols of the sun.

Arts and Handicrafts.

Next to those higher manifestations of reason, articulate speech and religion, come the power of producing fire and the possession of tools and instruments; these differentiate man psychologically, and give him his pre-eminent place in the animal world.

Fire.—Not even the highest of the anthropoid apes has ever succeeded in producing fire, and yet, on the other hand, no race of men, however degraded, has ever been found which has not been in possession of this art. Darwin considered that next to speech this was the most useful power ever acquired by the human race.

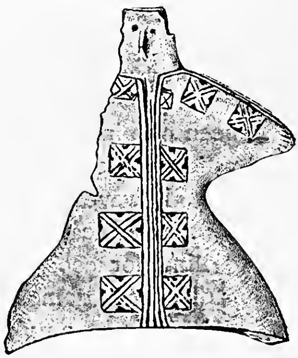


FIG. 138. Neolithic hollow clay figure, from Laibach Moor, ¼ natural size. (Hörnes, *Urgeschichte der Kunst.*)

It is quite possible, as M. v. Eyth has pointed out (*Weltall und Menschheit*, Bd. v., p. 9), there was a period in which fire was unknown, but it must have been in a climate which made life under such conditions possible. It is not necessary to suppose that there was no frost, but there cannot have been enough frost to kill man, or else his race would have come to a speedy ending. There are many ancient accounts of how man first came to recognise the value of fire and to learn the means of producing it. The poet and philosopher Lucretius, in his didactic poem, supposes that the idea of producing fire was suggested by the conflagrations often set up by the rubbing together of the branches and stems of trees. He thinks it still more probable that the lightning first brought fire to man, and if we study the legends concerning fire current among different races, we constantly find that it was brought down to man from heaven, either by an animal, or by a hero, or demigod. But in addition to its origin from lightning, or from friction between the branches of trees, fire may in primitive times have been obtained by man from volcanoes, or the spontaneous combustion of petroleum or naphtha.

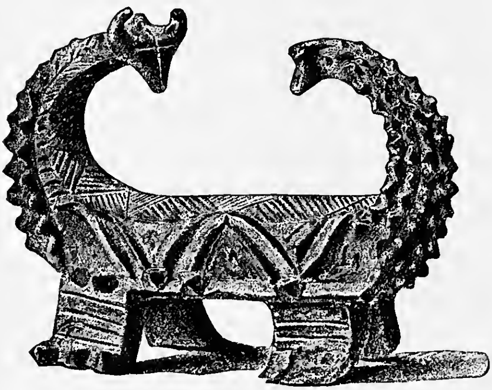


Fig. 139. Crescentic clay structure from a barrow near Oldenburg, ½ natural size. (Hörnes.)

These, however, were but occasional sources of fire. As soon as man had learnt the use of fire for warming and lighting his dwelling, for cooking his food, for hunting beasts of prey, and for driving in game, it became of paramount importance to him to be able at any time to obtain and kindle fire at will. Nature had revealed two methods for this, and by either one or other of these were all the numerous fires kindled, the traces of which may be found in all prehistoric settlements. (That remains of charcoal have been found in tertiary strata is no absolute proof that the fire which produced them was kindled by the hand of man. They may just as easily have been caused by the lightning which may set fire to and burn up the roots of trees even where deeply buried in the ground.)

One method for obtaining fire consisted in rubbing or twisting two different sorts of wood together; this was perhaps suggested by the fact that when smoothing or polishing

FIG. 140.

FIG. 141.

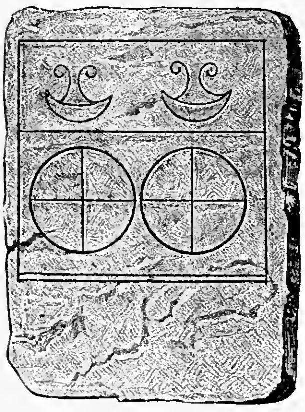


FIG. 142.

Stone plaques from the civic monument in Skåne. (Hörnes, *Urgeschichte der Kunst.*)

wood a sensation of increased warmth was always obtained. Further experiment led to the production of smoke and flame. This is the explanation of the legend of Prometheus which has its forerunner in the Indian sagas. Agmi, the heavenly fire, has been hidden, but is stolen by Matarishvan and given back to

Manu (man). Pramatta (or matta) is the reed, the fire-stick of the ancient Brahmins. The fire-stick is passed across the centre of two pieces of wood fastened together at a right angle, which form the ancient sign of the hooked cross. It is used to-day in a more or less elaborate form by the Polynesians, the Botokus and the Indians in Guiana, the Veddahs in Ceylon, the Bushmen, the Kaffirs and Hottentots of South Africa, and the Australians. Not long ago the aborigines in the Antilles and the littoral tribes in South America obtained their fire in this way. The ancient Germans, however, and other Aryan races had improved the fire-stick by twisting a cord round the perpendicular stick which was wound and unwound by pulling upon it. The inhabitants of Dakota, Iroques and the Aleutians employ a similar device at the present time.

The second method of obtaining fire was by striking together flint stones and so producing sparks which were dropped on to some easily kindled substance, such as tinder, and then blown into a flame. This method is of great antiquity, and goes back to prehistoric times. Sir John Lubbock (*Prehist. Times*, 1865, No. 473 f.) imagines that man discovered this in the course of manufacturing flint implements, heat and sparks being developed when the stones were struck together. It is certain that quite early in the flint graves of Suffolk and Norfolk there were people who had known how to produce sparks on dry moss by striking flints together, but only those which had fresh, sharply cut edges. In other cases good sparks were obtained, and there was a characteristic smell of burning, but the sparks did not fall on to the tinder. For this purpose, flints covered with sulphur must be used, as do the inhabitants of Alaska and the Aleutes. Pyrites gives an even more certain result; the Patagonians, the Terra del Fuegians and the classical peoples of antiquity adopted this method.

Flints in close proximity to pieces of pyrites are found in palæolithic settlements near the remains of mammoths.

Still more frequent are such finds in the neolithic graves and pallisade dwellings, and in the barrows of the Bronze Age right down to the Hallstatt period; later on in the Alemannic serial graves they are replaced by flint and steel.

It fell to the women to preserve the fire obtained in this laborious manner, which they did by covering it with ashes. Apparently also they conveyed it from one settlement to another; the cooking of food by means of fire was their concern also—such as the roasting and baking of meat on the open fire, roasting in holes between hot stones, the baking of bread into cakes and loaves, and later, when man had learnt how to make pottery, the cooking in pots over the fire or by means of hot stones plunged into the water.

Handicrafts.—The larger number of the known European examples of "fire" places furnish also the evidences of human handicrafts. Even before the discovery of fire, however, man was not entirely without defensive aids against the beasts of the field. Lucretius was probably right when he said: "Nails, hands and teeth were the oldest weapons, but there were also clubs of wood and stone". Here man surpassed the higher apes and the anthropoids merely in the possession of a more developed and useful thumb. Kaatsch supposes that probably man's tree-climbing ancestors used instruments of stone and wood; but the supposition becomes very questionable when we consider the capabilities of the primates in this respect at the present time. It is probably baboons which Darwin[1] describes as opening hard nuts by breaking them with stones, using stakes as levers wherewith to prize up rocks, and employing sticks and stones as weapons. Brehm,[2] however, thinks it doubtful if the chimpanzee, or any other anthropoid, can use any sort of weapon, as their rolling gait on the two hind-legs does not permit of free movements; the force necessary for throwing, or hurling, a weapon properly would involve such a movement of the arms as to cause any ape to lose his balance and fall to the ground. The acquirement and employment of tools is therefore a prerogative of man, and due to his power of standing firmly and uprightly on his two legs.

A pure Stone Age, however, in which man employed stone and nothing else for making his tools and weapons, certainly never occurred. It is much more probable that wood and bones were used either previously to, or simultaneously with, stone. Many writers describe a Wood and Shell Age preceding the Stone Age, a view for which much may be said, especially as the

[1] Darwin, *loc. cit.*, v., p. 104. [2] Brehm, *Tierleben*, i., p. 25.

South Sea Islanders use tools and weapons made of wood and the sharp-edged shells of mussels. As soon, however, as the advantages of using stone were recognised it was not in the nature of man to forget so useful a lesson when once it had been learnt.

The further question now arises—Which kind of stone was the first to be employed? It is most probable that at first every loose stone was taken up and tried. The superiority of the flint, with its hardness and sharp corners when fractured, was soon recognised, as in palæolithic settlements the number of flints is remarkably in excess of that of other stones. Indeed if we are to follow the defenders of the eolithic hypothesis, there were in France, Belgium, Germany and Italy men who possessed flints, shaped for various uses, even before the deluge at the end of the tertiary period. I have already expressed my views on the value of the eolithic theory (*vide* p. 35 *et seq.*), and will now therefore merely recapitulate the statement that doubts as to the existence of the so-called eolithic people will be justified so long as clear traces of the presence of pleistocene man cannot be found in all places where fossil remains exist.

Franklin defined man as "an animal which uses tools". Every suitable stone which a man throws, however, cannot be regarded as a tool, but only one fashioned in such a way as to fit it in a special manner for the purpose for which it is employed.

The tools and weapons of primitive man hitherto described were, for the most part, only modifications or extensions of his own limbs.

Kapp (*Grundlinien einer Philosophie der Technik*), who has worked out this idea more fully, remarks that man projects a likeness of his own organs into his tools, and carries into the region which lies outside his body those functions which he supposes reside within it. Thus the hammer is foreshadowed by his fist, and edged tools by his finger nails and incisor teeth.

Kapp calls the hammer, hatchet, chisel and gimlet "primitive tools"—probably the first foundations of human culture.

Originally, the rough tools fashioned by men had to serve all purposes alike; it was only later that the need for differentiation became apparent. The primæval man could not dream of attacking, or overcoming, the huge antediluvian animals by throwing stones at them, for at that time he had not constructed slings (of leather or perhaps the stems of the wild vine). He had to content himself with the capture of younger or smaller animals, or else endeavour to ensnare them in pits.

In order to kill with more certainty and afterwards to strip off the hides, man first made use of the small hammer (Fig. 143, *a* and *b*), a rude flint, roughly hewn from the flint beds,

Fig. 143. Carved flints, ½ natural size. (Hörnes.) a and b, hammers of the type of Chelles and Moustier; c, pointed instrument; d, boring instrument; e, skinning instrument of the type of Solutré.

and possessing a point and sharp angles. Later, he succeeded by means of bones, reindeer horns, etc., in crushing, or pounding, the rough flints into beautiful prism-shaped blades, and still later he laboriously fashioned knives (Fig. 144), spears, lance-heads, etc., with finely finished sharp angles. Some of the specimens resemble blades, others boring instruments, and others again saws, while the smallest of all appear to be arrowheads (Fig. 143, *c*, *d*, *e*). Darwin considered that to obtain such fine pieces of work must have been a task of extraordinary difficulty and probably only an occasional event due to special skill. The delicate shell-like finish, however, does not appear so difficult to attain since the exhibition of the Terra del Fuegians in Europe. It was then seen how they broke off the original rough edge of the splinter of rock, by means of little side strokes with a short, small whalebone, which was somewhat rounded underneath. And at the Anthropological Congress at Greifswald in 1904, it was shown that it was much quicker to work on a sword-blade with a small, long-handled wooden hammer, using a flint stone as an anvil. The shafts of the spears, lance-heads and arrow-heads were probably fastened on by simply tying them, or by first inserting the head into a piece of split wood and then binding and trying it on, just as do the South Sea Islanders at the present time.

FIG. 144. Flint knife of the La Madeleine type. (Hörnes.)

It is very remarkable that in the village of Brandon in Suffolk, where there is an ancient and prehistoric flint quarry, this industry still flourishes, and that in consequence extremely ancient methods are in use which must most assuredly be referred to remote ages. The flint quarries were so arranged that the quarryman first dug five or six feet deep and then two and a half to three feet horizontally and then again deepened his pit about eight feet. In this manner he dug both in a horizontal and perpendicular direction until he came to a layer of flint. At the present time he adopts exactly the same methods as of old, when ropes, buckets and pulleys were unknown, and the flints had to be brought to the surface step by step. When the flints have been brought up they are first spread out to dry and then cut into prism-shaped blades, which when split diagonally form the well-known flint instruments still used in Asia and Africa. Most of the tools and weapons of antediluvian man were made of flints, but he did not disdain the use of other materials if they appeared serviceable. Boar's tusks were made into knives, the jaws of cave bears with the incisor teeth attached were used to open marrow bones, the brow antlers of reindeers were ground into small daggers, the shin bones of small animals into awls, and pieces were cut out of the shoulder blades so as to form needles (Figs. 145 and 146). The tools which were fashioned and used at this period were, however, invariably of a very primi-

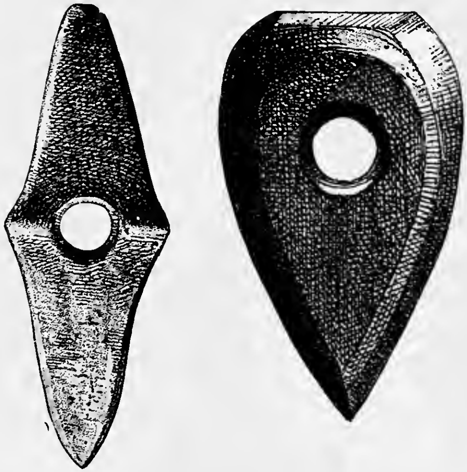
FIG. 145. Shoulder blade of reindeer with the needles which had been carved out of it. (Hörnes.)

FIG. 146. Lance-head from reindeer horn. (Hörnes.)

tive and simple character. It was very different when the neolithic period of the Stone Age began. Man did not then confine himself to tools made from flint, but chose other kinds of stone, whose hardness rendered them similarly suitable. He learnt, moreover, not only to polish them into shape, but also to drill a hole in them into which a handle could be fastened (Figs. 147, 148). At an even earlier period than this flints had been thrown up by the sea in certain places, such as Brest, in which a hole had been left by the falling out of a belemnite.

It seems doubtful, however, if the discovery of such a stone was what originally suggested to neolithic man the idea of boring through softer stones; it was much more probably due to the necessity of finding some surer way of fastening on the axe-head than by roughly tying it to the handle, otherwise this notion would have first been brought to the neolithic people at a later period, at the time when foreign races with a different civilisation began to migrate into Europe. We can easily see that quite different work could be done with axes and hatchets of this description; it was only with such tools as these that tree

Fig. 147. Neolithic reniform axe-head made of stag's antlers. (Hörnes.)



a b

Fig. 148. Neolithic polished stone axe-heads with holes for handles. (Hörnes.) a, double headed; b, single headed.

trunks could, without excessive labour, be hewn into piles and wooden buildings erected on land or water. The piercing of the hole for the handle was either done simply by hand with a flint awl first from one side and then from the other, or by means of a drill. A hollow long bone was ground into the stone by means of wet sand, so that eventually a small circular piece of stone was removed.

During the neolithic Stone Age also, stone was not the only material used for fashioning tools and weapons. Bones and horns were used to better purpose. Stag's antlers, for example, were turned to all kinds of uses (Fig. 149)—handles were made from them for the polished stone axes, and also hammers, harpoons and hooks. To this period also belong bows of wonderfully beautiful workmanship, whose preservation is due to the lake mud beneath the pile-built dwellings. And even after the first metal, copper, was gradually introduced into Europe, and later on bronze followed, it would be foolish to assume that the old stone, bone and wooden tools suddenly disappeared. They did not only remain in use for a long time, but they also left their mark on the early metal tools. Like the polished stone hatchets and axes which were first merely tied to their handles, and only later pierced, so the metallic tools of the Copper and Bronze Ages were first copied from those in which the head was only held in a cleft stick; later they were furnished with

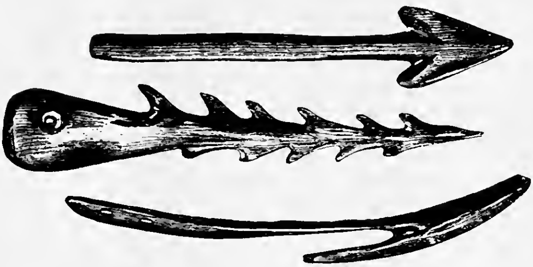
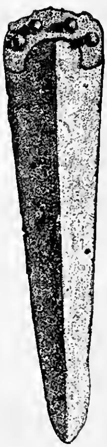


FIG. 149. Stag's horn arrow-head, harpoon and hook from the pile-dwellings at Font (reduced). (Hörnes.)

ties which fixed them to the shafts, and lastly holes were drilled in them into which the handles were inserted, as in the axes and hatchets of to-day (Fig. 155). It is obvious from the remarkably beautiful and numerous specimens belonging to this period that the art of working in metals introduced from Asia and the shore of the Mediterranean made it possible to fashion other implements besides axes and hatchets, such as chisels, awls, pincers and saws, of a durable quality and perfect finish; to say nothing of the agricultural implements and ornaments of metal which will be dealt with later.

How metals were first obtained is an obscure question which has not even now been settled. Where copper appeared in nearly pure metallic state, as in the neighbourhood of the great North American lakes, the sight of the shining metals might induce man to hammer it with stones into definite shapes. But how should this come about when it occurred as copper ore combined with other metals or metalloids, as a carbonate, arsenate, chloride, or iodide? Lucretius, who pondered on all things, thought that the art of working metals first came about after some ancient forest conflagration had

Weapons and implements of the Bronze Age (Hungary and Bohemia).



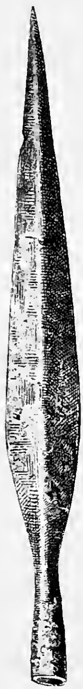


FIG. 150. FIG. 151. FIG. 152. FIG. 153. FIG. 154.

FIG. 150. Bronze sword. FIG. 151. Bronze spear-head. FIG. 152. Bronze lance. FIG. 153. Narrow chisel. FIG. 154. Flat chisel. (Hörnes.)

reached a place where there were ore-bearing strata and caused them to melt Struck by the lustre of the solid mass, man drew it out, and thus discovered the art of casting bronze. Later on he learnt how to hammer and polish the bronze, and so to form his first metal tools, hatchets, hammers, nails and chisels (Fig. 156).

Now it is not so easy to imagine how man could know that the solid, shining mass consisted of ninety parts of copper and ten parts of tin even in the very improbable event of the ores of these metals occurring next to one another. The fact that a Copper Age preceded that of Bronze makes it very probable that man first learnt how to obtain the former metal, and that by degrees, either accidentally, or owing to definite research, he discovered the way to combine it with tin.

"The use of bronze was known before that of iron, as it is

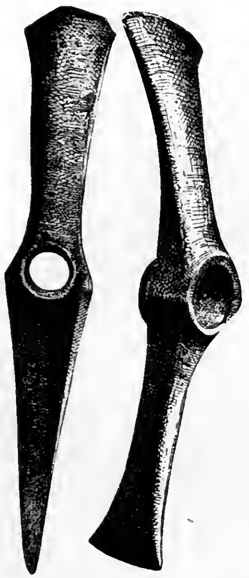


Fig. 155. Copper battle-axe from Servia. (Hörnes.)

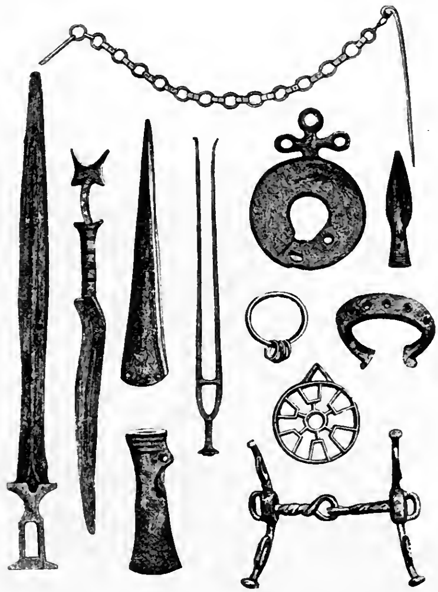


Fig. 156. Objects found in the Swiss pile-dwellings of the Bronze Age. (Hörnes.)

more pliant and occurs in larger amounts. Bronze stirred the soil of the earth, bronze mingled with the billows of the devastating battle, and dealt still deeper wounds." So Lucretius sings; later he thus alludes to the use of iron: "The people then began to break up with iron tools the soil of the earth, and with it decided the fight on a doubtful field of battle".

There appears, however, little doubt that even in the dim dawn of time, long before any knowledge of the use of bronze and copper was attained, an iron industry had flourished on the red, ferruginous soil of Africa. This is supported by the fact that the present African aborigines obtain iron quite easily in spite of their primitive apparatus, and work it into finished articles.

Fig. 157. La Tène sword from Hallstatt. (Hörnes.)

When the question arises as to where in Europe the point of junction between the Bronze and Iron Ages is most clearly seen, the anthropologist will point to the town of Hallstatt, situated on the lake of the same name, where in prehistoric times dwelt a people who had become rich owing to the possession of salt beds, and have left behind them in their graves valuable treasures, such as weapons of iron and implements and ornaments of bronze.

Similar researches in the lands of the ancient Norici, Veneti and Etrusci have shown that it is here that the birthplace of the implements of iron and bronze found at Hallstatt is to be sought, and that from here a brisk export trade arose towards the West and North. The merchants on their travels found iron weapons and tools, and even iron ornaments, more and more sought after, and this continued till iron in its victorious course reached even to the peoples of the North and gradually crushed out the bronze civilisation which had formerly flourished there. The final victory of iron in mid-Europe must be reckoned from the beginning of the fifth century B.C. The locality after which this period is named is La Tène, a place on the Lake of Neuenburg, where on the bottom of the lake a whole stratum of beautifully made iron weapons, tools and ornaments has been found. The iron industry attained its greatest development under the Romans who became successors to the civilisation of La Tène, and spread their manufactures over all the countries of which they became possessed.

Among utensils, or useful objects, one of the most useful, owing to its portability, is earthenware; it is also of great antiquity, and a special product of man. The mere working and kneading of earth and clay is, however, no special invention of man's; long before men made pottery, animals existed which knew how to make dwellings or nests as cradles for their offspring out of damp earth or clay mixed with saliva. Thus, among insects, certain bees (Chalicodoma muraria) and wasps (Odynerus parietum); among birds, the jackdaw (Corvus monedula), woodpeckers (Xenops genibarbis), nuthatch (Sitta cæsia), thrushes (Turdi), and certain swallows (Hirundo rustica), and martins and the Australian ariel (Chelidon ariel). All these animals can mould and knead excellently; they can raise layer on layer, and construct their dwellings with the tools given them by nature in a manner suitable to their requirements. The manufacture of an earthen vessel by the hand of man was, of course, a greater feat than any of these; but the fragments of clumsy vessels which are found in the transitional states between the palæolithic and neolithic, show that in their first beginnings these were of a very primitive kind. How it was that palæolithic man did not make clay vessels although surrounded by plenty of rich clayey soil, will always remain an anthropological puzzle. We may indeed assume that man first carried his water supply in bone pans and the skull-caps of animals, or in vessels of wood and hide which have long since perished; or he may have used vessels of plaited osiers, as do the Terra del Fuegians at the present time.

Well-made vessels of osier have been thought by some authorities (Ranke and others) to have suggested the making of pottery; man discovered that vessels, the interior of which had been lined with clay, were much more water-tight. Accidentally, one such clay-lined vessel was put on the fire; the osiers were burnt off, and the first piece of baked pottery was manufactured.

Potsherds have indeed been discovered on the outer side of which is the impression of basket-work, but the principal examples were carried out on pottery after the properties of clay had become known. Man, most probably, in different parts of the earth, got the idea of making his vessels for fluids and for dry provisions out of this convenient material. A glance at the way in which water will remain all day long in the hoof-mark of a wild animal on a clayey soil showed him at once the impermeability of clay; its plasticity was illustrated when he noticed how the impress of every finger which he placed on it remained, and he realised how it could be modelled into any desired shape. The clay vessels simply moulded by hand in a primitive manner were soon doomed to destruction. Later on he accidentally observed that any vessel which had been exposed to the fire for a long time exhibited a much greater hardness and durability. The first rude potsherds are found in transitional localities between the palæolithic and neolithic periods, such as the cave of Mas d'Azil in France, and in the kitchen-middens on the shores of the "Ostsee" in Norway.

From that time to this clay vessels have been manufactured wherever clay is obtainable. Pottery has never been known to the Eskimos, nor to the Northern Indians of North America; nor to the Botokudes and Kayapos, in Brazil, nor the tribes of the pampas and Terra del Fuego, in South America; nor to the Veddahs in Ceylon, the inhabitants of the mainland of Australia, the Maoris in New Zealand or the Polynesians. In most of these cases, but not in all, the cause of this is that the soil contains no suitable clay upon its surface. In all other regions of the earth pottery, at first simply hand-made, and later turned on a wheel, has risen from the simplest to the most elaborate forms, being gradually improved, partly by individual invention and partly by imitation of imported articles. Many potters indeed of the present day find it very difficult to manufacture on the wheel the same beautiful wide-bottomed vases which the men and women of old times made with a sure eye and free hand. Pottery was made by hand in this way in mid-Europe up to the period immediately preceding the Roman. At first, the squat, thick-sided pots had generally a spherical shape, almost like the pumpkins of Southern climes. As time went on they were better shaped, and stood more firmly on even bottoms (Figs. 158 and 159). Better clay, too, was used, which was polished after the vase was finished, and soon became ornamented with some simple design. Handles were soon added, and plates, cups and pitchers were made. Finally, during the Hallstatt period, richly decorated and coloured urns and plates were placed with the dead in the graves, and these even now may excite our wonder and admiration.

There were two ways in which the potters (who were the women) could carry out their object. They could either work from a lump, that is, from a mass of clay already roughly cut to the size required, or they could construct a vessel by degrees by building up or sticking together small pieces one upon another.

In the first method the tools used in hollowing out the lump of clay were either the fingers, or else the elbow which was twisted round in the mass; or a mallet was used to beat

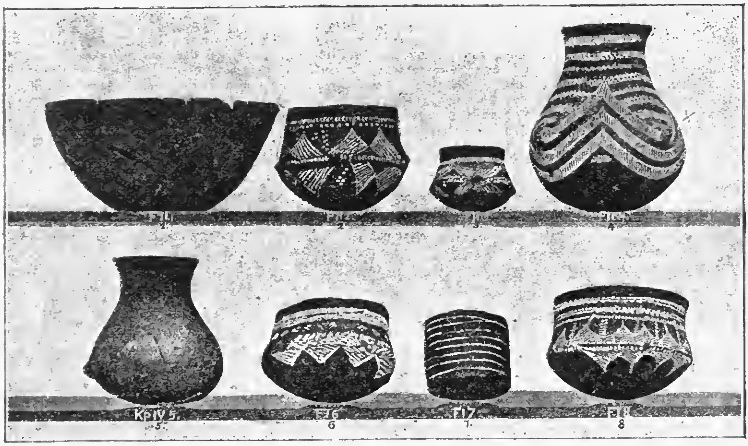


FIG. 158. Neolithic pottery from South-west Germany. (After Schüz.)

and hammer it from within outwards, while with the left hand it was held on one of the so-called anvil stones. Still simpler is the method of working on the lump employed by the inhabitants of the Andaman Islands, who merely scrape out the mass of clay layer by layer with a mussel shell until the pot has attained the desired shape. The method of gradually building up small pieces of clay is the converse of this; the woman either lined the walls of a hole in the earth with a layer of clay, or else, on a hand-made bottom, she piled little rolls or lumps of clay and modelled it into layers with both hands. The polish was attained as it is now among primitive peoples by rubbing with mussel shells or smooth pebble stones.

Afterwards the vessels were allowed to dry and then burnt either on the open fire, or, in later times, in clay ovens. In the East (Asia and Egypt), brick ovens were used from the earliest times.

Clothes, Plaiting and Weaving.—Animals carry their clothes on their bodies, as scales, feathers or hair. Man has to make clothes for himself in order to cover his naked body, and to protect himself from the cold. This is a characteristic difference between man and beast.

There are indeed many savage races in the tropics who go about either entirely naked, or clothed only with a loin cloth. Antediluvian man, however, had to protect himself against considerable changes of temperature, and to see that his body

FIG. 159. Neolithic pottery from South-west Germany. Vessel of the goblet type. (*Swabian Exploration Reports, VII.*)

was kept warm. Obviously it is impossible to say whether any feelings of modesty, such as generally distinguish man from animals, were experienced as early as this.

In the drawings of the prehistoric reindeer hunters man appears naked, but the large number of flint instruments for skinning found in palæolithic deposits show that he wore clothes, and that these were made of the hides of the animals he hunted. These hides must have undergone some kind of preparation to make them soft and supple. A sort of tanning, by means of rubbing and pounding the brains of a slaughtered animal on the inner side of the hide is, according to Conservator Krause of Berlin, of great antiquity, and produces a very soft leather. In the Bronze Age tanning with alum was known, as Olshausen noted in the leather found in the barrows of Amrum. O. Schrader, from the etymological point of view, states that tanning is one of the primitive arts. The hides of the prehistoric men were stitched together with the bone needles so frequently found in palæolithic deposits. The holes for laces were bored by awls found in the same places, and made of the shin bones of animals; the so-called sceptres of reindeer horn richly decorated, and provided with a large hole, apparently served to hold their clothes together across the breast. If palæolithic men also inhabited tropical and subtropical regions, they must have made their clothes of bark, leaves and grasses, as do savage races to-day.

In the matter of clothes the great contrast between the older and newer periods of the Stone Age is extremely well marked. In the Danish kitchen-middens spinning-wheels are found, and it may be gathered from this that the art of spinning (? flax) was by that time known to the neolithic people of the North. The spinning of threads is, however, no special acquisition of man, because, as Brehm points out, the tailor bird (Orthotomus longicanda) stitches together the leaves which form its nest with threads which it spins itself from the raw cotton. It was a long time before man learned the art of spinning, but when he had once acquired it, he at once made great progress, by making his threads into plaits and these again into a woven texture. Such materials made by the antediluvian man we do not actually possess, as they only exist in the indestructible representations of them found in Kesslerloch and the caves of Freudenthaler. It may be doubted, therefore, whether they were made of vegetable fibres, as neither spinning-wheels nor any fragments of such-like fibres belonging to this period have been found. It must be assumed, therefore, that sinews formed the original material for threads, and that with these their garments were held together, as are those of the Eskimos at the present time. We have more certain indications of the use of self-spun flax in the period of pile-buildings, for numerous spinning-wheels have been obtained from the bottom of the lake, as well as plaited and braided work, and also looms and woven material (Fig. 160). The braided work was always the older and simpler, and was followed later by the more complicated woven material made on an upright loom, such as is now used by the negroes in West Africa. In the materials found at Robenhausen there are stuffs woven with woof and warp, which, owing to the character of the lake bottom, have been very well preserved. Originally wool was not used either for spinning or weaving. There are no traces of a woollen industry among the dwellers in pile-built houses, although they possessed domesticated sheep. Possibly the wool was used for other purposes, such as being made into felt with the hair of other animals, although felt of this kind is not found in the lake villages, but first appears in the northern tree coffins of

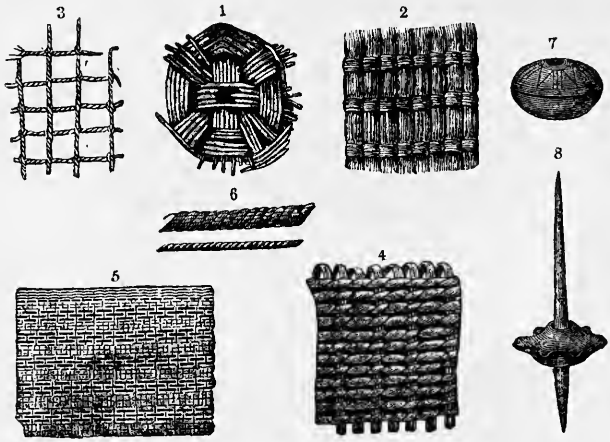


Fig. 160. Plaited and woven work, spindles and spinning-wheels from the Swiss lake villages. 1, basket-work; 2, mat; 3, net; 4, spun threads; 5, woven material; 6, thread and plait; 7, spinning-wheel; 8, spindle and spinning-wheel.

the Bronze Age, where the bodies are clothed in felt mantles, woollen coats, woollen jackets and woollen caps. Examples from the Hallstatt period show the men partly with short coats and partly with long mantles, and the women clothed in jackets and habits with capes. Whether these were woven of vegetable fibre or wool, cannot be made out on account of the few fragments of clothes which have been discovered.

It must be remembered, however, that man has no monopoly of the art of spinning. The same is true of plaiting and weaving, for quite apart from spiders and silkworms which spin and weave, there are many birds which are adepts at these arts, such as the weaver bird (Plocei), the golden oriole, the titmouse (Aegithalus pendulinus), the Chinese titmouse (Orites caudatus), and others; there is also a small mammal, Mus minutus, which constructs an elegant nest of threads between the stems of plants.

Dwellings.—Hörnes regards the tree-dwellings and huts made of interlaced boughs and stems, and furnished with a roof, as the type which most nearly resembles those of the beasts. It is probable that palæolithic man constructed much the same huts in trees as do the Battas in Sumatra, certain South Indian and Malay races, and some of the very low tribes in South Africa to-day, but we have no positive evidence of this (Fig. 161). If it was so, the men of that time differed but little from the anthropoid apes in the matter of their dwellings. According to Brehm,[1] the gorilla, the chimpanzee and the orang spend the night in nests, 20 to 30 feet above the ground, constructed of branches intertwined, and made comfortable with boughs and leafy twigs. Practically, the nest of the orang resembles that of a great bird of prey, and similarly is never provided with a roof. Thick boughs are either broken off, or bent and twisted together, interwoven with loose, leafy branches, and made impervious with foliage and grasses. Similar nests are constructed by many birds, such as jays, bullfinches, ravens, carrion crows, rooks, the American blue jay, the redwing, whereas the magpie, and also the squirrel, provide their basket-work nests with a roof.

There are, however, many simple animal dwellings of which primitive man might have availed himself, as for instance, hollow trees, clefts in the rocks, or caves in the mountains. That man actually lived in caves like the beasts of prey well into neolithic times is evidenced by the numerous discoveries of fire-places and manufactured objects of all kinds deep in the limestone caverns of the European mountains, often "petrified" by lime salts.. Many authorities assume that caves were only used in the winter, because hunter-tribes for the best part of the year settled here and there in suitable spots where they erected temporary dwellings. This view, which has much in its favour, has been recently supported by a remarkable discovery. Among

[1] Brehm, *loc. cit.*, i., p. 25.

the many pictures on the walls of the Grotte des Vezèretales in France one was found showing a hut, built of stakes and provided with a roof, showing that man at that period was able to do carpenter's work with his primitive tools. Like certain

FIG. 161. Tree-dwelling from Southern India. (Hörnes.)

savage races of to-day (the Hottentots, Gallas, Somalis, and Terra del Fuegians), he could cut off the stronger twigs or thinner branches, place them crosswise in the earth, fasten them at the top, and intertwine brushwood between them, and then cover the whole structure with hides. No doubt it was much simpler to twist together overhanging branches or brushwood into a roof, as, according to Tacitus, did the Finnish hunter-tribes, and as is the custom of the Hottentots and Bushmen to-day.

Æschylus makes the Titan Prometheus boast that it was he who first taught men to construct brick and wooden buildings, before which they had dwelt like ants beneath the earth. There are clear indications that man dwelt in such wretched and bestial habitations buried in the earth, at any rate in prehistoric times. In Armenia, Xenophon found a race of men who inhabited underground dwellings, having narrow entrances like a well, though spacious underneath. Tacitus says the Germans, besides their mud huts, dug pits for dwelling in, covering the openings with manure; they used them also as a refuge in winter, and as a storehouse for fruits. Virgil, too, sings of the Northern Europeans, "the Scythians live quiet lives deep in the earth in hollow pits".

The description which Vitruvius gives of a similar dwelling in Phrygia shows that these pits, which were partly or entirely beneath the soil, and had more or less complete earthen walls, also possessed a roof. He states that over the entrance was a rounded dome made of stakes tied together, and covered with straw or rushes upon which earth was thrown. Similar, almost circular, pit-dwellings dating from the earlier Stone Age have been found in mid- and North Europe in considerable numbers; inside them have been discovered numerous fire-places, crockery, and stone and bone tools.

In addition to these roofed pit-dwellings, mud-walled huts were built, even in the early Stone Age. They were square with four upright corner posts, and horizontal beams between them. The roof was pointed, and the walls double, consisting of basket-work coated inside and out with mud, the space between being filled with a mixture of mud and straw. Schlitz has discovered an entire village of the Stone Age at Grossgartach, consisting of about ninety similar houses, with stables attached, together with a whole catalogue of household utensils. Representations of similar houses, some round and some square, from the Bronze, Hallstatt and La Têne periods, have been preserved for us in the baked clay house-urns (Fig. 162). Similar houses belonging to the German races are to be seen on the triumphal column of Marcus Aurelius; it must be remembered, however, that these probably represent rough, temporary dwellings, as the Germans of that time understood how to construct log houses.

The use of posts, basket-work and mud for constructing substantial walls to dwelling-houses is a discovery which was known to prehistoric men of all eras; but there is also an animal, namely, the beaver, which had learnt how to build in this manner long before him.

This animal, which combines the work of a carpenter and a mason, can not only build strong dams with the logs and boughs which it has bitten off, mixed with mud which it collects and smears over them, but can erect its oven-like forts to which it betakes itself at high water to consume in peace the provisions which it has stored there.

Fig. 162. House-urn from Alba Longa. Hallstatt period. (Hörnes.)

Man, too, so early as the Stone Age, found it convenient in certain localities in Europe to take up his abode on the water. Thus in 1854 the first pile-built village was discovered in the Lake of Zürich, and since then numerous other examples have been found in the neighbouring lakes.

The strangest hypotheses have been brought forward as to the motives which induced man to choose such a site for his dwellings. The most natural and reasonable view is that man was compelled to make his dwelling-place in the water to secure himself against the attacks of animals or of other men. This is the object of the pile-built houses of North-West and South America, the Indian Archipelago, Melanesia and Africa. It must be supposed that the dwellers in the pile-built lake houses had formerly constructed similar buildings on land. The driving of the upright piles of oak, beech, birch and pine into the lake bottom was, however, a much more difficult matter than merely fixing them into dry ground. They succeeded, however, in completing their arduous task with simple wooden and stone tools, joined their upright poles by means of crossbeams; and on the platform thus formed they built their round or square huts with walls and floors of basket-work and mud, joining their lacustrine settlements with the dry land by means of easily moved wooden bridges.

The terramara, a contrivance of the Bronze Age, consists of a pile-built village on dry land surrounded by a wall, examples of which are found in Upper Italy, Hungary and Bohemia. The best explanation is that of Hörnes, who thinks that the object was to protect the storehouses and sleeping-rooms from beasts of prey, troublesome domestic animals, noxious vermin, floods, etc., by raising them above the level of the ground. They are comparable to the houses of many South African and Papuan villages, which are raised on piles, the only difference being that the latter are never surrounded by a wall.

Navigation.—All races who live on the shores of rivers or lakes are known to be proficient swimmers. It may therefore be assumed that the inhabitants of the pile-villages chose their lake dwellings owing to their familiarity with the water. But in order to sink their piles and to command the water, they must have had the means of travelling over it. We may understand easily how man first came to think of conveying himself in and steering a floating boat, when we consider how often he must have chanced to see broken trunks of trees floating in the water. If he swung himself on to one of them, he would discover that the trunk would bear him, and if he took a wooden pole in his hand he would find that with it he could steer in any direction he desired. This would lead to a new idea, namely, to bind together a number of trunks, and so to construct a raft which should be steerable and carry more than one person. Meanwhile, others would have discovered that the hides of animals when inflated (Fig. 163) were able to support considerable weights when placed in water. A stage made of longitudinal and cross beams fastened to four inflated hides, provided them with a ship able to brave all the billows; this could be steered either by means of a rudder attached to the stage, or by means of a man who swam behind and pushed the boat onwards, as is still the ancient custom in use on the Albanian lakes. Others again may have discovered that the bark of a strong tree removed *en masse*, fastened together fore and aft, and fitted with cross pieces floated capitally in water, and could carry at least one man, although great care was required to maintain equilibrium. Thus the first canoe was built. Under all circumstances, however, the solid tree-trunk must have inspired the most confidence, especially when hollowed out both in order to reduce its weight and to provide places for the rowers and for various appliances used on fishing and hunting expeditions. The hollowing out was probably accomplished by means of flint axes, the holes being further enlarged by burning with fire and then scraped out with sharp stones and shells. Neolithic canoes, two to five metres long, formed from tree-trunks, have been dug up at Robenhausen, Glasgow, and St. Valery (Somme) (Fig. 164).

Fig. 163. Inflated goat's hide for a boat. (*Corr. Bl. f. Anthr.*, 1904.)

Such craft have long remained in the service of man, for even to-day in the Bavarian and Austrian lakes the fishermen and boatmen use the old solid tree-stems instead of boats put together by the art of the carpenter. The rudder consisted at first of a wooden paddle, widened at one end, and was used either standing or sitting; it naturally permitted of very little actual steering. Sails were first used later on, when men had learnt to build larger canoes, or ships put together with planks, and caulked, and furnished at times with keels. And with this was combined the use of a movable rudder, attached to the stern of the ship. In such vessels man could navigate not only rivers and lakes, but also the sea itself, by cautious voyages along the coast, till at length, by additions to his invention, he could attempt further sea voyages, and so become not only lord of the earth, but of the ocean also. Hörnes says of the ship that it is in the fullest sense both a weapon and a tool; the most valuable instrument ever presented to man's hand, and the key which has unlocked for him all the regions of the world.

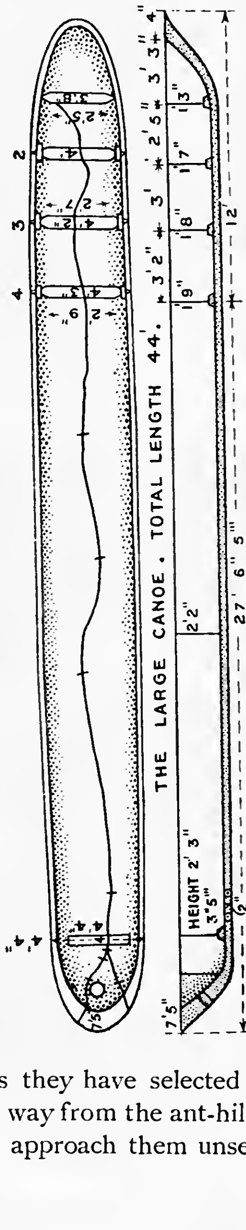


Fig. 164. Tree canoe from the pile-dwellings in Lake of Biel.

By this discovery man surpassed all the animals, and first established his right to be considered lord of the world, inasmuch as it made it possible for him to convey animals and plants to countries into which they had never come before.

Training of Domestic Animals.—Although we may regard navigation as a characteristic attainment of man, we cannot apply the same terms to the training of domestic animals, as there is one animal which also possesses domestic animals, and makes use of their products.

This is the ant. Like all *hymenoptera* the ant is remarkably fond of the sweet juice secreted by aphides; they do not only visit the scattered colonies of aphides in their settlements in different plants, but for the sake of convenience, seize the defenceless creatures and carry them off to the ant-hills where they can attach them to the underground roots of grasses. This is done in order to "milk" them, which is done by stroking the hind part of the abdomen till the sweet juice is excreted.

At other times the ants allow the aphides to remain quietly on the plants they have selected for themselves, and then construct a covered way from the ant-hill to the colony of aphides, by which they can approach them unseen.

An aphide with a particularly long proboscis (Lachnus longirostris) attaches itself to the young shoots of trees in the interior of which the tree ants (Lasius fuliginosus and Lasius brunneus) make their galleries, by which they can reach their cattle, the aphides. Where no aphides exist, as in the tropics, certain small sorts of locusts take their place, and are milked in the same way by the ants.

There are still considerable differences between the various authorities as to the time when men first began to domesticate animals. Woldrich and Piette, for instance, consider that domestic animals were kept even in antediluvian times, and that the men of that period, whom we know only as fishers and hunters, had already tamed the reindeer and kept him in herds, with the help of the two antediluvian dogs (Canis Mickii Woldr. and Canis intermedius Woldr.).[1] Woldrich bases his hypothesis on the fact that the reindeer bones found in the cave of Gudenus in South Austria belong to a small species. There is, however, no proof that this small species were tame, for differences in size exist in many of the wild deer.

Against the view that the antediluvian reindeer were tamed is the fact that in the reindeer strata entire skeletons are seldom, or never, found. This shows that the palæolithic man hunted the reindeer, and scattered them from place to place. Woldrich also maintains the possibility of the ox and horse having been tamed and domesticated, as well as the reindeer and dog. As far as the ox is concerned, there are no traces of this. Nor is it possible to suppose that the horse was tamed, unless we imagine that foals, taken after the mares had been killed and brought into human settlements, were entirely reared in the companionship of the human children. Band-like streaks have been found on the foreheads of many of the wild horses in prehistoric pictures, which have been taken for some sort of bridle. But all this stands on the very slightest foundation, as these animals which can only have been kept for pleasure, as is the case among all savage races, are certainly not indoor pets.

It is only the transitional period between the two Stone Ages that provides any sure indications of a commencement, and it was the dog that the hunter and fisherman of

[1] For dog ancestry, *vide* Flower and Lydekker's *Mammals*.

the kitchen-middens ("Kjökenmöddingen") chose to be his companion in the home. There is nothing remarkable in this occurrence if the habits of the half-wild dog are considered—how he fawns on man and follows at his heel, half-shyness and half-assurance. We must conclude then that in early neolithic times the dog obtruded himself on man, and was accepted as soon as the latter discovered his utility in putting up and hunting wild animals. Besides the dog (Fig. 165), whom man has ever since regarded as a trusty friend, other domestic animals have been found in the deposits both on land and below the water. Especially important sources of knowledge are the very definite remains of domestic animals recovered by Rütimeyer and Studer from the Swiss pile-

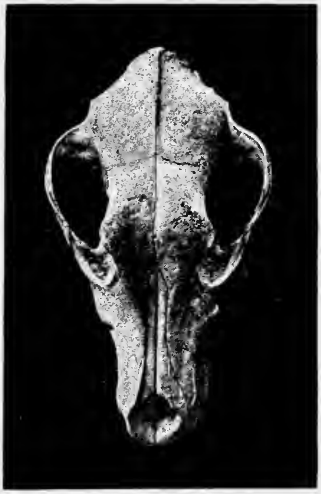


FIG. 165. Skull of hound. (Robenhausen.)

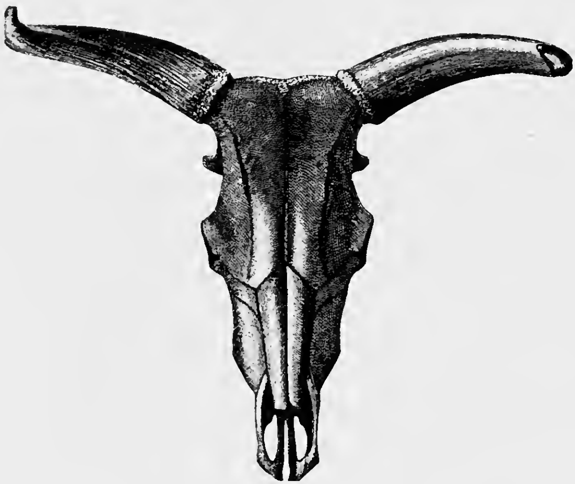


FIG. 166. Skull of *Bostaurus, var. primigenius.*

dwellings. The remains of two sorts of oxen, the larger primæval ox (Bos Primigenius) and the smaller bog ox (Bos

Brachyceros) (Fig. 166). The bog swine (Figs. 167 and 168), apparently derived from the European wild boar, a goat, and a goat-like sheep, have also been found (Fig. 169). The horse, so frequently found in the first Stone Age in the neolithic period, is not found till the time of the pile-dwellings, and does not rank as a domestic animal till the Bronze Age is reached.

In the same way the ass, the cat and domestic birds (the goose, duck, hen and pigeon) were not present during the earliest times in Europe. They were all later additions from the South and South-East.

Fig. 167. Skull of a bog swine from Lattringen.

Fig. 168. Mandible of bog swine from pile-buildings at Schaffis.

Fields and Gardens.—The food of man has never consisted of meat alone, for his dietary also comprised the edible types of vegetables. In the early Stone Age he picked berries, shook down the wild fruits, gathered mushrooms and dug up roots. No traces, however, remain of all this activity; it is only in the beginning of the second Stone Age that we come across distinct evidence of vegetable food, without, however, being able to say clearly whether it was derived from wild plants or from those cultivated by man. In the upper strata of the cave at Mas d'Azil, in Southern France, which clearly show the beginnings of neolithic civilisation with its polished stone tools, are found not only broken stones of plums and cherries (which Piette considers were cultivated), but also the earliest specimens of grains of corn, of which no traces have ever been found of an earlier date. This shows that man must have had at this time settled abodes, as otherwise it is impossible to suppose that he could have cultivated fields or gardens. The tendency to a fixed habitation must have become stronger in each successive period, for, from the dwellings on land and water which have been explored, there are unmistakable signs of considerable neolithic husbandry, especially from the pile-dwellings, though like evidences can

FIG. 169. Goat-like sheep. (Graubünden.)

be found in the huts on land. Heer, the botanist, has accurately classified the remains of household food-stuffs which have been found in the pile-dwellings.

Among field crops he found ordinary wheat, and six- and two-rowed barley and millet (Fig. 170). Among fruits, two kinds of apples (a wild apple and a cultivated one), pears, cherries and plums; and among plants used for spinning, flax. Besides these were grape-stones and poppy seeds. Other field crops, such as oats and rye, were only cultivated later by European races; even the sorts named above were probably introduced into Europe by newcomers during the neolithic period. The men of this period had no metal tools or instruments for tilling their fields and gardens. A pointed and hardened pole was all that served to break up the earth. More useful was the pole with a hook, from which later the primitive hooked plough was evolved; or a pole to which a stag's horn, or a stone, had been fastened, of which many examples have been found. And when the fruits of the earth had been gathered in, they could either be eaten in the form of roasted grain, or they might be ground, by means of a sandstone grinder, either on a flat stone or on one with a trough cut in it. The ground grains would then be made into a paste with water, and baked to make a sort of loaf.

The transition from the nomadic life of the hunter to the settled state of the agriculturist is the most remarkable epoch

FIG. 170. Cereals of the pile-builders.

FIG. 171. Bronze sickle from Dächingen (Würtemburg). (*Swabian Exploration, IV.*)

in the history of mankind. This step alone made the subsequent development of human civilisation possible. But as with the keeping of domestic animals, so it is in the case of agriculture. Man has no absolute monopoly, for the same remarkable little hymenoptera which employ aphides as cows, are also clever enough to plant certain grass seeds which are useful to themselves. An agricultural ant (*Aphaenogaster*) lives in a kind of cemented town, and takes certain measures according to the time of year. Within a smoothly laid yard they suffer nothing but a single kind of grass to grow, which bears a sort of grain. These grains are removed, carefully hoarded, and yield a rich crop of small, hard, white seeds. When ripe they are harvested, carried into the corn-loft by the workers and freed from chaff, which is thrown outside the house; all these procedures differ but little from those adopted by man.

Salt and how it was obtained.—According to the teaching of physiology a definite supply of mineral salts is very necessary for the maintenance of the human and animal tissues. The nutrient salts (sodium, potassium and calcium in combination with chlorine and phosphoric acid), which are lost in the urine and partly also in the fæces, have to be replaced by fresh supplies, or else the animal or man will die. This supply is ordinarily provided by the usual articles of diet, among which milk is especially important. There are, indeed, savage races who have no longing for special supplies of salt (sodium chloride) beyond that which is contained in the diet. Civilised man, however, finds salt indispensable, and many races obtain it from great distances by barter. There are also many animals (beasts of prey) which have no need of salt, whereas others (such as the ruminants) take energetic measures to satisfy their need for salt.

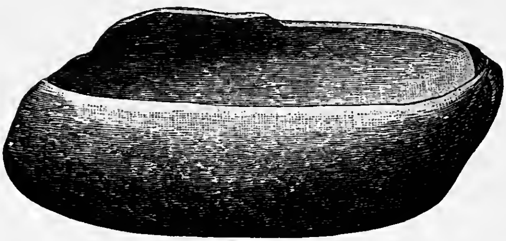


FIG. 172. Handmill from South Sweden.

We have no means of knowing whether palæolithic man took salt with his food, or if so, how he obtained it. It is probable that his meat diet provided him with sufficient salt; it is still more probable that he had learned that ashes contain salt, by cooking his meat in hot ashes; or that he obtained the salt which separated out from the pools near the sea-coast.

When once the use of salt was fully established, it became a source of activity which at once raised savage man far above the animal kingdom by which he was surrounded.

In all probability we may assume that the use of salt as a condiment belongs to the much more highly developed civilisation of the neolithic period, when agriculture and stock-raising flourished; moreover, in cases where there was no salt well in the vicinity, we may further assume that it was obtained from the Southern and Western races, with whom we know, from the contents of their settlements, they were in close commercial relationship.

The discoveries relating to earlier times have shown that in the following Metal Age (*i.e.*, the Hallstatt period) the obtaining and bartering of salt was an important industry. As at the present time, the salt was either excavated by miners, as in the celebrated Salzberg on the Lake of Hallstatt, or it was obtained by evaporating brine over a fire, as in the valley of the Seille, and in a region of mid-Europe which extends from Bohemia over South-West Germany as far as Alsace, Burgundy and the Franche-Conté. Near many of these brine wells hearths and clay supports have been found, over which the brine overflowed when boiling, and then evaporating on the hot brickwork left crystals of salt which can now be scraped or knocked off. Seeing that at the present time most bitter wars have been fought out between the desert tribes of the Soudan for the possession of the salt deposits on the road from Fezzan through Murzuk, we can easily imagine that similar sanguinary battles were waged over the prehistoric salt wells and salt mines.

Sense of Beauty and Love of Ornament.—Neither of these can be absolutely predicated of animals, as is sometimes done very illogically. The structure of the visual organs of animals makes it self-evident, according to Schleich, that they possess the power of appreciating and distinguishing colours. All animal types in which, owing to sexual selection, the males are either gorgeously coloured from the beginning, or else don a beautiful marriage garment during the breeding season, must have a definite sense of colour and of beauty; otherwise this sexual phenomenon is inexplicable. One need but look at peacocks and turkeys, and the rich colouring of the male butterflies, to see how they display their adornments, or to read in the accounts of travellers of the colonies of male birds of paradise which plume themselves on the branches of the trees glittering in all the colours of the rainbow. What other object can they have than to excite the admiration of the female? The desire to be of a pleasing appearance is therefore not peculiar to man, but is shared by other animals also. The endeavour to ornament the body by means of extraneous objects is also found among animals. The male bower bird, who builds a bower for himself and for the hen he wishes to attract, decorated with variegated stones, shells and feathers, will take a pretty feather or brightly coloured leaf in his beak and dance in and out of his arbour with it (Fig. 173).

This, indeed, is but a solitary instance, and is of slight importance compared to the universal desire for ornament which man has displayed from the earliest times. But I cannot agree with Waitz that the endeavour to decorate his body in some

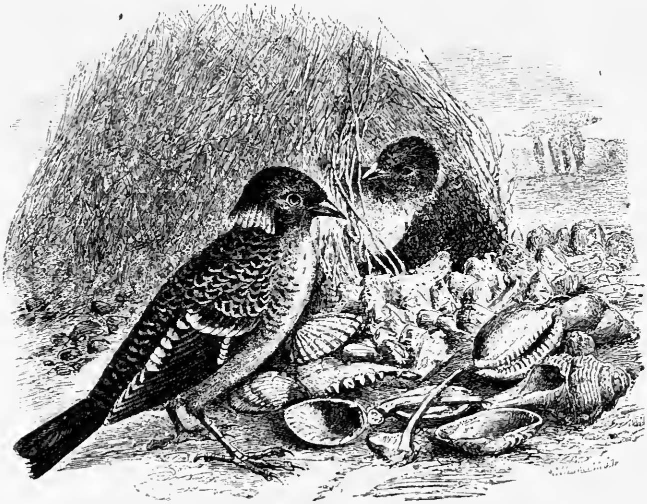


FIG. 173. The spotted bower bird (*Chlamydera moculata*). (Brehm.)

way constitutes a specific difference between man and other animals. Although, as we have seen, no absolute difference exists, the relative difference is extraordinarily great, seeing how manifold are the ways in which man's desire for ornament manifests itself.

In the first place, the coloured earths which are found in nearly all palæolithic settlements probably served for painting and ornamenting the body, possibly also with the addition of tattooing, for which the small flint knives of the Madeleine period may have been used. Then there were necklaces of teeth, small stones, shells of snails or mussels (Fig. 174), minerals, corals, ammonites, shark's teeth, and numerous other glittering objects, which the wandering hunter took to decorate himself withal.

In the neolithic period necklaces were made of beautifully polished shells, often brought from distant lakes, and armlets of large polished mussel shells. All these ornaments were buried with the dead in their graves. Even as early as in the transitional period, between palæolithic and neolithic times (Mas d'Azil, Mentone), skeletons coloured red have been unearthed; it is, however, uncertain whether the corpse was strewn with the coloured powder, or whether the bones were tinted after the flesh had been removed.

Fig. 174. Ornaments made of teeth and shells from La Madeleine. (Hörnes.)

Personal ornaments became much more varied when man learnt to employ the metals. Bronze especially allowed of great variety of working, and satisfied all artistic requirements; indeed, the perfect finish of the bronze ornaments excites our admiration even now (Fig. 175).

Should we be right, it may be asked, in constructing a picture of the prehistoric inhabitants of Europe from our knowledge of how modern savage races adorn their persons? I think this question may be answered by an unqualified affirmative. To-day savages decorate themselves with ornamental feathers, necklaces, armlets and carvings, and paint themselves in the most diverse manner. "Were the nations who paint their bodies," said Humboldt, "observed with the same care as those that wear clothes, the same diversity of design, and the same unending variety of fashion would be found in the manner of painting which has been observed in the composition of clothes." We may therefore also suppose that with regard to the dressing of the hair (and also perhaps of the beard), the same infinite variety obtained among prehistoric people as is seen among the savage races of to-day.

The Art of Painting.

Here again we find a region in which man stands alone among the entire series of animal life. No animal is able to reproduce his observations or ideas in a pictorial form. This man can do; not on account of his hands, as apes also possess hands, but on account of his human soul.

That artistic aspirations are inborn in all human beings, is seen by a glance at the attempts made by the children of all nations. They make playful attempts at scribbling pictures of trees, animals and men of the quaintest description, and when they can get hold of mud, they use its plastic properties to construct models of new forms suggested by their active imaginations. As this desire for art exists in all children, and in all savage races, so in the earliest times of human existence we meet with marked artistic activity. We might indeed almost imagine that this phenomenon was physiological in nature, and that art was as necessary to man as salt. To return once more to the children, we may learn from them that in many ways, both bodily and spiritual, the childhood of European and other civilisations reflects the natural life of the human race (Klaatsch).

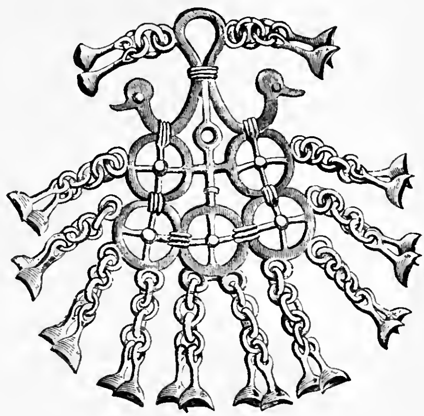


FIG. 175. Bronze ornament of the Hallstatt period, $\frac{1}{3}$ natural size. (Hörnes.)

Palæolithic art regarded with not unnatural wonder the entire natural world, as seen on Western European soil. It did not concern itself with decorative patterns, but produced free-hand drawings of animals (mammals, birds, reptiles and fishes), less frequently men, and least frequently of all plants. It attained within its own province a higher level than does the art of the savage hunter-tribes of the present day—the Australians, the Bushmen, and the Eskimos. These free-hand drawings, however, are not found in all the settlements of the reindeer hunters, but chiefly in France. They also occur in Thayringen and Mähren. At first it would seem remarkable that in the oldest settlements of the mammoth period plastic arts predominated (Fig. 176).

It may, however, be assumed with much probability that it was the convenient curve of a piece of bone, horn or ivory which enabled the artist to execute his small portable statuettes. It must have been still more alluring to the palæolithic hunter to carve out of wood the animal which interested him; we cannot prove, however, that this occurred, as the material must long since have perished.

Fig. 176. Back view of female torso in ivory from Brassempouy. (Palæolithic, $\frac{1}{3}$ natural size.)

A higher level in art, first attained by the hunters of the reindeer period proper, is characterised by life-like carving on bone, horn and pieces of chalk (Fig. 177). These are not often found in the camping places of the hunter-tribes, but are most frequent in the cave-dwellings which they inhabited later on; the idea, therefore, that the higher artistic development was occasioned by the greater permanency of the dwelling-place is not without some foundation. This higher development of art is especially noticeable at the time when the wild horse was mainly hunted in France; and to this period belong the beautiful reliefs of horses cut on reindeer horn, on which also are small carved patterns.

The highest grade of palæolithic art was attained by the employment of colour. The river flints in the grotto of Mas d'Azil, painted with the most varied figures in red paint, attracted very general attention as being the earliest specimens of composition in colour made by man. But the wonder grew still greater when the paintings of animals of great size were found in the mountain caverns of Northern Spain, and in the French district of Vezèretal. In this case the hunter-artist was not content merely to scratch on the walls of the cave an outline of the animals he hunted (bisons, mammoths, horses, antelopes, reindeer and ibex), but he added also shading and colour, using the pieces of yellow ochre and black manganese oxide found in the cave. How such animated pictures, so true to nature, could have been completed in the darkness of the cave, or lighted only by a torch, remains an insoluble puzzle. These cave paintings of Northern Spain and Southern France have something of the freedom of the palæolithic art. Without conscious effort they spring solely and entirely from the

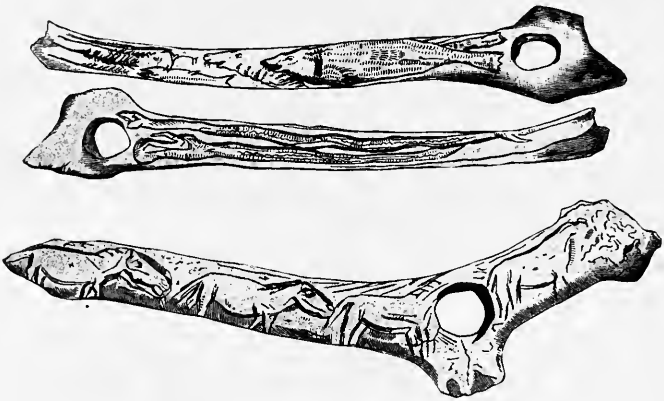


FIG. 177. So-called sceptres with figures of animals. (Hörnes.)

artist's enjoyment of form and colour. Together with the outline drawings on reindeer, horn and chalk plaques, which must be regarded as purely imaginary creations, they deserve the first place in the early history of art. Certain drawings and carvings may be given the second, which serve as a decoration to some useful article, such as a spear-head, or the so-called sceptres. These works of art also attained a position which was never reached in the next or neolithic period.

The characteristic of this period is the appearance of conventional patterns. The palæolithic hunter-artists did not disdain to fill in their outline drawings here and there with geometrical ornament by way of framing, or filling them in with squares or zig-zags; we even possess carvings which are decorated with purely conventional spirals, rings or curves; ornamentation of this sort is, however, to be sought in its most characteristic form in the neolithic period. The cause of this difference in the palæolithic and neolithic ornament is not difficult to discover. As the neolithic people appear to represent quite a new race, with their tendency to settled abodes, their agriculture and their stock-raising, so their art seems to develop along different lines and to arise from a different source.

Palæolithic art took its models from the animal world around it; it was a masculine art carried out by hunters.

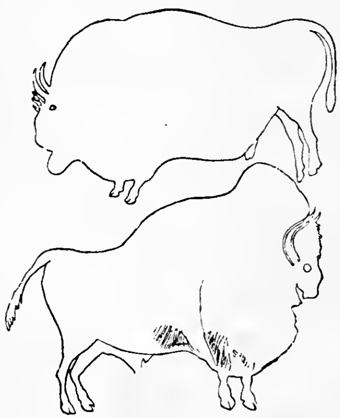


FIG. 178. Bisons. Frescoes from the wall of the grotto Font de Gaume (Dordogne.) (Hörnes.)

The neolithic, on the other hand, was a feminine art. The women who made the pottery and designed the ornaments for it took their ideas from the patterns of their weaving and plaiting.

It is immaterial whether basket-work especially gave rise to the introduction of geometrical patterns. This much, however, may be gathered from the consideration of the savage races of the present day, namely, that some form of industry must always have preceded ornamentation. The African Bushmen and the Veddahs, who possess many industries, show no trace of ornament. But in the neolithic period, and for long after, geometrical ornament, with its rhythmic repetition of design, its simplicity, and its power of adapting itself easily to any flat surface, established its place in the history of the origins of art. Strictly speaking, however, it ceased to be a pure art, but must be considered as a craft, as we can see that the ornament was no longer drawn by hand but was generally stamped with a die. The circumstance that the deeper lines were filled in with a white paste while the clay was wet, in order to heighten the colour effect, does not elevate this neolithic craft to the status of art (Figs. 158 and

159); the comparatively high finish shown on the pottery of Butmir (Serajewo) only places in more glaring contrast the unsightly plumpness of the only carved idol found belonging to the end of the neolithic period.

As we have seen, the employment of copper and bronze in the metallic period gave rise to an important era in the history of human civilisation. But the general advance in civilisation was not at first accompanied by a corresponding advance in art, indeed the latter for a long period remained under the influence of its neolithic predecessor. The oldest metal implements were merely unadorned copies of those of the Stone Age; subsequently, first under the influence of the people of the south and south-west, and later on spontaneously, ornament appeared on manufactured objects, and acquired a character definitely denoting the Bronze Age. The ornamentation of pottery was thus entirely by way of linear designs with the exception of two localities, which developed independently a culture of their own in the Bronze Age. These were North Scandinavia with its highly finished bronze statuary, and the coasts and islands of the Ægean Sea in the south, where a marvellous delicacy of execution both in drawing and sculpture was developed. The most beautiful examples have been unearthed at Hissarlik (Troy), Mycenæ and Tiryns, and at the recent excavations in Crete. They include not only carved objects in bronze, the noble metals, amber, marble and alabaster, but also the oldest painted vases partly decorated with geometrical ornaments and partly with pictures of men and all kinds of animals.

In the earliest Iron Age, which ushers us nearly into the domain of history, metal work is only prominent in contrast to works of art; the latter, as far as the drawing of men or animals is concerned, is far inferior to Mycenæan art. On the other hand, high praise must be accorded to the women potters of the Hallstatt period, as they were evidently filled with the desire of imitating in their clay designs the workers in bronze who had preceded them. Their ornaments included small figures of men and animals, as did those of the last named. They also tried to make vessels in the shape of mammals and birds, and could not resist ornamenting the faces on their urns with earrings and necklaces of bronze.

A well-developed sense of colour is shown in the large ceremonial urns and platters taken from the barrows of south-west Germany. They have geometrical patterns deeply engraved on the clay, and painted with various colours.

In Greece, and the Greek colonies, the painting of their beautifully shaped vases soon began. These vases were turned on a wheel, and were much valued throughout antiquity; even now they are the delight of all lovers of Art.

It is not iron itself that has left its mark on the art of the early Iron Age. Still less can this be said of the later Iron Age (La Têne), which may be put at about B.C. 400.

The Celts indeed, the diffusers of the La Têne civilisation, were masterly ironsmiths, who employed this valuable metal not only to manufacture arms and tools for the household and the field, but also for ornaments of every description. The output, however, was modest, unless we reckon the patterns engraved on the iron sword blades, the animals' heads on their chains, and the enamel inlaid work on the more deeply-cut engravings. The characteristic ornaments of this period are the triangle, the spiral, and especially the conventional flower pattern which are all rare in the previous periods. The Celts, however, employed it extensively; and even hundreds of years later it appears in the miniature paintings executed by the Irish monks. On the other hand, the pottery turned on the wheel was faultlessly made though considered poor from the artistic point of view.

The art of La Têne, which we know mainly from its relics, leads on into historic times—times in which Greek Art, the model for all subsequent ages, was fully developed, and in which that of Egypt was already waning. When we take a general survey of the prehistoric art of Europe, that of the palæolithic hunters is the only one which strikes us as autochthonous.

The subsequent periods can only be understood by duly considering the influence of the south and east, where even in the grey dawn of the world, races were established endowed with what we must regard as a most amazing genius for Art. Thence, from Egypt and from the coasts and islands of the Ægæan Sea, from Asia Minor in the Mesopotamian "hinterlands," flowed forth the European races in devious lines, stimulated by the all-important commercial instinct, till they reached the furthest north of Scandinavia. Even Greek art was influenced in its beginnings by southern and south-eastern models, although later on this influence was entirely discarded and it established itself in its own brilliant individuality. Eventually indeed it inspired the art of the Mediterranean races, the Illyrians, the Etruscans, and finally the Romans themselves. The same thing was repeated in the case of the Celtic art, which we knew as that of La Têne. For the Celts the place of entry for artistic influences was Massilia, but here streamed in not only the products of Greek art, but those also of the Egyptian from North Africa and of Phœnicia from Asia Minor. From these the Celts could take their examples and work them out in Celtic fashion, till their influence, in its turn, could stimulate the productiveness of the surrounding races, and extend even to the art of Scandinavia and Britain.

Vocal and Instrumental Music.

The power of artistic thought, and the power of expressing it in works of art is, as we have seen, an attribute of man alone; this does not apply, however, to vocal and instrumental music, for both of these can be produced by certain species of animals.

The sounds made by mammals are produced usually by the vibrations of the vocal cords in expiration, and partly also in inspiration; with the exception of the Hylobates agilis, and possibly other varieties of hylobates, and the singing house mouse, these sounds are mere noises and not musical. "A female hylobates," says Brehm,[1] "utters a loud cry which is peculiar, and quite melodious. It can be perfectly well represented in musical notation. It begins with E as a ground note, and then rises in semitones through a full octave, thus completing a chromatic scale. The ground note is heard throughout, and forms a kind of *appoggiatura* to each subsequent note. In the ascending scale the notes follow each other more and more slowly; in the descending scale they become quicker and end with extraordinary rapidity. The end is always a piercing shriek which is uttered with all

[1] Brehm, *loc. cit.*, i., p. 39.

her power. The regularity, rapidity and certainty with which the animal screams out the scale is extremely remarkable. The ape herself appears to be very much excited by it, as every muscle is thrown into contraction, and her whole body is shaken by a shivering movement." This is in effect a true song, although it only consists in repeating the same scale over and over again. The song of the singing house mouse is quite different, and is often mistaken by the uninitiated for the squeaking of young mice in their nest. But it is really no mere squeaking noise, but a perfect song moving in accurate intervals, and produced by a full-grown mouse, as I was able to observe long ago in a singing mouse which I kept in captivity. Bamfield has explained the song of the house mouse in his home as an imitation of that of a canary in his kitchen, which is not so very improbable considering the well-known fondness of house mice for music. Other observers, however, besides myself, have noted that the house mouse will sing quite independently of hearing a canary. The only remarkable thing is that singing mice are so seldom heard, as it has been proved that they form no special class of mice, but are only of the ordinary variety found in houses.

These two examples of singing mammals have no real connection with singing birds, and these differ from one another though comprised in allied orders. Their distinguishing mark is the possession of five or six pairs of muscles in the larynx which produce the characteristic sounds. At the same time all birds possessing this apparatus cannot be accurately classed as singing birds; ravens and birds of paradise can only produce a kind of shriek. The remaining birds are more definitely song birds, finches, yellow-hammers, tanagers, stilts, pipers, tomtits, tailor birds, thrushes, starlings and butcher birds. The very various songs of the birds may be classed in three groups according to their loudness, their beauty of tone and their richness. Those birds are said to warble whose voice is strong and sweet, and whose song always or generally consists of a sequence of notes such as the nightingale, the chaffinch, the canary, the wren and the black-cap; those birds are simply said to sing when their notes flow forth without any regular sequence, mingled with softer twittering sounds, such as the lark, the grey hedge-sparrow, the green-finch and the redbreast. Piping is the name given to singing which consists of clear fluty tones which may be expressed as notes and which well out in beautiful melodies like those of the blackbird, linnet and oriole. Many consider the song of the nightingale the most beautiful thing of which a bird is capable. When, however, we compare it with the glorious and ever-varying song of the field lark, and other varieties of lark, or when we listen to the song of the mocking bird, or the red-backed butcher bird, or the reed-warbler, we cannot hesitate to award the palm among all birds to these singers.

In men also the love of song is inborn ; this is seen in the children of all nations, who can sing long before they can talk, and try to perform "songs without words" of their own composition. The songs of the mountain folk consist of these lays without words, which they produce either alone, or accompanied by songs with words, through the actual joy of living. When we come to examine savage races, we find that there is no emotion of any importance, whether sad or pleasurable, to which they do not give expression in extempore song often accompanied by dancing. Herder and Wilhelm v. Humboldt called man a "singing animal". Ludwig Noiré, the gifted pupil of Lazarus Grieger, the etymologist, described as peculiar to man "the song which arises from pure delight in his own existence, in which thought is wedded to beautiful sounds, and thus has contributed not a little to the development of language". Darwin comes to the same conclusion from the biological point of view. As the males of most kinds of quadrumana have more highly developed vocal organs than the females, and since the hylobates (male and female) can produce a whole octave of musical notes, it is not improbable that the predecessors of the human race before being able to express their love in any kind of language, tried to excite each other's passions in musical tones and rhythms.

In course of time men learnt by experience to increase the æsthetic value of their songs by attention to harmony and rhythm, until finally the laws governing these things were discovered by the appointed genius, and it was found that "æsthetic satisfaction can only be obtained when, on the one hand, harmonies and discords succeed each other, by the simultaneous production of several notes, and when, on the other hand, in the course of various musical productions, a definite accentuation of tone recurs at regular intervals of time (rhythm)" (Wundt).

It may again be pointed out that instrumental music is no monopoly of the human race, as when the drum, tambourine and rattle were added to the musical instruments employed by man, the corresponding instruments used by animals could everywhere be seen and heard. Woodpeckers drum, tapping on a bough with a rapid succession of blows with the beak delivered with a swinging movement; the North American woodcock (Tetrao umbellus) drums, beating his wings together across his back. The cockbird of the black West African weaver-bird glides with quivering wings through the air and so produces a rapid whirring noise like that of a child's rattle. Many male goatsuckers during the breeding season make a peculiar buzzing noise when flying through the air. Storks produce a clapping sound by shutting their bills; peacocks and birds of paradise rustle the quills of their plumage; the male lapwing combines vocal and instrumental music by first drawing in the air, and then in a moment blowing it out again, at the same time striking the end of his beak straight on to a stone, or tree-trunk. Becassines have a number of tail feathers specially arranged so that in their rapid flight through the air a remarkable whirring, humming, or even clattering sound is produced; the cock Chamæpetes unicolor in America, the Indian Florican (Sypheotides aurita), and a species of pipra have a similar mechanism in their wing feathers.

Certain arthropods are keen musicians. The males of several kinds of Theridia (spiders) are able to make a kind of whirring noise. The buzzing of Diptèra and Hymenoptera is not a mere involuntary result of the movements of the wings in flying, but a voluntary act, produced by squeezing the air out of the trachea. The death's head moth (Acherontia atropos) makes its shrill piping noise by rubbing its proboscis upon the strong ridges on the inner surfaces of its antennæ. The droning of chafers can be heard at a great distance and is mainly due to the rasp—a part of the body marked with paralell ridges, which is scratched by the so-called "scraper," a neighbouring part which is furnished with a hard edge (Fig. 179).

Some Hemiptera (bugs), such as Pirates stridulus and Reduvius personatus, produce a shrill sound by moving forward their thighs within the cavity of the prothorax. The male locust or cicada has this power still more developed, and was said by the ancients to "sing". According to Landois the sound is produced by the vibrations of the margins of the respiratory tubules; Powell attributes it to the vibrations of a membrane which is put in motion by a special muscle. The male crickets and grasshoppers also chirp and squeak continuously. According to Darwin, there is a kind of locust on the river Amazon which produces so melodious a sound that the Indians keep it in little cages made of plaited willow. Although the musical instruments of the three sub-orders of the Orthoptera are so various, they are all remarkably simple in construction. In crickets a toothed ridge, or vein, on one wing-case is rubbed transversely with great rapidity against a smooth hard ridge on the upper surface of the opposite wing; in locusts the left wing is the violin bow, lying across the right wing which is used as a violin; there is a fine "nerve" with a saw-like edge on the under surface of the left wing which is drawn transversely over the "nerve" which rises from the upper surface of the right wing. The Acridides do their fiddling in a different way: generally speaking, the inner surface of the upper part of the thigh, which is furnished with little elastic teeth, acts as violin bow (Fig. 180), and they play either on the ridges attached to the wing cases, or on a ridge on the abdomen, the lower part of which is expanded so as to form a large bladder in order to increase its resonating powers.

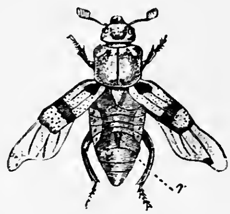


FIG. 179. Chafer. (After Landois.) r, the rasps.

These examples, I think, show that there is no lack of musicians among animals; I shall now proceed to give a short *résumé* of what is known concerning prehistoric musical instruments and the beginnings of instrumental music. A complete history of musical instruments, or an account of the instruments of the savage races of to-day, would require a large book to itself.

According to Darwin, it must be generally assumed that singing is the basis or the source of man's instrumental music. I have considerable doubts, however, as to the correctness of this assumption, and believe it to be highly probable that the latter is quite independent of the former.

As, in their games, our children, and the children of all nations, will produce a note by blowing down a reed, or by tapping a pot, a vessel or a board covering a hole, obtain further sounds owing to their resonance; or as, when they pull on a stretched cord, they are surprised at the duration of the vibrations, so the prehistoric men arrived at the construction of instruments by dint of experiment in playing. Pipes made of the phalanges of the reindeer bored with a hole (Fig. 181), were found in the palæolithic settlements in France and in the Swiss pictures. Lartet has described two flutes made from the bones and horn of reindeer which were found in palæolithic caves in France. In the same way flutes could be made of the long bones of birds simply bored with holes in them, and like many flutes of elderwood or pieces of reed, may have rotted away in these caves. It may be assumed as very probable that such wind instruments were first made for children, and by children out of willow, or reeds, which are easily cut. Very likely this was first done by the neolithic dwellers in the lake villages where they were surrounded by reeds. We do not know whether the palæolithic hunters blew upon horns taken from the bisons and bulls which they hunted, nor do we know whether they possessed wooden drums covered with hides like modern savage races; if this was the case they must long since have decayed like the wooden pipes and flutes. We possess a single drum of clay (Fig. 182)

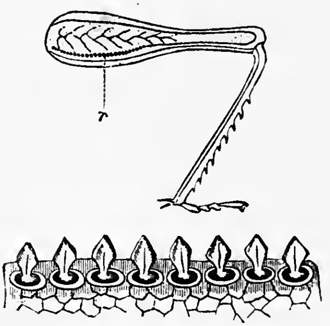


FIG. 180. Hind leg of Stenobothrus pratorum. (After Landois.) r, the ridge by which the sound is produced. Below are the teeth of the ridge magnified.

of the Neolithic Age, which is very similar to those of the savage tribes of Southern Asia and America. Balfour (*The Natural History of the Musical Bow*, Oxford, 1899) says that the first stringed instrument must have belonged to the same period as the clay drum, because the bow used in music was developed from the bow used for shooting, and the first example of the latter is found in neolithic settlements.

Balfour distinguishes three stages of development:—

(1) The bow used for shooting, which now among the Kaffirs, Mandingos, Damaras, etc., in South Africa is occasionally used as a musical instrument.

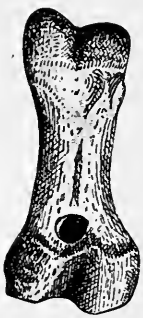


FIG. 181. Pipe of reindeer bone.

FIG. 182. Clay drum from Ebendorf, near Magdeburg.

(2) One-stringed bows solely made for musical purposes (Zulus, Niam-Niam, Bongos, Basutos, Mashonas).

(3) As an addition the bow has a resonator, usually a hollow gourd, to improve the tone. This kind is the most widely distributed.

The bow, according to Balfour, was the true prototype of stringed instruments in ancient Greece and Rome, in Northern and Central India and in Central Brazil. If we imagine this bow made rather more solidly and furnished with several strings of various thickness, we have a harp in its simplest form.

There is, however, another mode of origin for stringed instruments played on by the finger. If they did not wish to use a large gourd with strings stretched across it, it was but a step to employ the empty carapace of a tortoise for this purpose. The fact that a six-stringed "chrotta" has been found in the Alemannic cemetery at Oberflacht shows that the forefathers of the German people had attained to this kind of musical instrument. And it was also only a short step in advance to fill in the space between the branching horns of an ox, or antelope, with strings, and so to create the famous lyre.

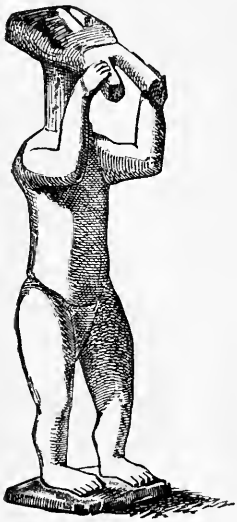


FIG. 183. Flute player of limestone from Keros, near Amorgos, ½ natural size. (Hörnes.)

Prehistoric musical instruments are but so rarely found that any representations of them either in statuettes, or in outline drawings, are of extreme value. There are two almost perfect marble figures belonging to the period of that civilisation which surrounded the Ægean Sea which were found at Keros, near Amorgos. One represents a player on a double flute (Fig. 183), and the other, a sitting man with a round-shaped harp. On an urn from Oldenburg (Hallstatt period) small figures playing on stringed instruments near some large female figures may be seen rather crudely outlined. Also of the Hallstatt period but much better executed is the representation of an artist playing on a seven-stringed lyre on the bronze platter from the temple of Alphæus at Olympia. All these indeed belong to a time when outside the boundaries of Europe the skilful races of Asia and Egypt had long been in possession of perfect musical instruments.

Writing.

Writing is the final point in man's monopoly of the intellectual world, and springs from an inborn desire for the power of recording thoughts, experiences and events.

The need of such a record must have been felt by the palæolithic hunters, for in many utensils made of reindeer bones we find, besides the carving and outline drawings of animals, peculiar linear stripes and curves (Fig. 184) arranged in a definite way which must be considered to be either figures or marks to denote proprietorship. The remarkable drawings previously described on the flints of Mas d'Azil (Fig. 185), consisting of crosses, rings with dots in the middle, serpentine lines, ladders, tree-shaped signs, zig-zags, etc., were explained by their discoverer Piette as letters, while R. Andrée thinks the flints were used for counters, and the marks painted on them denote the proprietor.

This very probable view implies the existence of hieroglyphic characters, which, according to the opinion of all the authorities, was the first foundation of the art of writing in all parts of the world. Wundt has traced the process of the development of writing with great clearness and accuracy. Hieroglyphics, or word-pictures, form naturally the universal starting

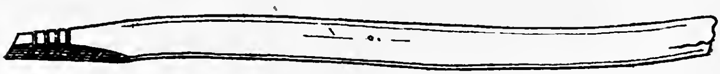


FIG. 184. Rod with marks scratched on it, made of reindeer-horn. (Hörnes.)

point; this consists in copying the shape of an object, in order to represent it graphically. "As soon as speech became capable of expressing abstract ideas, writing had to follow. From the hieroglyphics were developed sound-symbols, but every one of our letters shows traces of its hieroglyphic origin. Eventually the sound-symbols which had originally denoted one word developed into the alphabetical elements of speech, in order to keep pace with the extended powers of verbal expression."

Hieroglyphics, which preceded writing proper, consisted either in imitations of natural objects and could thus be understood by all the nations of the world, or in symbols, certain simplified outlines of natural objects which could only be understood by the learned. At the present day the Eskimos and Tsuktseu with their signs scratched on wood or ivory, the prairie Indians with their drawings on hides, the inhabitants of Central America with their paintings on paper made from the

Agave americana, and the Bushmen with their inscriptions on rocks and slates, do not bring us much beyond the region of hieroglyphics. Even now the prairie Indians paint their so-called winter annals on the inner surface of hides. In all these cases the figures and their meanings are easy to understand, and the same may be said of the celebrated Walam Olum, the painted board of the Leni-Lenape, on which the entire story of the wanderings of this tribe is represented in plain outlined characters. On the other hand, the rock inscriptions in South America, and in certain South Sea Islands, are not even yet clearly explained, any more than the prehistoric hieroglyphic symbols from the south or north. The signs employed by the tribes from the south and south-west are often derived from objects in daily use, such as the spinning-wheel (crosses,

Fig. 185. Flints, painted in red, from Mas d'Azil. (Hörnes.)

hooked crosses, or crosses with handles), and apparently have a tropological character. The Phœnician T cross, and the Egyptian cross with a handle to it, are known to be abbreviations, standing for the human form, and the volute and double volute as symbols of the female breast.

The hieroglyphics on the carved stones at Mycenæ, Tiryns, Menidi, Vaphio and Corinth are very difficult to interpret, possibly they are figures put together from several animals.

Hörnes may very probably be right in supposing that they are hieroglyphic words and sentences in which the chief of some small clan and his relatives gave naïve expression to their views on the mightiness of their totem or tutelary deity as compared with foreign demons.

The northern hieroglyphics, dating from the end of the neolithic and the succeeding Bronze Age, are also very difficult to interpret; so too are the rough irregular figures cut on flat stones, and the "Dolmen" stones from the North of France, England, Ireland and South Scandinavia which are symbolically decorated with shells, crooks, yokes, combs, hatchets, axes and bucklers. Then there are the inscriptions on the rocks at Bohuslän (Sweden), the ornamented stone plaques in the civic monument in Schonen, and the small stone basins found in Switzerland and other countries, all of which are hard to decipher.

We must suppose that much of these hieroglyphics deal with the exploits of various races and their chieftains, of voyages and raids, and ideas as to the rule of the gods; but we have nothing on which to base an accurate interpretation.

To pass on to the hieroglyphics of the ancients, those of the Egyptians must by rights be first mentioned (Fig. 186). Flinders Petrie, however, thinks that the earliest beginnings of the Egyptian hieroglyphics are to be found on a neolithic vase discovered by himself, which is painted with a mixture of geometrical figures and conventionally drawn natural objects (plants).

Fig. 186. One side of the hieroglyphics inscribed on the obelisk at Luxor. (Karpeles.)

By-and-by, in the course of the next thousand years, the sacred writings were put together; 500 signs were used, more or less true pictures of men, animals and objects of all sorts, and their values and meaning may be classified under four headings, namely, alphabetical signs, signs representing syllables, signs representing words, and determinatives. These are not all engraved on stone, or metal, but are written, or rather painted, with reed pens on papyrus leaves.

Passing over the hieroglyphics of the Mesopotamians, the ancient Persians and the Armenians, which are thought to be the historical antecedents of the later cuneiform writing, we come to the ancient Cretan hieroglyphs which are of quite exceptional importance, owing to the fact that they are the parents of not only the Aryan but also of the Semitic characters. They are very similar to the hieroglyphs of the Heths and the peoples of Asia Minor, and to a certain extent to those of the Egyptians, and were evolved in the nineteenth century B.C.

In the Egyptian hieroglyphics many parts of the human body are used as signs, as also are various plants and animals, weapons and tools, gates and walls, half-moons and stones and numerous geometrical figures.

FIG. 187. Example of a Chinese inscription of Yu. (Karpeles.)

The Chinese, Japanese and Korean characters (Fig. 187) are derived from a similar hieroglyphic origin; but whereas these nations have exchanged their hieroglyphics for letters proper a thousand years ago, the Spanish conquerors found the natives of Central America still using their ancient and obscure hieroglyphics, in which both realistic pictures and conventional signs were used to express ideas.

In the far East the Chinese exchanged their hieroglyphs for letters proper, turning the original pictures and symbols into the well-known characters which are arranged from above downwards one below the other. They are painted on paper with a pencil and Indian ink, and were later on adopted in a modified form by the Japanese. The Mesopotamians, the ancient Persians and the Armenians changed their early hieroglyphs into cuneiform characters (Fig. 188), which consist of straight lines drawn at one end to a point, and arranged either horizontally with the broader end to the left or else vertically with the broader end at the top. Exceptionally they are oblique, with the broader end either above or below. Thus by means of repeating the signs, placing them either next to or over one another and crossing them, a number of complicated figures were obtained. They were engraved on stone with wedge-shaped chisels, or moulded in wet clay with wedge-shaped sticks.

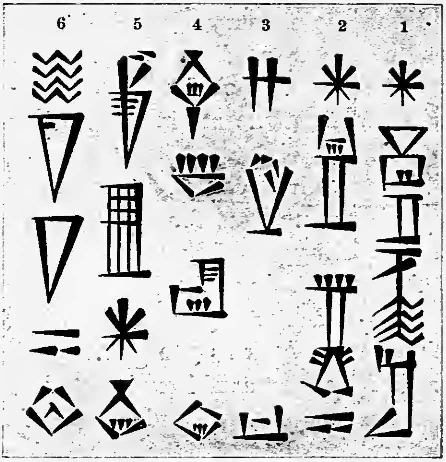


FIG. 188. Example of the arrangement of the lines in an ancient Babylonian inscription. (Karpeles.)

On European soil it was in Crete that the inhabitants of the Ægean Islands first changed the hieroglyphs which had been in use for hundreds of years into a regular system of writing, which differed from that of the Cypriots in that each sign stood for a sound only, and not for a syllable. The main foundation for a practical system of writing was, however, laid by the Phœnicians, who formulated an alphabet of twenty-two characters, containing consonants and semi-consonants and written from right to left. From this was developed the early Semitic writing, and this again was the mother of the Greek, in which the alphabet was increased from twenty-two to twenty-six characters.

The Italian peoples (and perhaps even earlier the Etruscans) obtained their alphabet in an altered form from the Greeks, and the Celts derived theirs partly from the Greeks and partly from the Italians. Among the old German peoples the priests, in order to discover the will of the gods, threw little beechwood darts, each of which carried a "rune"—that is, a sign or picture engraved on it—as a symbol of a god or of the thing whose name the rune bore. These sacred signs became changed later on under the influence of the Romans, till they became what we now know as "characters".[1] Ulfila, in the fourth century, constructed the Gothic alphabet from these metamorphosed runes.

The word "Kerbholz," meaning a tally, or literally, a notched stick, still used in Germany, shows how the old Germans relied on a piece of wood with notches cut in it, both as an aid to the memory, and also in order to show how much was due to the creditor in commercial transactions. A tally about the size of one's finger is still used by miners; the master scratches his name on it, and it is used to summon certain persons.

Among other peoples, however, and at other times, another method was in vogue for assisting the memory for figures and such-like things, namely, writing by knots.

A short history of this practice has appeared, written by Martin Beck. The system of writing by knots is primæval in China; as far back as 3500 B.C. important historical facts were recorded by means of long knotted cords, in which not only were the length, form and colour of importance, but also the kind and number of the knots had special meanings. The system fell into disuse in 3000 B.C. when the Emperor Tchang-Kai invented hieroglyphics. In colour, in shape, and in the way the colours are mixed the Quippus, or knotted cords of the Peruvians, when they were discovered by the conquering Spaniards, were remarkably similar to these. Not only was all acquired knowledge recorded in the Quippus and only understood by the higher classes, but also the whole national budget, the revenue and expenditure, the census, the occurrence of wars, and the government annals were set down. Moreover, certain specially skilled officials were appointed to keep and interpret the records as occasion demanded. For a single

[1] The German words are similar, *Buchenstab*, means a beechwood rod; *Buchstab*, a letter or character.

coloured cord, or the number and character of the knots, did not denote (as in hieroglyphs) an idea, a number or an event, but they were only a means of refreshing the memory as to these things.

In the same way the knotted strings of the South Sea Islanders (Figs. 189, 190) are genealogical registers and historical records, which in earlier times could only be recounted, or sung, by a few individuals, and only when the strings with

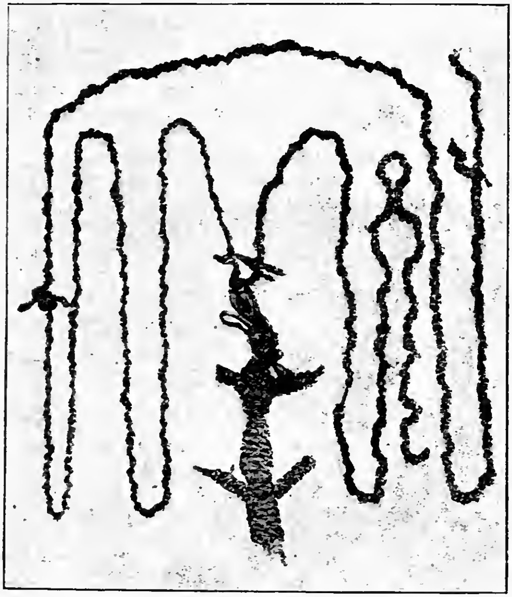


FIG. 189. Knotted cord from Hepatone, Tahuata, Marquesas Islands. (After v. d. Steinen.)

their knots were actually in their hands and before their eyes.

Finally, to take another glance at America, the North American Indians had the same mnemonic device in their strings of mussel shells and their wampum girdles, as had the Peruvians with their Quippus. The girdle of a distinguished person was artfully constructed of animal tendon, with knots, separated by strings of pearls and shells presented by the envoys on important occasions, such as the making of a treaty of peace. It had all the significance of a state document, for each colour, each knot, and each shell had its own particular meaning. It was the duty of the tribal chief to preserve the wampum girdle in the treasury of the tribe, and to teach the growing youths from time to time the history of their tribe by showing them the girdle; its peculiar arrangement was thus impressed on their minds and served to refresh their memory.

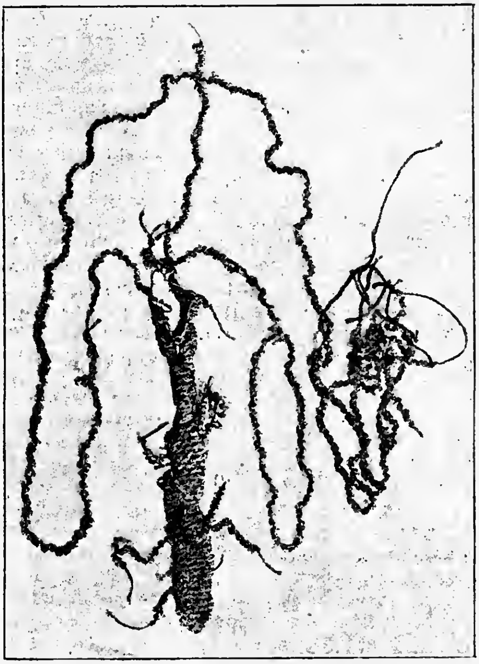


Fig. 190. Knotted cord from Hepatone, Tahuata, Marquesas Islands. (After v. d. Steinen.)

Psychological Retrospect and Forecast.

We who live in the twentieth century with our rapidly printed books and newspapers may well smile at the naïve inadequacy of these knotted cords and hieroglyphs. It is only right, however, to remember that these things are but the prelude to a higher civilisation, just as the freehand drawings of the palæolithic hunter-artists and the geometrical ornament of the neolithic period formed the foundation of all human art. We may observe the same advance from lower to higher things in all regions in which man's special attributes are exercised. The races from which civilised nations have sprung have gradually developed their originally meagre and inadequate language with a rich fount of speech, by which the expansion and exchange of ideas has been facilitated, and which, in conjunction with science, has become a power encircling the entire earth.

In place of the miserable sparks obtained in the infancy of mankind by rubbing together pieces of wood, and replaced some thousands of years later by flint and steel, or pyrites, we have to-day at our command matches which may be kindled in a moment; gas, oil and electric light illuminate the darkness, and steam, produced and controlled by fire, drives the various machines by which we manufacture our industrial products and convey them at express speed over land and sea. We overcome the influence of cold by warming our dwellings, and by the use of clothes, which can be modified according to the condition of the temperature; and we have learnt to construct a host of vessels and tools of iron which enable us to fashion any substance to suit our wishes.

With regard to the question as to whether man during the course of his development in the past has at some time overstepped the barriers which now divide him from the beasts, Wundt thinks that we can certainly give an affirmative answer. This is shown by human history. For as man during his individual development passes from simple association of ideas to a condition of intellectual consciousness, so the whole race has once passed from a state of nature to a state of culture.

In contrast to man's struggle and progress from savagery to civilisation, the further question arises whether it is to man alone that this spiritual development has been granted, or whether animals also can rise to higher things. Wundt, dealing with this question from the point of view that animals have only a simple power of associating ideas and no actual intellectual capacity, thinks that for them any such spiritual development is in the highest degree improbable. He considers the psychological organisation of animals so circumscribed that further development can only take place within certain narrow limits. These limits, however, are not so very narrow. Many of the higher wild animals, whose existence is threatened with extinction, or with diminution, by man, most certainly develop higher intelligence as the result of the struggle for existence aided by extended experience. This has undoubtedly taken place among the domestic animals which man has chosen for his close companions, namely, the horse, and still more, the dog; whereas the others, namely, the sheep, cattle and swine, have attained to no improvement over their condition as wild animals, but have rather suffered some diminution in intellectual capacity. The opinion of a naturalist of Brehm's eminence is particularly interesting in this connection. Speaking of the intellectual powers of the apes, he says, "The mental superiority exhibited by apes over other mammals (excepting man) is by no means so great as is commonly supposed". Brehm does not deny that they possess a certain degree of reflection, a good memory, cunning, craft, and the power of dissimulation; they can also express love and affection. As compared, however, with man, he drily observes, "Man increases in judgment and wisdom with the years; the ape can only be taught when young, the brute in him becomes more and more prominent with age".

Can any races be found among the savages now existing who have any prospect of developing into civilised people? We think it is hardly possible. Human history has long since drawn the dividing-line between the races who are sluggish, cowardly and retrogressive, and those who are energetic, brave and progressive; to the latter belongs the victory, whereas the former either die out, or stagnate in lazy passivity. The present savage races are not, as is often erroneously assumed, degenerates, but, as Hörnes has strikingly demonstrated, are those which remained impoverished and stationary after the migration of the stronger elements. Christianity can effect but little change in them; it can but cover them with a thin varnish of civilisation, under which remains their primitive savagery. The history of the German South-West African war is a striking instance in point.

And now as to the civilised nations. Will civilisation always continue to advance, and man attain the position of super-man? Many, perhaps, do not doubt that this will be so. They point with pride to the tremendous advance which occurred between the hypothetical speechless man of the tertiary epoch and the man of the diluvial period, endowed with speech and using fire and tools; then from this to the barbarians of the later Stone Age, who cultivated fields and tamed animals; then on through the dawning culture of the Bronze and Iron Age to the civilised races of ancient and modern times. Is not a vast intellectual advance, they ask, apparent here? Charles Morris (*The American Naturalist*, 1886) thinks the way of civilised man must lead to still greater heights of intellect. Man to-day cannot be the end product of intellectual development; he is only the beginning of a new developmental process, in which the brain will attain still further supremacy over the body, and the final product will be a being of whose structure we can form no adequate conception.

This is the actual super-man which Nietzsche evolved as the result of the continual progress of development. Branco, however, in the clever chapter which ends his essay on the supposed human teeth found in the Swabian Alps, inquires "is it not logical to regard this super-man not as an end-product but as a stage after which further super-men may follow? And again, is it absolutely necessary that development must always take place in the same direction? The history of many organisms shows that development may lead to a bad end, and that instead of leading to victory in the struggle for existence, it may, on the contrary, lead to defeat." Branco cites the machaerodus as an example in palæontology. In this animal the powerful and saw-like incisor teeth grew to such a size that eventually the animal could not open the jaws sufficiently widely, and so the species died out. Branco therefore thinks it impossible that the progressive enlargement of the human brain for thousands and thousands of years can take place without the body of the super-man becoming progressively feebler, until it dies out owing to its inability to nourish or defend itself, or to propagate its species.

At what period has human civilisation now arrived? My own opinion is that we are still on the upward intellectual path, and that this is undoubtedly proved by the advances made during the last century, and especially during its latter half. During the twentieth century we shall make still further discoveries in the heavens and on the earth; we shall make still more improvements in the construction of our machines and in the conditions of life. But the struggle for existence, which even now is fierce enough, will become still more determined owing to the increase in the population; whether in the course of future ages it will be possible for the body to keep pace with the feverish activity of the brain is a very open question.

I am far from asserting, as does R. Arndt, that all genius, and even talent, or superior endowment of any kind, is a sign of degeneration. It cannot, however, be denied that civilisation itself, especially in its most advanced form, carries with it certain risks to the minds and bodies of men. At the present time it is no secret that the increase in cases of neurasthenia, insanity and suicide must be attributed to the struggle for existence, especially when the harassed brain has been spurred on by alcohol, as so frequently happens. In civilised races we often see increase in intellectual power go hand in hand with a narrowing of the jaw and an early loss of the teeth; in men premature baldness, and in women inability to suckle their children. In both sexes we find imperfect development of the thorax, and consequent predisposition to tuberculous disease of the lungs. In the third part of this work we shall deal with the pathological changes peculiar to man, as well as with those which he exhibits in common with other animals.

It is impossible to foresee whether hygienic efforts will be able to keep pace with the knowledge of these risks, and so be ever more and more able to ward off degeneration from civilised peoples. Instead of prophesying an unlimited advance for mankind through future ages, it would seem more rational to withhold our judgment, as does Branco, for "when we rashly attempt to explore the future, we find, instead of an answer to our questions, that a bandage is laid across our eyes".

C. Comparative Pathology and Pathological Anatomy.

As human characteristics are illustrated by a comparison between the behaviour of men and that of animals, so the pathological side of the question, as well as the anatomical and physiological, must be treated by distinguishing general and special processes.

By comparative researches of this kind we can determine which pathological changes, both of external and internal origin, are common to man and other animals, and which others are proper to man alone.

1. General Pathology and Pathological Anatomy.

Comparative pathology and histology teach us that the foundation of all animal bodies, including man's, is the cell from which the primitive tissues are developed, aggregations of which go to form the different organs and parts of the body.

Comparative physiology further teaches that the chemical composition of similar cells, tissues and organs in all animals, including man, is practically identical, and that what we know as life is manifested as a chemico-physical process in the cells.

Further, since disease is only life under altered conditions, consisting of deviations from the average as regards shape, relationship or activity, human and animal pathology must be regarded as essentially a cellular process, and the remarkable changes which take place in the diseased cells, tissues or organs must be admitted to be, to all intents and purposes, the same both in man and in animals. Pathologically, this correspondence between the two is first noted when we consider the causes of disease.

The animal body is directly damaged by anything which alters the composition of the tissues, either mechanically, as by external violence, or chemically, as by the presence of noxious vapours or gases in the atmosphere. Injury may be also brought about by extreme changes in temperature, such as chilling or freezing, heating or burning, and by extreme rarefaction of the atmosphere at great heights; this, however, is well borne by certain animals (*e.g.*, the condor), though man and other animals are severely affected by it. Other direct causes of disease, of a specific nature, are parasites and poisons.

Animals are also susceptible to the indirect causes of disease; but this is less easily seen in wild animals than in domestic animals, whose constitution, hereditary disposition, age, temperament and sex play an important part.

The symptoms of the processes of disease in man and animals, do not merely consist in the elevation or depression of the body temperature and the concomitant sensations of heat or cold, but in other elementary anomalies of function, such as pain, or loss of sensation, or spasms and motor paralysis.

Diseases may, in all cases, end either in complete recovery, in one or more relapses, in chronic illness, or in death; the last may occur either with or without a struggle; may be sudden, or in the form of a gradual decline.

In the last case the symptoms observed in man do not differ from those seen in the higher animals; psychical activities fail, sensation gradually disappears, the temperature becomes irregularly distributed, and the muscles suffer a general loss of power.

Man, however, differs from all other animals in one point, and that is in his tendency to suicide. No animal, even when suffering from the most severe and painful disease, ever brings its own life to an end.

All the cases of apparent suicide in certain animals which are detailed in works on natural history and other publications, can easily be otherwise explained if a little quiet thought is given to the matter. Even the scorpions, which if placed in a ring of burning coals run directly into the flames, behave in their rage like other animals, or even like man—they lose their heads and rush on to their own destruction. There is never any clear intention of suicide.

Anatomically, similar changes in the cells, tissues and organs correspond to similar pathological conditions. The same changes in the blood as are evidenced by hyperæmia, hæmorrhage and anæmia can be seen in all red-blooded animals just as they are seen in man.

The same thing is true with regard to the unorganised deposits (concretions, atheroma, fat), the formation of water and gas, and especially organised new growths consisting of blood vessels, muscle, nerve, glands, cartilage, bone, connective tissue, epithelium, true skin, mucous membranes and serous membranes; not to mention malignant new growths composed of cells with or without intercellular substance, or connective tissue stroma, and swellings due to tubercle or abscess formation.

Inflammation plays an important part in comparative pathological anatomy, the well-known result of irritation which causes a quantitative and qualitative increase in local metabolic processes, and which varies according as the organ which is attacked possesses a rich capillary network of its own between the cells, or only experiences an influx of plasma as the result of irritation. The inflammatory reaction often goes on to the formation of pus-cells; in other cases permanent new tissues are formed (connective tissue, vascular tissue, bone, etc.), or a degeneration of the cellular elements occurs.

Pathological degeneration may take place, both in man and animals, without any preceding inflammation. Tissues may undergo fatty or granular degeneration, may become calcified or pigmented, or may be converted into a mucous or cheesy granular mass.

Senile atrophic and degenerative changes occur in animals, especially domesticated animals, as well as in man.

Portions of the body may be destroyed by moist, or dry gangrene, a process which in young persons is sometimes due to extremes of temperature (freezing or burning), and sometimes to mechanical violence.

When a man or animal dies the phenomena of dissolution are identical in both cases: the skin becomes bloodless with *post-mortem* lividity in the dependent parts; *rigor mortis* followed by relaxation occurs; fluid collects under the skin and within the body; gas is set free, and the blood coagulates in the veins and right side of the heart.

The acquired hypertrophies and atrophies of certain parts of the body (such as acromegaly and the stunted growth of rickety children) are not the only ones which are included in the domain of comparative pathological anatomy. All congenital anomalies, whether affecting the whole body or only a part, are not less common among animals (at any rate among domestic animals) than among men.

Giants and Dwarfs.—A man 190 centimetres (6 feet 3 inches) is abnormally tall; giants proper are men who reach at least 200 centimetres (6 feet 6 inches), but their maximum height cannot be definitely settled. Their bones alone are hypertrophied without a corresponding increase in the size of the muscular, nervous and vascular systems. They are therefore less resistant to external influences, they are sluggish and have little energy, and are usually incapable of reproduction. This applies less to the shorter, thick-set giants with large trunks and almost normal limbs, and more to the lanky long-legged ones, the upper part of whose bodies is short. Those of the first type are often shown *post-mortem* to be subjects of acromegaly with tumour of the pituitary body in the brain. Giants seldom live to any great age.

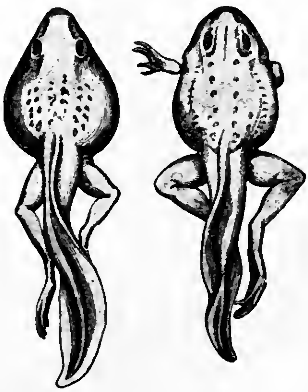


FIG. 191. Giant tadpoles of Rana esculenta, ½ natural size.

Giants are less common among animals than dwarfs. Among wild animals giants have been found in all classes and orders (for example, among stags, elks, turtles, salamanders, sharks); these forms, however, which have become fixed species are of less interest than those which under peculiar circumstances have exceeded the normal size, as, for instance, the enormous pike and carp of certain lakes, and the tadpoles which were found in a wet secluded grave at Frankfort-on-the-Main by Brugsch.[1]

[1] Brugsch, C., "Ueber Riesen- und Zwergformen bei den Betrachiern," *Zoolog. Garten*, 1864, p. 349.

They were half as long again as the normal animal, and their size was attributed to their having had an excessively rich diet of small water animals which inhabited the mud. The domestic animals show the influence of diet in producing giants; continued selective breeding has produced large horses, cattle, pigs, sheep, dogs, cats and rabbits, besides giant geese and ducks, and pigeons the size of fowls.

Dwarfs are much more common than giants, and there are whole races of them in Africa, Eastern Asia, some of the Sunda Islands and in America; their small size is hereditarily transmitted.

Fig. 192. A Bush pygmy. (After Fritoch.)

These pygmies (Fig. 192) have well-proportioned bodies, though their heads are disproportionately large and their arms are too long. Similar pygmies were found in France in palæolithic times, and in Switzerland in neolithic, and according to Sergi are still quite common in Italy as descendants of the African pygmies which had wandered over the isthmus which once united Africa to the south of Europe. In the fact that their bodies though short are well proportioned, these pygmies closely resemble the much smaller dwarfs which are occasionally born of normal parents and among normal brothers and sisters. These elegant lilliputians have a generally infantile appearance and have never produced any offspring. They are the result of a total inhibition of development during intra-uterine life; there are, however, other dwarfs who when born are normal and like other children; in the course of their further growth, although the body becomes normally long and powerful, the extremities remain short, and thus their height remains that of a child. These are giants when they sit down and dwarfs when they stand up. Another pathological variety of dwarf is that which remains small and stunted as the result of rickets; and then there are the saddest of all, the Cretins (Fig. 193), in whom the thyroid gland is either completely absent or much degenerated; not only are their fat bodies and large heads imperfectly developed, but their mental faculties are similarly retarded.

The circumstances noted with regard to human dwarfs also obtain among animals. There are dwarf races among animals corresponding to the pygmies among mammals, birds, fishes, snails, butterflies and beetles. As normal parents here and there produce a lilliputian child, so among the normal litters of domestic animals absurdly small but well-proportioned and elegant individuals are occasionally born. As rickets, too, reduces human children to dwarfs, so young calves, horses, dogs, and also the young of beasts of prey kept in zoological gardens,[1] remain stunted in growth as a result of rickets.

FIG. 193. Cretin. (Virchow.)

Cretinoid animals would also occur were they not soon put out of the way as useless and imbecile consumers of food. I only remember seeing a single case of a full-grown cretinoid animal.

There are also dwarfed animals whose growth has been interfered with by external circumstances without any such pathological changes. These conditions have been studied in batrachians and fishes by Klunzinger.[2] He was able to recognise the following circumstances as conducive to the production of these stunted forms: scarcity of food, too low a temperature in the water (as for example in alpine lakes and pools), too little light at great depths, insufficient volume of water and thus insufficient space for movement and exercise. The dwarf forms among fish have gradually become races and species, but under more favourable conditions they may regain their normal size. Klunzinger cites the river trout (dwarfed sea trout), the torsk (a dwarfed codfish), the small East sea herring, and the dwarf perch.

[1] Friedberger und Fröhner, *Spez. Path. u. Therapie d. Haussäugetiere*, i., p. 714.
[2] *Jahresh. d. Ver. f. vaterl. Naturkunde*, 1900, p. 519.

Deformities.—Förster, from whose works the main part of the following chapter is drawn, has classified deformities generally into those involving simple deficiency, stunting or smallness of the body, and those due to arrested development. All these phenomena, which play so sad a part in the life-history of men, are caused by diseased processes occurring during the early development of the fœtus; these processes so disturb the permanent form of the mature individual, that the whole body (or a part of it) becomes misshapen. The causes are hereditary influence, pathological changes in the ovum or spermatozoon, general or local disease of the mother, or external mechanical influences.

The processes of hypertrophy and atrophy, inflammations and hydropic conditions which occur during the inter-uterine life of the fœtus can only be recognised by their consequences after it has been expelled from the uterus.

(*a*) The worst examples of deformity owing to imperfect development are the formless carneous moles, headless trunks or trunkless heads. Those with imperfectly formed skulls, brains or faces are equally incapable of life, but this is not the case with the microcephalics (produced by premature closing of the bones of the skull), or with those in which the backbone, the thorax or the limbs are imperfectly developed.

These deformities are possible among wild animals, and the paucity of reported cases is probably due to the fact that the old animals immediately destroy them.

The teratological preparations in veterinary museums are nearly always from domestic animals. With the exception of microcephaly, the possibility of which among animals I am not at all disposed to doubt, deformities from imperfect development are fully illustrated by the domestic animals. Much is recorded in the literature of the subject. Darwin (*Variation of Animals*)[1] has published a series of striking examples. Thus he mentions a pig which was born without hind-legs, the deformity being transmitted through three generations. In a litter of rabbits one was born with only one ear; from this a whole race of one-eared rabbits was produced. Exactly analogous to the cases of hereditary baldness among men

[1] Darwin, *loc. cit.*, vols. iii. and iv.

associated with complete or partial absence of teeth, are the hairless dogs with incomplete dentition, especially the incisors, the canines and pre-molars.

The most interesting cases of deformity owing to imperfect development are those in which an acquired deformity is transmitted, a possibility which is still very irrationally disputed. Darwin relates, as absolutely credible, the case of a child with a shortening of the little finger of the right hand whose father had lost the same finger; also the case of a man whose eye had been removed owing to suppurative disease, and whose child had micro-ophthalmos on the same side of the head. Acquired defects are also transmitted in animals, such as dogs, cats, horses, cows. It is not known with certainty whether all tailless cats and dogs are descended from ancestors who once lost their tails by mechanical violence. The fact of its occasional occurrence cannot, however, be denied. A stag which had lost one antler produced one-antlered progeny, and a cow, one of whose horns had been lost owing to suppuration, afterwards brought three one-horned calves into the world.

Fig. 194. Hare-lip. (Bardeleben.)

(*b*) The deformities caused by arrested development are either due to the persistence of an earlier embryonic condition till birth, or to an error in the original development of the part. They are common to animals (domestic) and man. They result in fissures (Fig. 194), or in the closure of cavities and canals which are normally open, in the union of normally separate parts, and in the stunting and deficiency of certain organs.

In this class may be included the complete or partial union of the small bones of the extremities which normally are separate. In man the congenital union of two or more fingers in one or both hands may occur in varying degrees. It may be merely a kind of partial webbing, or may be a complete union of the skin of two fingers right up to the knuckles. Web-feet are found also in certain dogs (*e.g.*, Newfoundlands), and by heredity have given rise to whole races. It is still more remarkable that this abnormality may also occur in fowls, for example the Polish fowls which Darwin describes (*Variations in Plants and Animals*).[1]

Finally, Förster includes in this class the hermaphrodites. *A priori* it would seem more correct to include individuals possessing both male and female sexual organs in the category of those with redundant development, and not of those in which development is impaired. The history of development shows, however, that in all metazoa both sexual organs are originally present, and that, with the exception of the normally hermaphrodite animals, one sex is developed at the expense of the other, after a certain period of embryonic life. I have, however, shown elsewhere, that the undeveloped organs are always present in a latent condition. When this fact is remembered it will be seen that hermaphrodism is in reality an arrest of the process by which one or other of the sexual organs is suppressed or atrophied.

Cesare Taruffi, to whom we owe a new and excellent exposition of this difficult subject,[2] has formulated two main divisions, one that of the true anatomical hermaphrodites, and the second that of the clinical or external pseudo-hermaphrodites. Anatomical hermaphrodites may be considered as genuine when both sexual glands are present in the same individual. This is always rare, but occurs in man and also in other mammals, in birds, in batrachians, and other amphibia and in fishes. Another class of true hermaphrodites is that called by Taruffi atrophic or neutral. In these the glands are rudimentary and sex indeterminate; examples occur in man, dogs, goats and cattle. The third class or false hermaphrodites comprises men with female appearance due to persistence of the Müllerian ducts, and women with a masculine appearance due to persistence of the Wolffian bodies. Taruffi cites as examples among animals a lamb, some hares and a stag, eight swine, eight calves, an ass, two sheep, four goats, several horses, a bitch, a steer, an ox, a ram and a newt.

[1] Darwin, *loc. cit.*, iii., p. 288.

[2] Cesare Taruffi, *Hermaphroditismus und Zeugungsunfähigkeit*, Berlin, 1903.

The cases of clinical hermaphrodism are not less numerous. Among these are classed the men with female appearance, character and breasts, and women with masculine appearance, hypertrophy of the clitoris and beards. The cases of men with female breasts (gynæcomastia) are fairly common ; this is not to be wondered at if we assume with Darwin that the male mammary glands are not rudimentary but merely imperfectly developed, and so not functionally active organs. On the other hand, the accounts of men and male animals with glands which were capable of lactation should be received with extreme caution. In the first place, certain male animals may be excluded, which after castration developed large nipples and eventually secreted milk, as these do not come under the category of deformities. Setting these on one side, there still remains a very small number of genuine cases in which men after their wives have fallen ill have suckled their children. These cases have been collected in Ploss-Bartel's great work, *Das Weib*, and include a peasant in Arenas in New Andalusia (Al. v. Humboldt), an Ojibbaway Indian (Wenzel Gruber), and a Greek master shipbuilder (Ornstein). An analogous case in the animal world has not been demonstrated.

Taruffi includes in a special division of clinical hermaphrodism urethro-genital deformities which often give rise to doubts as to the sex of human beings and animals. On the one hand, men with a divided scrotum cryptorchis and a small hypospadic penis may be mistaken for women, and, on the other hand, a large clitoris may simulate a male penis. Many such cases are illustrated in veterinary journals, and attested by the original specimens, which though called pseudo-hermaphrodites are merely deformities caused by hypospadias.

In all the phenomena hitherto described as anatomical and clinical hermaphrodism, analogous examples may be found in men and animals.

In one matter, however, man has a monopoly which is hardly creditable to himself, namely, in what is known as sexual perversion. Actual homo-sexuals (Krafft-Ebing) appear not to exist among animals. The attempts of dogs with dogs and cows with cows are not due to any inveterate, inborn homo-sexuality, but merely to a foolish eroticism which disappears as soon as an opportunity for the natural exercise of the function occurs. It is very different with human homosexuals, who are mostly so from birth. And here again we must distinguish true homo-sexuality from the irregularities of blasé wastrels. Normal thought and feeling cannot explain how a man can choose another man for active sexual action, or a woman passively submit herself to another woman. But when a man with female instincts submits to another man, or a woman with male instincts chooses another woman to satisfy her desires, Taruffi is entirely right in regarding this as psychical hermaphrodism, as these abnormalities can only be explained by supposing that the opposite sexual powers have remained present in a latent form.

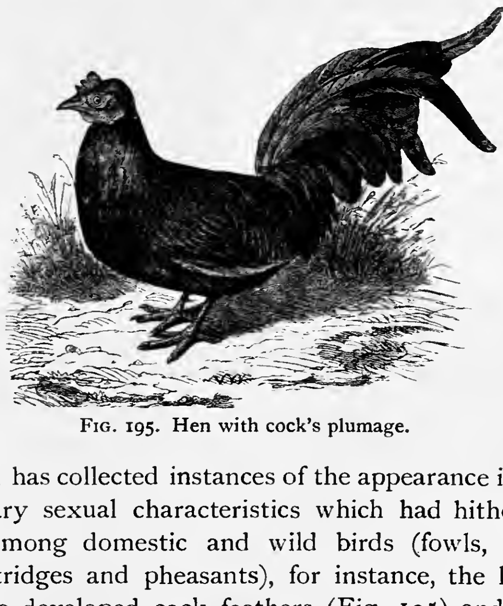


Fig. 195. Hen with cock's plumage.

Darwin has collected instances of the appearance in animals of secondary sexual characteristics which had hitherto been latent. Among domestic and wild birds (fowls, peacocks, ducks, partridges and pheasants), for instance, the hens have after a time developed cock feathers (Fig. 195) and behaved like the cock birds. In the same way does from some cause which has aroused the latent male potentiality have developed antlers.[1] Males have also assumed female characteristics, as among domestic fowls when the cocks sometimes take the appearance and manner of hens.[2]

[1] Darwin, *loc. cit.*, iv., p. 58. [2] *Ibid.*, iii., p. 280.

Tailed people do not exist, though they were supposed to till quite recently. Instances of men with tails occur, however, owing to developmental errors during fœtal life (Fig. 196). Virchow thought that this could only be considered as a reversion to an animal type when there could be shown to be an actual increase in the length of the spine. He did not consider every case in which the terminal portion of the spine and its coverings were free as reversions, still less the tails composed of soft parts only which he compared to stumps of tails. Bartels, Wiedersheim and Ornstein explain their origin differently. Since embryologists admit that man has descended from ancestors who had free tails, the tails, often 12·5 cm. long (nearly 5 inches), consisting of connective tissue, fat and blood vessels, can only be explained as a prolongation of the so-called tail-fibres, and the large overgrown vertebral tail consisting of a joint-like elongation of the caudal spine must be regarded as a reversion. Man is not the only animal in which these reversions occur; they have also been observed in the *Inuus ecandatus*, the gorilla, the orang and the chimpanzee.

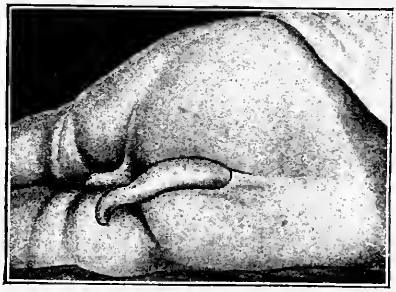


FIG. 196. Tail on a boy, six months old. (Granville Harrison.)

(*c*) Deformities due to supernumerary parts are usually noticed in an increase in the number of the fingers, toes, vertebræ, ribs, breasts, teeth and jaws, but also occur in the internal parts such as the tongue, spleen, etc. Supernumerary fingers are the most common (Fig. 197), supernumerary toes being next, and almost as frequent. There may be only a small appendage covered with skin but without bones, or a proper finger with the normal number of phalanges. Usually one digit only (a thumb or little finger) is present, but the number of supernumerary digits may amount to a complete double set. In accordance with the law of correlation, both hands and both feet are equally deformed, and the malformation is hereditary and is present in several generations. Ac-

PLATE IV.

Deformities.

Fig. b.

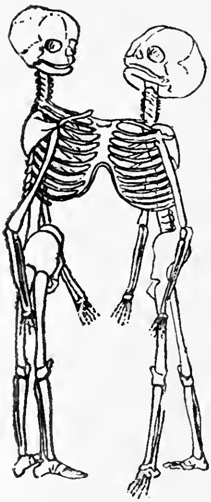


Fig. a.

Fig. c.

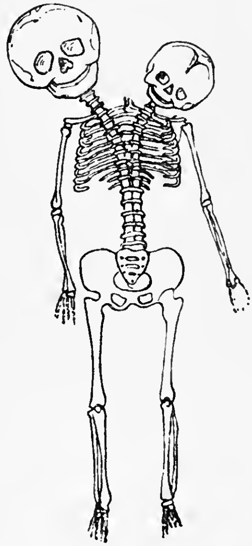


Fig. e.

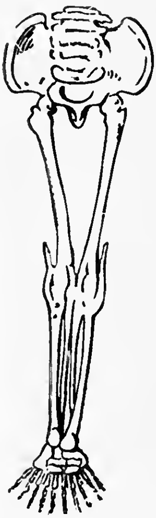


Fig. d.

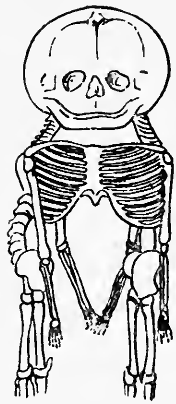


Fig. f.

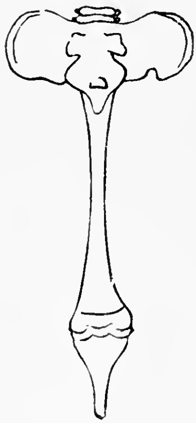
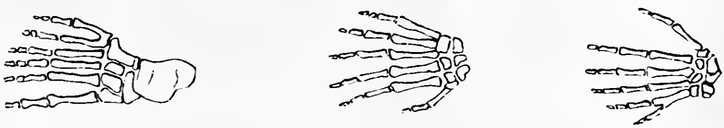


Fig. a, The fused twin Helen and Judith. Fig. b, Fusion at sternum. Fig. c, Two heads and fusion of trunk. Fig. d, One head and two bodies. Figs. e and f, Fusion of lower limbs. (Ranke, *Der Mensch*.)

cording to Darwin's investigations, the deformities are not confined to Europeans but occur in negroes and other races. In animals with four toes on their fore-feet, a fifth supernumerary toe has often been observed; the deformity is still more common on the posterior extremities. Dorking fowls have five claws on their feet; dogs and cats, the large newt and the frog are often seen to have six toes on their hind-feet.[1]

Supernumerary breasts are not uncommon in women. They are generally symmetrically placed, but may occur irregularly on any part of the body, *e.g.*, the shoulder, thigh or axilla. They frequently secrete milk.[2] In domestic animals' supernumerary udders the cause is found in the abnormal activity of two usually rudimentary teats; Darwin quotes instances of a sheep with four, and a cow with six teats.

Another form of this kind of deformity is seen in "mon-



c b a

FIG. 197. Supernumerary digits. a and b, in the hand; c, in the foot. (Ranke.)

sters," which are produced by the division, or duplication, of the primary layers of cells. They occur both in men and animals, and when they survive are exhibited in shows, and when incapable of survival find their way into museums of pathological anatomy. The division may begin either at the cephalic or caudal end of the embryo, or at both simultaneously. This explanation is recent; formerly it was supposed that double monsters arose from the junction of two originally separate embryos, developed from separate ova. If the division begins at the cephalic end, monsters are produced with two heads, two faces or two heads and two thoraces (Plate IV., fig. c); or with two heads and bodies and four lower extremities, double men only united by the sacrum and rectum (Plate IV., fig. a). When the division begins at the caudal end, either a monster with double lower limbs is formed, with two pelves

[1] Darwin, *loc. cit.*, iv., p. 14. [2] *Ibid.*, iv., p. 65.

and genital organs, a single body and head (Plate IV., fig. d), or the so-called "Janus-head" is produced. In this monster the lower part of the body is double, and the two heads, necks and breasts are conjoined. Lastly, a completely double body may occur and the heads only be conjoined either by the temples, occiput or forehead. When division begins from both ends of the embryo, the monster often lives and is seen in exhibitions. They are united only by the thorax or abdomen (Plate IV:, fig. b). The union may extend to the neck and jaw; in other cases there is a single backbone; finally, there are cases in which as a result of cell-division, a stunted

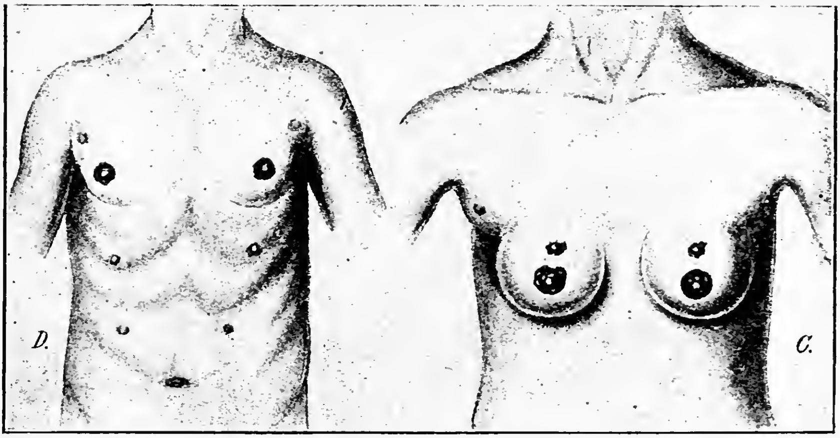


Fig. 198. Supernumerary milk glands. C, in a Japanese female; D, in a Baden soldier.

individual incapable of separate existence is attached to the epigastrium of another, or is enclosed in his abdominal cavity.

Calves and other domestic animals with two separate heads, two faces, "Janus-heads," limbs growing out of their backs and similar double monsters are not infrequent. They also occur in wild animals. Hunter and others have observed lizards with two tails and Lereboullet has carefully studied fifteen cases of fishes in which the gradual union of two previously separate heads has given rise to a double-headed monster.[1]

(*d*) Excessive development of hair on the face or body combined with poor development of the teeth is a rare

[1] Darwin, *loc. cit.*, iv., p. 386.

monstrosity, and is peculiar to man, owing to the fact that he is usually hairless except in certain regions (Fig. 199). This monstrosity is always considered most remarkable, especially as it is hereditary.

Darwin mentions a Siamese family in which the face and body were covered with long hair in three successive generations.[1] In another case in a Burmese man the face and the entire body, with the exception of the hands and feet, were covered with fine silky hair which on the back reached a length of five inches. Only the incisor teeth were present. One of his daughters had the same peculiarity, and her appearance was even more singular, as the nose was covered with thick soft hair.

Fig. 199. Russian hairy man. (Ranke.)

Fig. 200. Julia Pastrana. (After Haeckel.)

The family of the Russian hairy man were similar in appearance, their faces, which were completely covered with hair, resembled that of a poodle or Skye terrier. The most celebrated instance was the Spanish dancer Julia Pastrana (Fig. 200). The whole of her face was covered with hair as was also her chest; she had a beard and a double irregular row of teeth in both the upper and lower jaws.

The face of the fœtus is covered throughout with downy hair, which during the fifth month is longer than that on the head. Darwin, therefore, is inclined to consider the hairy man as a reversion, that is to say, a persistence of the embryonic condition.

[1] Darwin, *loc. cit.*, iv., p. 4.

II. Special Pathology and Pathological Anatomy.

In the foregoing pages the outlines of general human and animal pathology and of pathological anatomy have been described. Special pathology and pathological anatomy will now be dealt with and similarly compared; we shall see in what way man occupies a special position, and in what way he resembles other animals.

In order to make our survey clearer, internal pathological conditions will be divided into infectious and non-infectious diseases, and these again subdivided. This will be followed by a short comparative description of surgical diseases, of diseases of the eye, nose and ear, and finally by an account of comparative obstetrics.

1. Internal Diseases.

(*a*) Infectious Diseases.[1]

Cholera, the organism of which was described by Koch in 1883 (Plate V., fig. 1), is only seen primarily in man. Spontaneous cases do not occur among animals. The cases of a chimpanzee and other animals in the Zoological Gardens of Antwerp and Amsterdam, which were reported by M. Schmidt during the cholera epidemic in those towns of 1830 and 1831, cannot be regarded as genuine merely because the animals exhibited choleraic symptoms. Watery stools, vomiting, thirst, dry lips, bluish colour and coldness of the skin, and a small and very rapid pulse are symptoms which may be set up simply by acute intestinal catarrh.

Experimentally, however, the majority of animals can be infected by injections of human cholera stools or by pure cultures. Guinea-pigs are especially susceptible. The animals exhibit symptoms absolutely similar to those seen in man, and *post-mortem* show the characteristic reddening and loss of epithelium in the intestine (Marx).

[1] Friedberger und Fröhner, *Spez. Pathologie der Haussäugetiere*, 5th edition. Stuttgart: F. Enke, 1900. Marx, *Experimentelle Diagnostik, Serumtherapie und Prophylaxe der Infectionskrankheiten*. Berlin: A. Hirschwald, 1902. Schmidt, M., *Zoologisehe Klinik*. Berlin: Hirschwald, 1870, vol. i.; 1872, vol. ii.

The same is true of enteric fever (Plate V., fig. 2), with a few minor differences. It is a disease originally peculiar to man, which does not primarily occur in animals.

On the other hand, most experimental animals are susceptible to this disease. But the characteristic typhoid symptoms are absent, and at the autopsy, except in the case of apes,[1] the typhoid ulceration is not found in the small intestine. The animals simply die of typhoid septicæmia (Marx).

Fowl typhoid or fowl cholera is a disease which is never communicated to man, but at certain times numbers of fowls and other birds die of it. Infection with the short non-motile bacillus produces profuse diarrhœa, rapidly increasing weakness and cramps.

In contrast to cholera and enteric fever plague does not attack man only, but also primarily affects other warm-blooded animals, including apes, rats and mice. Birds, horses, cows, sheep and goats are quite insusceptible to the bacillus discovered in 1894 by Kitasato and Yersin. These animals are, however, susceptible to the poisons contained in the bodies of the bacilli; recently it has been discovered that fleas and flies may become fatally infected, apparently from rats. If the skin of a guinea-pig is artificially infected with the plague bacillus, pustules containing the organism form on the skin and the animal dies; hæmorrhagic œdema of the subcutaneous tissue takes place, and the lymphatic glands are considerably enlarged (Marx).

The bacillus of tuberculosis, first discovered and investigated in pure culture by R. Koch, is not only pathogenic for man, but also for guinea-pigs, rabbits, rats and dogs. According to M. Schmidt, it is the most frequent cause of death among the apes and large felidæ in the Zoological Gardens, whereas bears and the smaller beasts of prey are less frequently attacked. The only distinction between man and these animals is that in the latter tubercles are not formed in the viscera, though they are loaded with tubercle bacilli and undergo finally the same destructive process.

Fowl tubercle and bovine tubercle are somewhat specific, although there is no doubt that all these kinds arise from a

[1] Grünbaum, *B. M. Journal*, 1905.

common stem (Marx), and may be grown on suitable media at 37°-38° C., although the optimum temperature is 40°-41° C.

Cultures are somewhat slimy in character and cannot be inoculated into guinea-pigs. As yet it has not been found possible to convert fowl tubercle into mammalian tubercle or human into bovine tubercle by experimental methods. Koch indeed considers that the transmission of human tubercle to cattle has been shown to be impossible.[1] Cattle may become immune to infection with human tubercle without any apparent illness.

The "Perlsucht" of cattle arises from another bacillus, very closely related to the human, and is not, as Behring states, identical with the latter.[2]

A pathogenic bacillus closely related to that of tuberculosis is the bacillus of leprosy (Plate V., fig. 3), although numerous researches and experiments have shown marked differences between the two diseases. It is a remarkable fact that the bacillus of leprosy cannot be cultivated, and a still more remarkable one that it occurs almost exclusively in human epithelial cells. The main point of difference consists in the fact that leprosy is an exclusively human ailment and has never been communicated to animals.

The bacillus of diphtheria discovered by Klebs in 1883, and Loeffler in 1884, in addition to man attacks both cats and horses, and, according to Schmidt, apes may also be infected, though spontaneous infection in these animals is rare. On the other hand, all mammals, with the exception of rats and mice, and also fowls and pigeons, may be artificially infected. When guinea-pigs are infected the lymphatic glands are enlarged, the animals become weak and cyanosed and die of suffocation. The *post-mortem* appearances are similar to those seen in man, *viz.*, hæmorrhages, œdema, serous effusion into the pleura, pericardium and peritoneal cavity, and considerable engorge-

[1] The possibility of such an infection was proved at the Imperial Society of Hygiene in 1905.

[2] Dr. Paul Bartels has brought forward interesting evidence before the German Anthropological Society at Görlitz (1906), showing that tuberculosis has been one of the deadliest enemies of man from the earliest times. In a neolithic grave, together with tools, he found human vertebræ showing clear signs of tuberculous disease which had healed, leaving an "angular curvature".

ment of the internal organs. The proper fowl diphtheria differs from the human variety, and is caused by a special bacillus of a different type.

The bacillus which gives rise to lockjaw or tetanus primarily attacks many mammals; it is, however, specially dangerous to all kinds of horses; it may be conveyed by infection to other mammals, especially guinea-pigs and rodents, whereas fowls are nearly insusceptible to the tetanus poison. Cases occurring spontaneously, or due to artificial infection, exhibit the same symptoms, *viz.*, muscular contractions, gradually increasing in severity, till life eventually becomes extinct owing to paralysis of the respiratory muscles; these phenomena also occur in man.

The causal organism of influenza was long sought for and eventually discovered by Pfeiffer in 1893 (Plate V., fig. 4). Man alone is attacked during any epidemic, and it was long thought that animals could not be artificially infected. Pfeiffer, however, has succeeded in conveying the disease to apes. The influenza ("Pink-eye") in horses is not identical with the human disease, and is caused by a different organism.

Whooping cough, not only in its symptoms, but also in its almost absolute limitation to man, resembles influenza most nearly. It has not been determined whether the short thick bacillus described by Jochmann and Krause is the actual cause of this disease.

As long ago as 1873 the spirillum discovered by Obermeier was recognised as the cause of relapsing fever (Plate V., fig. 5). Tictin discovered that the transmission of the spirillum, and with it of the disease, from man to man took place by means of the bed bug, and that apes could be infected by crushed bugs.

As far as is now known spontaneous cases occur only in man; even fowls are not attacked, though whole nests of bugs are often found in fowl-yards; we must conclude from this that relapsing fever is peculiar to man, and that when bugs attack and infect fowls, they are immune to the spirillum. R. Koch reported on his return from German East Africa that African relapsing fever was only a variety of the European, and was caused by a spirillum of rather larger size. He charged a kind of tick (ornithodorus monbata) with being the carrier of the infection; as this is found on rats and apes it is possible that these animals also are infected, as well as man. This would form an important distinction between the African and European recurrent fevers.

All the diseases hitherto described have been caused by bacilli. Pneumonia illustrates the transition from the bacillary to the coccal form of organism, as both the bacillus of Friedlænder and the coccus of Frænkel play a part in its causation (Plate V., figs. 6 and 7). Inflammation of the lungs caused entirely by the bacillus only occurs in man. Artificial infections have a marked effect only in mice and guinea-pigs; rabbits are immune. The pneumococcus, on the other hand, gives rise to spontaneous attacks not only in man but also very frequently in animals; in all cases of artificial infection the appearances in the lungs and other organs are similar to those found in man.

We will now pass on to the description of the remaining diseases caused by cocci, of which we may remark that their influences both locally on the tissues and generally on life and health is the same in man and in the other animals. The danger to life is less with the staphylococci which produce pus; both in man and animals, and in the latter also under experimental conditions, pus formation, abscesses and boils are produced. Streptococci are more dangerous, not only on account of their tendency to increase in the body of the patient, but also on account of their power to set up erysipelatous inflammations, and so to produce general blood-poisoning, or sepsis. As regards this there is no difference between man and other animals.

Malta fever is a disease peculiar to man, and commonly observed among the inhabitants of Malta. The cause of the disease had been vainly sought for some time, when Bruce in 1896 discovered and described the coccus Melitensis (Plate V., fig. 8). Recent investigations by the English Commission has shown that the goat acts as a carrier of the organism, and through its milk transmits the disease to man. Inoculation experiments with cultures of this coccus produce in monkeys (and in these animals only) a fatal disease showing the same symptoms as that in man.

Acute articular rheumatism and meningitis are diseases caused by cocci in combination with some other agent. In

PLATE V.

Bacteria, cocci and amœba primarily pathogenic for man.

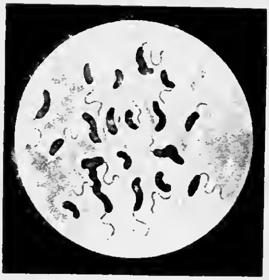


FIG. 1.
Cholera bacilli.
Lehmann and Neumann's
Atlas.)

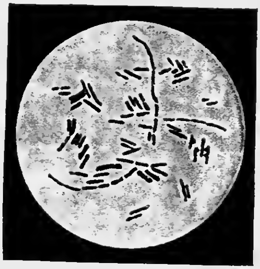


FIG. 2.
Typhoid bacilli.
(Lehmann and Neumann's
Atlas.)

FIG. 3.
Leprosy bacilli.
(Lehmann and Neumann's
Atlas.)

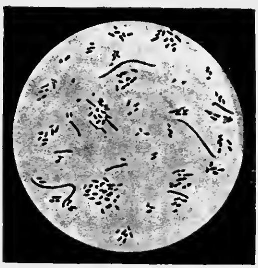


FIG. 4.
Influenza bacilli.
(Lehmann and Neumann's
Atlas.)

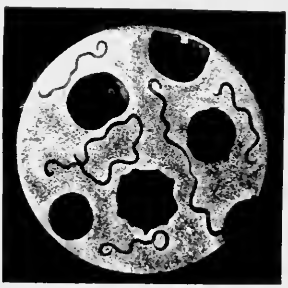


FIG. 5.
Spirilla of relapsing fever.
(Lehmann and Neumann's
Atlas.)

FIG. 6.
Pneumo bacilli.
(Lehmann and Neumann's
Atlas.)

PLATE Va.

Bacteria, cocci and amœba primarily pathogenic for man.

Fig. 7.
Pneumo cocci.
(Lehmann and Neumann's
Atlas.)

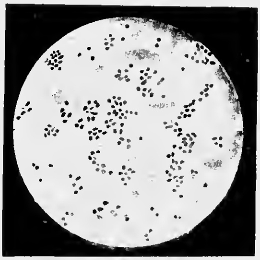


Fig. 8.
Cocci of Malta fever.
(Lehmann and Neumann's
Atlas.)

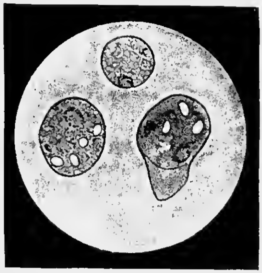


Fig. 9.
Amœba of dysentery.
(Lehmann and Neumann's
Atlas.)

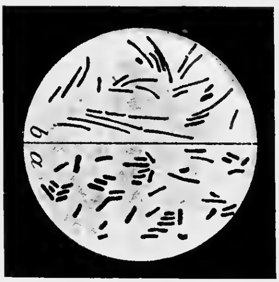


Fig. 10.
Bacteria of dysentery.
(Lehmann and Neumann's
Atlas.)

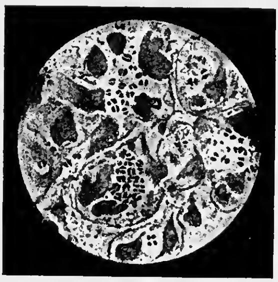


Fig. 11.
Gonococci.
(Lehmann and Neumann's
Atlas.)

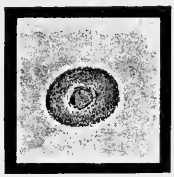


Fig. 12.
Parasite of tertian fever.
(Lehmann and Neumann's
Atlas.)

acute rheumatism, pneumococci, meningococci and streptococci occur as well as staphylococci, while some observers describe a micrococcus rheumaticus as the precise causal agent of acute rheumatism. Besides man, cows, and less frequently, dogs, goats, pigs and horses, may be spontaneously attacked.

Septic and pyæmic arthritis are frequently seen in calves and foals. Experimentally, the usual laboratory animals are all susceptible.

Meningitis, which has recently again become epidemic, is due, like acute rheumatism, not merely to one micro-organism, but to many. Recent investigations point to the meningococcus and the pneumococcus as the most frequent cause of meningitis in man, horses, sheep, cattle, goats and dogs. Naturally occurring cases are usually produced by the meningococcus, but, curiously enough, mice and guinea-pigs do not die under experimental conditions unless this organism is injected into the peritoneal cavity, and other animals appear to be quite insusceptible (Marx).

Dysentery is among the diseases the pathological appearances of which may be produced by more than one micro-organism. The amœba discovered by Lösch and a bacillus may both produce this disease (Plate V., figs. 9 and 10). Dysentery is a disease peculiar to man, spontaneous cases not having hitherto been observed in animals; it is only after the injection of very large quantities of amœbæ, or bacilli, that the characteristic lesions can be produced in the large intestine of cats, rabbits, guinea-pigs and mice.

Venereal diseases are also peculiar to man. No spontaneous cases of gonorrhœa, soft sores or lues have been observed in animals. Experimental inoculation of cultures of gonococcus in animals produces suppuration in the mucous membranes but no true gonorrhœa (Plate V., fig. 11). In 1902 Marx declared that all attempts at inoculating lues into animals (even monkeys) had ended in failure. Since then, however, other results have been obtained. At the fifth International Congress of Dermatology in 1904 Van Niessen mentioned pure cultures with which he stated that he had produced symptoms analogous to those of human syphilis in monkeys, pigs and horses.[1] Quite recently

[1] Confirmed by Finger und Landsteiner, "Untersuch. ueber die Syphilis der Affen," *Akad. d. Wissensch. in Wien*, 14, 1905.

John Siegel of Berlin, who regards syphilis as closely allied to the acute exanthemata, found a microscopic protozoon belonging to the flagellates which he considered as the exciting cause; he traced its development from the early stages by means of a special culture medium of the blood of syphilitic men and rabbits; and finally he produced iritis and other syphilitic lesions in other animals, although he admitted that all previous cultural experiments had failed.[1]

Metchnikoff and others have now established the transmissibility of syphilis to apes by means of dermal inoculations, and a blood reaction for syphilis has been worked out by Wasserman. These results may prove of great importance for the prophylaxis of the disease in man.

The biology of the acute exanthemata is still very obscure, and will require much more laborious investigation for their elucidation. According to references in the earlier literature collected by M. Schmidt, monkeys as well as man can be primarily infected with small-pox. Thus, in an epidemic of small-pox in Trinidad (1858), the wild monkeys were attacked, and in the year 1841 a traveller in a forest on the way to David (Chiriqui) saw monkeys suffering from small-pox which four or five days later broke out in David. Except for these isolated reports, small-pox has always been regarded as a purely human disease. Since, however, it has been recently shown that small-pox can indubitably be conveyed to calves, and vaccine pustules be produced in man by inoculation from this material, the identity of cow-pox and small-pox seems fully established.

The remaining acute exanthemata, namely, measles, rubeola, chicken-pox and typhus fever, are absolutely specific for man, all attempts at infecting animals having produced negative results. Human typhus is not identical with the petechial fever in horses and cattle. For none of these four very elusive diseases has any causal organism been found, although certain protozoon-like forms have been observed in small-pox, and their connection with the disease more or less established.

[1] Apparently the Spirochæte pallida (a species of protozoon) discovered by Schaudinn and described as the specific cause of syphilis is only a modified form of the round protozoon described by Siegel.

Siegel, J., "Untersuch. über die Aetiologie der Pocken, und der Syphilis," *Med. Klinik*, 1905, No. 18, p. 446.

Scarlet fever, which has always been regarded as peculiar to man, appears from the observations of Siegel, previously referred to, to be an exception. He describes a protozoon similar to that of syphilis as the exciting cause of the disease.

Diseases which are originally confined to animals, but which may easily be transferred to man, are anthrax, glanders, rabies and foot-and-mouth disease, which must be included among the acute exanthemata.

Anthrax, the spore-bearing bacillus of which was described by Koch, is communicated to man partly by the blood of infected animals being inoculated through cracks in the skin, and partly by inhaling the dried bacilli and spores with the dust from hides and wool. Symptomatic anthrax, which occurs in cattle, sheep, goats, and occasionally in horses and pigs, is not identical with true anthrax.

Glanders is caused by the bacillus Mallei (Löffler) and occurs primarily in horses, donkeys and goats. It is very infectious for man, and also experimentally for guinea-pigs, cats, hedgehogs, rabbits and field mice.

The cause of rabies has not yet been isolated ; it is primarily seen in wolves, foxes and dogs, though man and all domestic animals may be secondarily infected, nearly always directly through a bite.

Foot-and-mouth disease is transmitted from cattle not only to sheep, horses, pigs, cats, goats and dogs, but also to man, frequently through the use of milk from an infected cow. Siegel states that the exciting cause is a protozoon.

A peculiar disease, hitherto only observed in parrots in captivity, though occasionally transmitted to man, is that known as psittacosis. The birds are attacked with diarrhœa, become extremely weak and somnolent, and die after a short time. Nocard found a special bacillus as the cause of this disease. In the years 1892-97 there were seventy cases in man recorded, and since then two others have occurred, namely, those of the owner of a sick parrot, who died with symptoms of a severe broncho-pneumonia, the bacillus of Nocard being recognised by the serum test. His wife succumbed to a similar attack.

Finally, actinomycosis in cattle must be noted as an animal disease. Since Israel's communications in 1878 it has been known that this disease is caused by a ray fungus (Actinomyces bovis), and that it is not infrequently communicated to man, especially to agricultural labourers whose teeth are carious. The grains of corn in which the fungus is contained become lodged between the teeth. The skin, both in man and in cattle, becomes undermined and there is a spreading suppuration.

The power of producing suppuration and abscesses is also possessed by another streptothrix, that producing the Madura-foot, and also by the streptothrix of Eppinger, which, however, also produces in rabbits and guinea-pigs secondary multiple abscesses and suppuration in the bronchial and supraclavicular glands.

The three forms of malaria (Tertian, Quartan and Autumno-Æstival) represent a disease conveyed by mosquitoes, which is characterised by the destruction of the red blood cells and is only of importance in man (Plate V., fig. 12). Primary disease in mammals, such as proves fatal to man, has not been observed, although certain other animals are stung by the female Anopheles. Secondary infection from man to other animals is ineffective according to R. Koch. On the other hand, according to Friedberger and Fröhner, cattle, horses and dogs suffer from diseases similar to malaria both in Africa and Italy.[1] No microscopical researches have as yet been published on this point. Possibly these diseases which resemble malaria are identical with the dog's disease described by Dr. Sigmund Taussig in Herzegovina, as endemic gastric catarrh accompanied by fever.[2] According to more recent reports (C. Steiner) this disease is a local mosquito fever, from which many persons and also domestic animals of all kinds suffer during the summer months. It is set up by the sting of a mosquito (Culex pipiens).[3]

The Trypanosoma Ugandense (Castellani) is the asexual generation of a flagellate protozoon; it reaches the blood of the negro (and also as has recently been shown of the European)

[1] Friedberger und Fröhner, *loc. cit.*, ii., p. 732.

[2] Taussig, *Wiener Klin. Wochenschr.*, 1905, 6 and 7.

[3] Steiner, *Wiener Klin. Rundschau*, 18, 65.

through the sting of the tsetse fly (Glossina palpalis); there it undergoes a change and multiplies, setting up the fatal "sleeping sickness". In monkeys which have been secondarily infected with the blood or cerebro-spinal fluid of these patients, the disease takes the same course. Dogs and rats are only infected with difficulty; donkeys, oxen, goats, sheep and guinea-pigs have so far appeared insusceptible.

Another kind of tsetse fly (Gossina morsitans) stings horses and cattle, infects them with the Trypanosoma Brucei, and thus produces the dreaded Nagana, which has never been communicated to man. It is analogous to the Surra of India and the Mal de Caderas of South America.

Since the bacillus icteroides described by Sanarelli in 1897 has ceased to be regarded as the cause of yellow fever, evidence has accumulated to show that this disease is due to the sting of a mosquito (Stegomya fasciata) whereby an incredibly small protozoon is introduced into the body. The death of Walter Meyers was attributed in England to his having been stung by mosquitoes which had settled on yellow fever patients; and more recent researches have confirmed the correctness of this view. Yellow fever has always been regarded as a disease only occurring in man, but according to Friedberger and Fröhner horses and dogs are also attacked.[1]

At the close of this chapter on the infectious diseases, malignant new growths, carcinoma and sarcoma may also be mentioned, as a number of investigators in all countries (*e.g.*, v. Leyden) take the view that they are caused by a parasitic inoculation and by the growth of an infective agent. We cannot here enter into the pros and cons of this view; still less can we describe the numerous cancer parasites discovered by various investigators. For our present purpose it is enough to state that dogs, horses, cattle, mice, and even salt-water fishes, are subject to malignant new growths, as well as man; that the tendency towards it at any rate is hereditary, and that it is possible to inoculate an animal with cancer, or to transplant it from one animal to another of the same species.

As we have seen, a large series of infectious diseases are peculiar to man, and are only primarily seen in him, namely,

[1] Friedberger und Fröhner, *loc. cit.*, ii., p. 737.

cholera, enteric, leprosy, influenza, whooping cough, relapsing fever, inflammation of the lungs, dysentery, gonorrhœa, soft sore, lues, measles, rubeola, chicken-pox, typhus, scarlet fever, Madura-foot, Malta fever, the various forms of malaria and sleeping sickness.

All other infectious diseases are common to man and animals, or the latter are altogether immune. Man, on the other hand, is immune to certain animal infections, *e.g.*, swine erysipelas, swine fever, rinderpest, fowl, cholera, etc.

Between the different races of men there exists a considerable difference in relative, or absolute, immunity against certain infections.

No race is immune to cholera; it is most fatal among negroes. In the same way enteric, bubonic plague, tuberculosis and diphtheria attack all men alike. The Malagese, the South African negro races, and also the inhabitants of Iceland and Greenland are almost entirely immune to syphilis. Only negroes and Mongolians possess an immunity against yellow fever; negroes lose their immunity little by little from childhood upwards, if, after a journey into the north of the United States, they return into the yellow fever zone. No race is immune against the acute exanthemata; negroes are most sensitive to small-pox. Finally, if cancer is to be included among the infectious diseases, we must conclude that in Tunis and Abyssinia, where it is less known, that the people are completely immune to it, and that this immunity is passed on from one generation to another.

The general question of immunity, its hereditary transmission, and the part it plays in the life-histories of men and animals, has been very clearly dealt with by Grober.[1] The great change in the intensity of contagious diseases, their gradual loss of virulence, and often their complete extinction, is a phenomenon which may be explained from various points of view. Bacteriologists are inclined to attribute it to loss of virulence in the exciting cause; clinicians think either that the sensitive individuals may have died out, or assume a congenital or acquired immunity for the survivors, as for example, with plague, cholera and influenza. The occurrence of immunity is attri-

[1] J. Grober, "Die Vererbung der Immunität," *Med. Klinik*, 1905, 18, p. 429.

buted by Metchnikoff mainly to the leucocytes, which in all human and animal bodies act as sentinels and destroy any harmful matter which invades them. Buchner talks of alexines, and many other writers of various specific "anti-bodies". All, however, agree that there are two sorts of immunity, (1) an active immunity acquired after passing through an attack of the disease, and (2) a passive immunity gained by the transference of the active and acquired protective substance to a second and previously healthy body, in order to guard it against some definite disease. Obviously, hereditary immunity can only be passive; according to Ehrlich the transmission of the protective substance does not take place either in the ovum or spermatozoon, but only by means of the placenta and the milk of the mother. He does not consider that either of these methods of transmission clearly indicate a definitely hereditary immunity. As, however, the question of acquired immunity is not finally settled, Grober thinks it probable that certain variations are present in the germ cells which lead to the development of special powers or tendencies.

(β) Non-Infectious Diseases.

Diseases due to animal parasites naturally come next to the infectious, for parasitic animals maintain their existence at the expense of the human organism, and partially secrete poisonous substances, such as occur in the infectious diseases. The difference is that the parasite produces local more than general disease.

Internal Parasites.—Of parasitic nematodes only the following are peculiar to man:—

Oxyuris vermicularis (Plate VI., fig. 1); Trichocephalus dispar (Plate VI., fig. 2); the rare Filaria labialis of Pane (Plate VI., fig. 3); and the Filaria bronchialis (Plate VI., fig. 4); the Filaria loa of Guyot, which lives beneath the conjunctiva of the negroes on the Congo and Gabon; the Filaria lentis of Dies, which is sometimes found in lenses after removal (Plate VI., fig. 5); the Filaria sanguinis hominis, found in its embryonic condition in large numbers in the blood of man in the tropics of both the Old and New World (Plate VI., fig. 6), and two tiny varieties of Anquillula (A. stercoralis and A. intestinalis) found respectively in Cochin China and Italy.

The trematodes peculiar to man include the Distomum rathouisi, perhaps identical with D. crassum (Plate VII., fig. 7); the Distomum heterophyes, a rare suction-worm in Eastern Asia, once seen by v. Siebold in Egypt (Plate VII., fig. 1), and the Distomum ophthalmobium Dies once observed in the capsule of the lens of a child (Plate VII., fig. 2).

Tapeworms which inhabit man only in their adult form are Tænia saginata (mediocanellata), the tapeworm of diseased beef (Plate VII., fig. 3); the Tænia solium, from measly pork (Plate VII., fig. 4); the Tænia nana, found by Bilharz in Egypt (Plate VII., fig. 5); the Tænia flavopunctata, first discovered in America by Weinland (Plate VII., fig. 6), and the Tænia madagascarensis of Davaine.

Intestinal worms parasitic in various animals as well as in man are Ascaris lumbricoides; the common round worm which also infests the gorilla is common to all the races on earth; Ascaris mystax, commoner in dogs and cats, is also found in man; Trichina spiralis is found in men, swine, rats, mice, cats, martins and foxes. The Filaria medinensis occurs in man, dogs and horses in all the tropical regions of the Old World. Eustrongylus gigas occurs in man, dogs and horses; the small Strongylus duodenalis, which produces extreme anæmia in man, is also parasitic in the gorilla; Strongylus longevaginatus has been frequently observed in animals and seldom in man, and finally the Echinorhynchus hominis, which is usually parasitic in the larva of insects, has on a few occasions been found in man. Flukes living in man and various animals are Distoma hepaticum and Distoma lanceolatum; neither of these are peculiar to man but are more frequently found in sheep, cattle, rodents, pachyderms and marsupials; Distoma spathulatum occurs in man and cats in Eastern Asia; Distoma conjunctum occurs in man and in the liver of pariah dogs in India and Eastern Asia; Distoma pulmonale occurs in the lungs of men and of tigers in Eastern Asia.

Tapeworms are parasitic in man and in various animals. The eggs of Tænia cucumerina are transferred from the dog to the dog-louse, and thence into the bodies of those who keep dogs. Tænia echinococcus occurs in man, dogs, swine and herbivorous animals; Bothriocephalus latus, which is transferred from pike

PLATE VI.

Specific internal parasites of man.

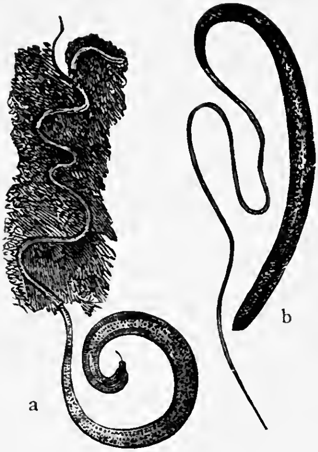


Fig. 2.
Trichocephalus dispar.
a, male, with the anterior part lying beneath the mucous membrane;
b, female.
(Leuckart, *Parasiten.*)

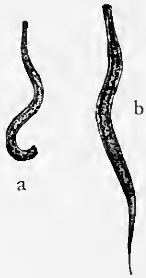


Fig. 1.
Oxyuris vermicularis.
(Five times enlarged.)
a, male; b, female.
(Leuckart, *Parasiten.*)

Fig. 3.
Filaria labialis.
(Enlarged.)
(Leuckart, *Parasiten.*)

Fig. 4.
Filaria bronchialis.
(Treutler.)

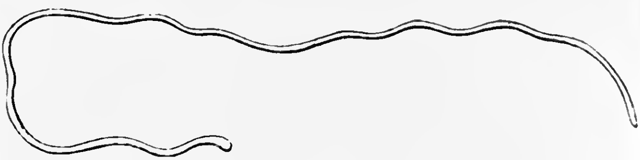


Fig. 5. Filaria lentis. (About 35 times enlarged.) (Ammon.)

PLATE VIa.

Specific internal parasites of man.

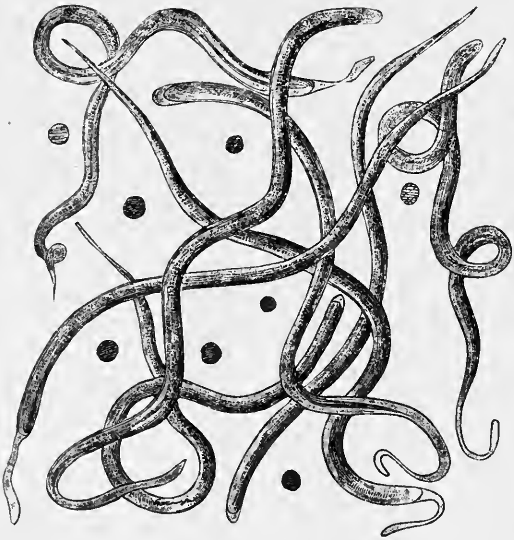


Fig. 6.
Filaria sanguinis hominis. (Lewis.)
(Leuckart, *Parasiten.*)

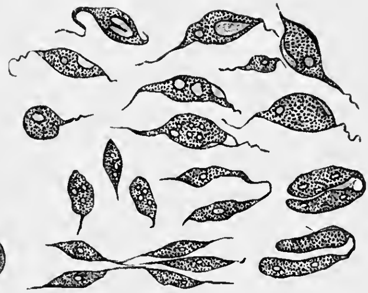


Fig. 7.
Cercomonas from the liver.
(After Lambl.)

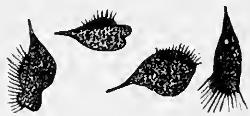


Fig. 8.
Trichomonas intestinalis.
(Zunker.)

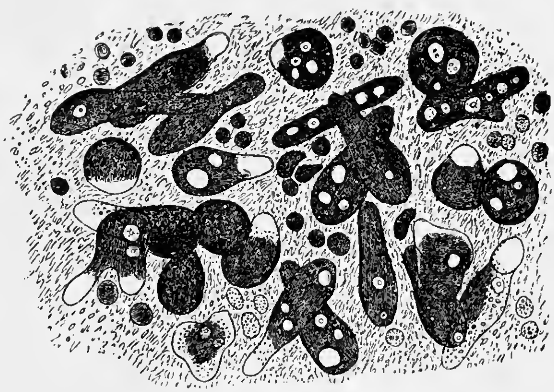


Fig. 9.
Amœba coli in intestinal mucus. (After Lösch.)
(Leuckart, *Parasiten.*)

PLATE VII.

Specific internal parasites of man.

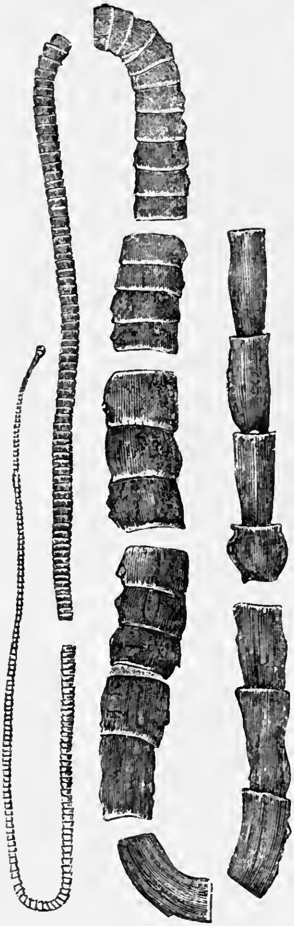


FIG. 3. (Natural size.)
Tænia saginata.
(Leuckart, *Parasiten.*)

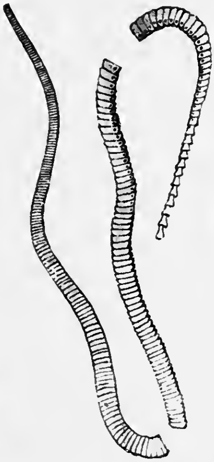


FIG. 6.
Tænia flavopunctata.
(Weinld.)
(Leuckart, *Parasiten.*)

FIG. 4.
(Enlarged.)
Head of Tænia
solium.
(Leuckart,
Parasiten.)

FIG. 7.
Distomum Rathouisi.
(Leuckart, *Parasiten.*)

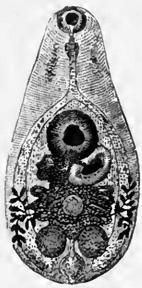


FIG. 1.
Distomum
heterophyes.
(v. Siebold.)

FIG. 5.
Tænia nana (18 times
enlarged).
(Leuckart, *Parasiten.*)

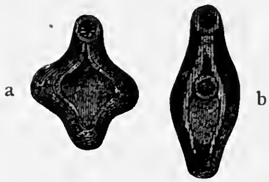


FIG. 2.
Distomum ophthalmicum.
(Ammon.)
a, contracted; b, extended.
(Leuckart, *Parasiten.*)

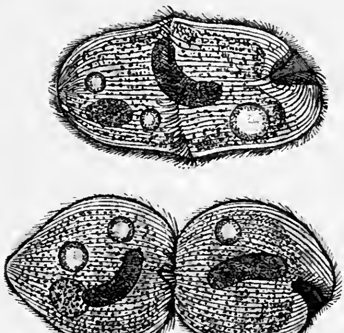


FIG. 8. (Enlarged.)
Balantidium coli.
In different stages of division.
(Leuckart, *Parasiten.*)

to man, dogs and cats; Bothriocephalus cristatus, which is seldom found in man, and is commonest in dogs in Northern Greenland.

Besides these worms, certain unicellular organisms are not infrequently observed as internal parasites in man. Thus among the Infusoria, Cercomonas intestinalis is found in the intestine in cases of cholera and diarrhœa (Plate VI., fig. 7); Trichomonas intestinalis in acute and chronic diarrhœa and also in typhoid (Plate VI., fig. 8); Balantidium coli in severe chronic affections of the intestine (Plate VII., fig. 8); Coccidium oviforme, a sporozoon, is often transferred to man from rodents, such as mice and rabbits. Amœba (A. coli) has been recognised by Lösch in the large intestine in men suffering from dysentery.

Very few external parasites are peculiar to man; the flea, Pulex irritans (Fig. 201); the head-louse, Pediculus capitis (Fig.

FIG. 201.
Flea.

FIG. 202.
Human head-louse.

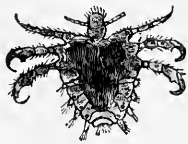


FIG. 203.
Crab-louse.

FIG. 204.
Bed bug.

202), found, according to Darwin, on various races in different parts of the world; the clothes-louse, Pediculus vestimentorum; the crab-louse, Pediculus pubis (Fig. 203); and the bed bug, Cimex lectuarius (Fig. 204).

Many other sorts of fleas may be transferred to man from dogs, cats, etc., but they soon leave his body.

Parasites not peculiar to man but found also upon other animals are the sand flea, Pulex penetrans, the Sarcoptes or Acarus scabiei (causing itch), which according to Ziegler also lives on horses and some sorts of sheep; the Macrogaster folliculorum, which is parasitic on the skin of man and of various animals (dogs, cats, swine, cattle and goats); and the sheep tick, Ixodes ricinus, which occasionally occurs as an unwelcome parasite on man, though common on dogs, cattle, sheep and wild animals.

Among vegetable parasites only three are undoubtedly peculiar to man, namely, the fungus of Pityriasis (tinea) versicolor, Microsporon furfur, the fungus of thrush, Oïdium (or Saccharomyces) albicans, and the fungus which is parasitic in gastric mucus, Sarcina ventriculi (Figs. 205, 206, 207).

The remainder occur also in animals, such as Microsporon Audouini (ringworm), Achorion Schönleini (favus), and the fungus of Tinea circinata, which is common to man, dogs and cats; and Trichophyton tonsurans, which produces the characteristic ringworm among men, cattle, dogs, horses, goats and cats.

Intoxications.

Seeing that there is a general physiological similarity between man and the remaining red-blooded animals, and

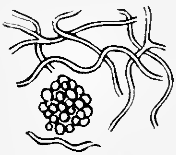


Fig. 205. Microsporon furfur.

Fig. 206. Oïdium albicans.

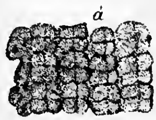


Fig. 207. Sarcina ventriculi.

especially with those which are warm blooded, it may very naturally be assumed that the poisons which are dangerous to man will also damage all Vertebrates, and to a greater degree the higher they stand in the zoological scale. Gradually acquired or inherited immunity may cause exceptions to this general rule. Reports on the action of various poisons are nearly all with reference to domestic animals, as for obvious reasons observations on wild animals are very few and far between. As regards the former class, Friedberger and Fröhner[1] have demonstrated their complete correspondence with man in the sphere of toxicology.

Among corrosive poisons, which act upon the skin and still

[1] Friedberger und Fröhner, *op. cit.*, Bd. i., p. 240.

more on the mucous membranes of man and other animals, the most important are the caustic alkalis (potash, soda, lime and ammonia), and the acids (oxalic, sulphuric, nitric and hydrochloric acids). Next come the poisonous metals, zinc, antimony, chromium, cobalt, copper and mercury with their salts, and the metalloids, iodine, phosphorus and arsenic. Among plants with an irritant action on the stomach and intestinal canal may be enumerated the following, which are among the most powerful of those indigenous in our soil: the autumn saffron, the spurge laurel, the yew, various kinds of spurge, the laburnum, the ranunculus, the larkspur, the aconite, and the poisonous fungi, etc. A sharp local inflammation, accompanied by severe general symptoms, are produced by poisons found in the bodies of certain kinds of melolonthae and the Spanish fly; here, too, may be classified the poison of the scorpions, the millepedes and the poisonous spiders. The poison discharged from the skin of the salamander, if taken internally, acts as an irritant, and even may prove fatal to small animals like dogs. The same thing occurs when concentrated formic acid is ejected from the poisons of wasps, hornets and bees in large quantities into men or animals. The poison leads not only to painful local symptoms, but to marked general intoxication.

Narcotic poisons, causing congestion of the brain, spinal cord, heart and lungs, are present in the poppy, deadly-nightshade, the black henbane, the honeysuckle, the thorn apple, tobacco, the red foxglove, the variegated hemlock, the water hemlock, cow-parsley, the darnel, the broom, the ergot, and in a less degree the chick pea, the edible pea, and the leaves of the potato.

An extremely powerful poison is that obtained from St. Ignatius' bean—strychnine. Here, too, may be mentioned prussic acid and the cyanides, alcohol and various gases, such as carbon dioxide and monoxide, ordinary coal gas, ammonia vapour, and sulphuretted hydrogen. All these narcotic poisons, when introduced in certain quantities, produce the same symptoms in animals as they do in man.

An equally close similarity of effect exists with regard to the hæmolytic snake poisons, though there are remarkable exceptions in the case of certain animals. Generally speaking, the smaller the body of the man or animal, and the fuller the poison sac has become through a prolonged period of activity, the sooner does a fatal result take place.

From the earliest times exceptions have been known to the general rule—cases in which men and animals were immune to animal poisons, and in which animals had become immune to vegetable poisons.[1] In the old authors (Ælianus, *Hist. Anim.*, lib. i., cap. 57; Celsus, v., 27; Plin., *Nat. Hist.*, vii., 2, etc.; Lucan, ix., v., 95 *et sqq.*) there is an account of a race, the Psylli, in Lybia, who were absolutely immune to snake bites. Pliny mentions another race, the Ophiogenes on the Hellespont, who were similarly immune, and moreover had the power of healing those who had been bitten by snakes, by means of their saliva.

The hedgehog is one of the animals possessing natural immunity to poisons. The naturalist Lenz states he has observed that the hedgehog is not affected by the bite of an adder, and can devour Spanish flies with the keenest appetite, and without coming to any harm; Brehm has confirmed this observation, and also mentions the Iltis and Mongoose (Herpestes javanicus) as champions who can receive many bites in their contests with snakes without being poisoned. The wasp buzzard (Pernis apivorus) is quite insensitive to the stings of wasps and bees, and so is the Edolius paradiseus, and the bee eater, Merops apiaster. The Batrachians react very variously to wasp and bee stings. While the ordinary pond frog avoids both bees and wasps, the grass frog is immune against bees but not against wasps; the toad, on the other hand, devours both with avidity and without damage to itself.

(γ) **Diseases of Special Organs.**

Most of the material available for a comparison between the internal diseases of man and animals is derived from the observations of veterinary surgeons upon domestic animals either during life or after death; for such diseases in wild animals can only occasionally be observed among the inhabitants of our zoological gardens. In this class of disease also we may note a far-reaching agreement between animals and man, dependent on the general

[1] Hopf, L., *Immunität und Immunisierung*. Tübingen, 1902, pp. 1-4.

similarity in the anatomical construction of man and the class of Vertebrates now under consideration.

Diseases of the Digestive Organs.—A glance through the veterinary text-books on special pathology, or through the mortality lists of the zoological gardens, reveals the same features, both in pathology and pathological anatomy, as may be seen in man. The mucous membrane of the mouth is subject to the same lesions both in man and in animals. Among the herbivora (horses, cattle, sheep) we find the same catarrhal and aphthous stomatitis, and in cats and dogs, and also in horses and cattle the same ulcerative processes as occur in the mouth of man. Mumps (an inflammation of the parotid gland of variable character) is not peculiar to man, but also occurs in dogs, cats, horses, cattle and goats. Suppurative parotitis has been observed in a leopard, and noma has been met with several times in apes (M. Schmidt). Actinomycosis of the parotid occurs in cattle, and sore throats similar to those seen in man may occasionally, but not commonly, be observed in horses and cattle. Diverticula and enlargements of the gullet are now and then observed in cattle; stenosis, lacerations, inflammation, paralysis and spasm are much more frequently seen in all domestic animals.

The descriptions of diseases of the stomach (acute and chronic catarrh) in horses, cattle, apes and beasts of prey, and of catarrh of the intestinal canal in apes, dogs, cats and pigs, might be taken straight from a work on human pathology or pathological anatomy. Horses, cattle, dogs and swine suffer from colic as do men; cattle suffer from ulceration of the stomach and intestines, and these and other domestic animals, and also wild cats, foxes and wolves, also suffer frequently from hæmorrhage from the stomach and intestines, and from inflammatory conditions due to various causes but not differing materially from those found in man. Schmidt has had the opportunity of observing an intussusception of the cæcum into the colon in a monkey, and in another a prolapse of the rectum.

To pass on to the diseases of the liver, catarrhal jaundice is frequently observed in dogs, hypertrophy and fatty liver in apes, parenchymatous inflammation and abscess in various domestic animals, acute yellow atrophy in sheep and horses, cirrhosis (not due to alcohol!) in horses, dogs, cats, cattle and swine, and cancer in dogs, horses and cattle. In all these conditions there is a complete similarity between animals and man.

The sole point in which man differs from other animals is that he suffers occasionally from movable liver.

All domestic animals, as well as the apes and smaller beasts of prey in menageries, like man suffer from acute peritonitis which frequently becomes chronic, and is due to both internal and external causes. These animals may also develop ascites as the result of disease of the liver, spleen, heart or lungs.

Diseases of the Organs of Respiration.—Horses, sheep, cattle, swine, dogs and cats may suffer from acute nasal catarrh which often becomes chronic. Epistaxis occurs in horses, especially after severe exertion, and tumours of all sorts, from mucous polypi to sarcoma and carcinoma, all frequent pathological findings in most of our domestic animals.

Dogs and horses, in which the organs of respiration are so important, are subject to acute and chronic laryngitis. Œdema of the glottis, a condition once observed in a jaguar by Schmidt, often occurs in horses. Acute and chronic bronchitis are frequently seen both in domestic animals (such as horses, dogs, cattle and sheep) and in apes and the smaller felidae and canidae in zoological gardens (M. Schmidt). Horses, cattle, sheep, swine, dogs and cats frequently suffer from catarrhal and interstitial pneumonia. Both in men and animals inflammation of the lungs may go on to gangrene. Hæmorrhage and emphysema are very common in horses and cattle.

Inflammation of the pleura with or without effusion into the pleural cavity, has the same etiology and course in animals as in man. The acute cases in apes, and in beasts of prey, are usually complications of pneumonia; the chronic cases in apes, dogs, sheep and horses end in chronic pulmonary disease, chiefly tuberculosis.

Hydrothorax may occur in horses, cattle, dogs and other animals owing to dropsy, and pneumothorax owing to other causes.

Diseases of the Circulatory Organs.—Inflammation of the pericardium, so frequently seen in man, is only common in domestic cattle. It is sometimes found *post-mortem* as the result of a tuberculous pleurisy in apes, and in the larger and smaller beasts of prey (Schmidt). Inflammation of the heart muscle, observed by Schmidt in tuberculous apes, is otherwise only seen in horses and cattle; this is also the case with acute endocarditis, which is rare in dogs, swine and other domestic animals. As in man, the nature of the lesion causes the acute endocarditis frequently to become chronic, setting up valvular defects; and on this again depends the final hypertrophy and dilatation of the heart which ensues. Concentric hypertrophy was seldom found by Schmidt in apes; excentric hypertrophy he found much commoner both in apes and in beasts of prey. Horses suffer from hypertrophy and dilatation, owing to the special demand for efficiency which is made upon their hearts; they share also with men the peculiarity of developing aortic aneurysms (though Schmidt found an aneurysm of the thoracic aorta in Cercopithecus pluto); cattle as well as horses may suffer from thrombosis with consequent gangrene or hæmorrhage.

If the spleen, owing to its blood-forming function, is considered as an annex to the circulatory system, we may here mention the acute enlargements which may occur in cattle and pigs, as in man, as the result of cirrhosis of the liver and portal obstruction.

On the other hand, the chronic enlargement associated with malaria and leuchæmia is peculiar to man. So is the rarer condition known as wandering, or movable, spleen; this, like the movable liver and kidneys, is apparently the result of the upright position.

Inflammation and abscess of the spleen, which are not infrequent in animals as the result of injuries, are among the rarest of pathological conditions in man.

Diseases of the Urogenital Organs.—Here, again, we find general consonance with the corresponding pathological processes in man. Acute (diffuse) inflammation of the kidney is a frequent disease in all domestic animals, such as horses, cattle and dogs; chronic (parenchymatous) inflammation, corresponding to Bright's disease in man, attacks cattle and horses, but rarely beasts of prey; in the latter, contusions and other traumatic lesions not infrequently set up inflammation of the capsule or pelvis of the kidney, and thus lead to interstitial nephritis, and the large accumulations of pus called pyonephrosis.

Schmidt observed that fatty degeneration of the kidneys has been found in a wolf, and atrophy of the kidney in a macaque (Inuus cynomolgus).

Inflammations of the pelvis of the kidney going on to suppuration (pyelitis) are usually caused, as in man, by the irritation of a calculus, or retained urine (dogs, horses, cattle).

Movable kidney, which is much more frequent, especially in women, than movable liver or spleen, does not appear to have ever been observed in animals; at any rate I have found no note of the condition in the literature.

Hæmaturia, which is especially common among ruminants, depends on disease either in the kidneys or bladder. Catarrh of the bladder in horses, cattle and dogs results usually from retention of urine, which may be due to a calculus, or to stenosis of the urinary passage at any point.

Diseases of the genital organs mainly fall within the domain of surgery (hypertrophy of the prostate, phimosis and paraphimosis). Among internal diseases may be placed catarrh of the vagina and the mucous membrane of the uterus, while puerperal fever, from which female domestic animals and those kept in zoological gardens frequently suffer, must be included among the infectious diseases.

Diseases of the Organs of Locomotion.— Acute articular rheumatism has been already mentioned among the infectious, the greater number of the remaining diseases of the organs of locomotion are considered under surgical diseases. Only a few, therefore, remain for discussion in this place.

Among idiopathic diseases of the muscles, muscular rheumatism, which occurs in horses, dogs and cattle, and less frequently in sheep and swine, is etiologically closely related to the disease as seen in man.

Further analogies are found in certain bone diseases which only come under the care of the surgeon when considerable deformity or destruction of the bone has occurred. Rickets, a disease of infancy, which is said to begin frequently in fœtal life, consists in alterations in the growth of the bones, due to inflammation and to delayed ossification; it affects not only the long bones, but also the bones of the pelvis, spinal column, ribs and skull. Young dogs and pigs especially suffer from the lesions which are characteristic of the disease in human children, namely, enlargement of the ends of the bones, bending of the bones, deformity of the spine, etc. Foals and calves are similarly affected, and the condition is met with also in artificially fed young beasts in zoological gardens. According to A. Hirsch, rickets is not seen as a disease of children either in Madagascar, Mayotte, or the Archipelago adjacent to these islands. Ebbell, however, states that he has frequently seen the disease during his ten years' stay in Madagascar.

A disease of the bones which is limited to adult life is osteomalacia, in which a softening of the bony skeleton takes place owing to the abnormal absorption of lime salts, and the replacement of the firm osseous tissues by bone marrow. This disease both in man and animals is limited to the female sex, and generally comes on during pregnancy or after childbirth. It is most frequently seen in cattle, less often in sheep, goats and swine, and least often in mares and bitches.

Besides rickets and osteomalacia there is a third disease of the bones which occurs both in man and in animals, namely, osteoporosis. Here there is atrophy due to absorption of the bony substance.

In man this is often a symptom of senility, but under the influence of certain lesions it may occur earlier. It has not yet been observed among wild animals, but it occurs in domestic animals, especially cattle, as the result of insufficient food, and also in animals in captivity in zoological gardens, either as a result of insufficient food or exercise. The so-called giraffe's disease described by Brugsch[1] may be classed as osteoporosis; and on this condition depend the frequent spontaneous fractures which occur in zoological gardens among cassowaries, herons, etc., in captivity, when they are handled.

Diseases of the Nervous System.

The gross pathological, and anatomical, changes which take place in the brain and spinal cord are the same in domestic animals as in man. From various causes horses, dogs and sheep may suffer from hyperæmia or anæmia of the brain; chronic hydrocephalus and actual apoplexy may occur in horses,

[1] *Zoolog. Garten*, 1864, no. 5, p. 129.

cattle, sheep and swine, and Schmidt has recognised the same conditions in various beasts of prey. Meningitis is not infrequent in apes, horses, cattle, dogs, swine, sheep and goats, and in all animals tumours of the brain may be found similar to those in man. Swine, sheep, cattle and horses when running close together in herds, or when packed in carts, may suffer from sunstroke or heatstroke, especially the latter. Cases of bulbar paralysis, with the same progressive and fatal course as in man, and the same pathological findings (atrophy of the bulbar nerve roots), have been noted in horses.

Horses and dogs are especially liable to inflammation of the spinal cord and its membranes, generally in a chronic form. Sarcoma, glioma, myxoma and other neoplasms of the cord may be diagnosed during life in various domestic animals.

Peripheral nerve palsies occur in various domestic animals, and have the same causation as in man, namely, pressure, atmospheric influences and infectious diseases. Single or double facial paralysis is frequent in horses, rarer in cattle and dogs. Single or double paralysis of the hypoglossal nerve is frequent in horses and dogs; paralysis of the masseters and temporal muscles, due to lesions of the third (motor) division of the fifth, is not unusual in dogs and cats, but is less common in horses and cattle.

Horses may suffer from paralysis of the pharynx and gullet due to disease of the ninth and tenth cranial nerves; unilateral laryngeal paralysis in horses depends on lesions of the recurrent laryngeal branch of the vagus; paralysis of the sphincter muscle of the bladder in dogs depends on disease of the centre lying in the upper part of the fifth lumbar segment of the cord.

Muscular paralysis in the upper extremities in man, consequent on lesions of certain motor nerves, occurs in exactly the same way in animals. Paralysis of the shoulder-blade muscles in horses and cattle is caused by disease of the nerves arising from the cervical plexus (suprascapular nerves); lesions of the brachial plexus in horses and dogs cause paralysis of all the motor nerves arising from it, among which the paralysis of the radial nerve is especially met with in horses and cows. Paralysis, complete or partial, of the posterior extremities in cattle, horses and dogs is due, as in man, to acute or chronic pathological changes in the spinal cord above the paralysed part. Schmidt has noted such total, or partial, paralysis in apes, canines, and other beasts of prey in zoological gardens.

Paralysis of certain sensory nerves in the lower extremity is very rare, and only seen in horses and large dogs. The nerves most frequently involved are those supplying the thigh and shin and calf. Still less frequent is paralysis of the two mixed nerves—the crural and obturator.

Pathological irritation of sensory nerves (neuralgia) is probably similar in animals and man, but is difficult to diagnose. Pathological irritation of motor nerves (spasm) is most clearly seen in the so-called springhalt in horses: it is probably due to a painful sciatica, and consists of regularly recurring spasms of the posterior thigh muscles. Schmidt notes that muscular spasms accompany certain diseases in apes, and are still more frequent symptoms in beasts of prey.

The neuroses seen in men, which manifest themselves in motor disturbances of various kinds, are also reproduced in certain animals. Horses, and according to Schmidt apes and jackals, suffer from epilepsy. Eclampsia is commonest in young dogs and pigs, less frequent in bitches and other grown animals, such as cows; catalepsy is very seldom seen (prairie wolf, wolf, dogs, horses, cattle). St. Vitus' dance is also observed in young dogs and jackals. Two severe diseases depending on pathological changes in the thyroid gland, especially as regards the suppression or increase of its internal secretion, show the close relationship of human to comparative pathology. Cretinism and myxœdema, which depend upon degeneration of the thyroid gland and suppression of its internal secretion, are unknown in animals, either in the endemic or sporadic form. Records of well-established cases are available, in which, after complete extirpation of the thyroid, owing to goitre, cachexia strumpriva, similar exactly to that seen in man, was observed. The reverse of hypothyroidism is hyperthyroidism, which in man gives rise to Graves' disease (proptosis, goitre and severe nervous disturbance of the heart); it is not infrequently seen in certain animals (dogs, horses, cattle).

Mental Diseases.—Can animals become mentally deranged?

This question is but little discussed in pathological literature. As regards the more highly gifted vertebrates, a partial affirmative cannot be denied offhand. If the disturbances set up by morphia and alcohol are to be included in the organic psychoses of man, then we may correctly speak of psychoses in animals due to the *ingesta;* thus the swallowing of belladonna, hyoscyamus, datura strammonium, allium, cannabis and poisonous fungi produces severe disturbances going on to delirium; Pteris aquilina (bracken) produces unconsciousness; the administration of melampyrum is followed by depression.

Rabies is a remarkable psychosis due to the poisonous action of some infective material on the cerebral cortex, and may be communicated to dogs and other animals by mad wolves and foxes. The clinical picture is well known from cases in man; it begins with peevishness and anxiety, and goes on to the most violent psychical excitement, with furious delirium and violent convulsions. We must conclude from the behaviour of the rabid animals that similar processes take place in their cerebral cortex. It still remains to ask whether it is possible for a psychosis to develop in animals, with or without recognisable pathological or auatomical changes, quite apart from any poisoning or infection? I have ransacked the literature in order to obtain some light upon this question, and have only been able to find a reference to it in the work of Lindsay (*Journal of Mental Science*, July, 1871). He begins by drawing a distinction between "insanity," which is applied to man, and denotes very various mental disturbances, and "madness," which is applied to animals, and denotes, more or less vaguely, a number of very heterogeneous diseases. He is quite aware that veterinary surgeons deny that any parallel exists in the region of psychology between man and animals; in their view animals have no true intellect, and so cannot lose it; that is to say, it cannot be damaged by any morbid changes. Lindsay, however, rightly disputes this point of view, and holds that the higher animals, whose intelligence stands so near to that of man, must suffer from similar mental disturbances. Insanity in man and madness in animals convey the same idea to him, and he resolutely opposes the foolish view held by many other veterinary surgeons that all madness in animals is a kind of hydrophobia, but he admits that those psychical disturbances in animals which are not due to hydrophobia manifest a very similar sort of mania. Lindsay describes many cases of acute mania in elephants, horses and dogs. When, at certain times in the year, elephants go mad, and become dangerous to man, their condition may be compared to the "running amok" of the Malayans. Similar acute disturbances occur in horses and dogs. In the latter, all cases of extreme excitement and madness after bites are not due to hydrophobia; the bites of such dogs are harmless to man. There are no pathological or anatomical findings to explain these conditions—we have to fall back on surmises. When, however, Lindsay, on the authority of Lord Royston, mentions certain psychical disturbances in fish, manifested by their swimming round and round in circles, we can only suppose that these fishes had some parasitic affection in the brain. Actual examples of mania may be seen when cows and mares during the œstrum drag at their chains with rolling eyes and chattering teeth, and finally fall down in tetanic convulsions; or when sows in their madness devour their own young ones. The converse of this nymphomania is the satyriasis of the male animals (stallions, bulls, bucks, stags), and, according to a widespread popular opinion, also the male hares. The moderately careful observer will have no difficulty in diagnosing these conditions of morbid excitement from the changed and unnatural behaviour of the animals, and will certainly attribute them to the congestion and unusual excitability of the genital organs.

Not infrequently a condition of extreme depression is noticed in mares, cattle and swine, accompanied by increasing deficiency of sensation, such as is seen in cases of imbecility in man. This condition, and the corresponding one seen in males, has its pathological and anatomical cause in the effects left on the brain by a previous attack of meningitis. It would, however, be useless to expect to find such a condition in those animals which, after remaining motionless and refusing their food for a few days, die owing to grief at the loss of their liberty, or at separation from a beloved master.

During an elephant hunt in Ceylon, Tennant[1] saw a captured elephant, after a violent exhibition of rage, quietly lie down and

[1] Brehm's *Tierleben*, Bd. ii., p. 707.

die in twelve hours. The story of Stanley's dachshund is well known. When Stanley started for his last great African journey he left the dog behind. The animal from the first refused all nourishment and died after three days. I myself know of a yellow-hooded cockatoo which, two days after its mistress had sold it, was found dead in its cage. These are well-authenticated instances of extreme depression of spirits which might well be identified with melancholia in man, were it not for the absence of any evidence of the characteristic psychical incapacity, the hallucinations, delusions, etc., so that we can only conclude that it is a simple physiological and psychological depression. Thus melancholia in man must be regarded as a specific psychosis.

Lindsay considers it self-evident that it is very difficult for veterinary surgeons, or other observers, to determine the onset and progress of intellectual disturbances in animals owing to their being unable to speak. Now as regards the gradual onset of imbecility as a sequel to acute cerebral processes, the behaviour of the affected animal gives plenty of ground for the establishment of the diagnosis; nor is it easy to pass over the semi-conscious condition which is connected with epilepsy in animals. On the other hand, it would be useless to look for symptoms of insanity (paranoia), hysteria or hypochondria in an animal, for the morbid delusions, which are peculiar to these conditions, can only occur in a brain gifted with higher reasoning powers, such as that of man.

(δ) Chronic Constitutional Diseases of a Non-Infectious Nature.

Among morbid blood changes, such as are seen in man, ordinary anæmia has been observed among young dogs, cats, swine, horses and cattle; pernicious anæmia only in the last-named. Hydræmia attacks sheep, swine and cattle, and leuchæmia occurs in cattle, horses, cats and swine. Hæmophilia has as yet only been noticed in horses; scorbutus, on the other hand, occurs in swine, dogs and sheep; Schmidt has seen a case in a gorilla. Horses occasionally suffer from Diabetes insipidus, and dogs, cats, cattle and horses from Diabetes mellitus. Among wild animals in captivity, Schmidt has seen cases of the last-named in two apes and a panther. Other common metabolic diseases, such as gout and obesity, in man are not unknown in domestic animals; dogs suffer from the former, and also parrots, when too closely confined and too richly fed. Dogs, cattle and sheep suffer from the latter, and also pigs. Scrofula, frequent in young horses and swine, is, as in man, no definite disease, but a general term denoting a number of morbid symptoms which are due to tuberculosis (Friedberger and Fröhner). Finally, there is Addison's disease—a chronic ailment, causing general cachexia and pigmentation of the skin, produced by cancerous, tuberculous or other changes in the suprarenals. No notice of this disease has hitherto appeared in veterinary text-books, and for the present therefore it must be regarded as peculiar to man.

Diseases of the Skin.—We will conclude the section on internal diseases by considering the diseases of the skin which will form a link with the diseases of a surgical nature. Our discussion of the infectious and parasitic diseases of the skin left for further consideration a series of other pathological conditions of the skin, which partly resemble those affecting man, and partly differ from them. The same atrophy of the skin which leads in old men to the disappearance of the pigment, and also of the hair itself, is also met with in old animals. In animals, too, hypertrophy of the papillæ leads to warts and polypi, which are preceded by a hypertrophy of the cutis. On the other hand, Elephantiasis arabum and Ichthyosis, which depend on hypertrophy of the epidermis, are peculiar to man.

The various forms of inflammation of the skin show many points of resemblance between man and animals. Sheep, swine, dogs and horses often suffer from erythema; cattle, horses, dogs and swine from urticaria; and these animals, with the exception of swine, also develop pemphigus and acne. Schmidt has reported a case of psoriasis in an orang-utan and in an ape.

On the other hand, the well-known text-book of Friedberger and Fröhner says nothing about herpes, impetigo, ecthyma or prurigo, so that for the present we must conclude that these conditions are peculiar to man.

2. Surgical Diseases.

Staphylococci and streptococci play the same part in surgery as they do in internal medicine; and both in man and animals cause inflammation, suppuration and blood changes. M. Schmidt[1] has recorded an interesting autopsy on a *Nasua solitaria*, which died of pyæmia following injury; there were the same changes in the pleura, lungs, heart, kidneys and liver as are found in similar cases in man.

Contusions, in man and animals alike, usually run a favourable course; contused, lacerated and incised wounds take a different course according as they are infected with cocci or not. Surgical skill is able to ward off the damage done by the inflammation and suppuration of wounds in man. Animals when not treated by man unconsciously protect themselves from infection by licking the wound as far as possible. Further investigations must decide whether this merely removes the causes of inflammation mechanically, or whether the saliva has any special healing power. If the healing process is prevented, the character of the wound, such as its depth, etc., will determine the sequel, which may occasionally be abscess formation, and in severe cases gangrene and destruction of the soft parts, or even of the bones.

In the following section I shall follow in detail the work of Möller and Frick,[2] dealing with the surgery of special organs.

Surgery of the Digestive Canal.—In dogs, cattle and horses certain cystic tumours not infrequently occur under the tongue, known as "Ranula," the cause of which, as in man, is obscure. The treatment is the same in all cases.

Stenosis of the gullet occurs in horses; œsophageal diverticula are met with in horses and cattle; foreign bodies may be found in all domestic animals, and in wild animals during captivity. The importance of an abdominal wound varies, as in man, according as merely the body-wall or the contained viscera are damaged. If the latter, experience with animals has shown that wounds of the intestine are less dangerous than those of the stomach and liver. Ruminants (sheep and cattle)

[1] *Zoolog. Klinik*, i., 2, p. 260.

[2] Möller und Frick, *Lehrbuch der Speziellen Chirurgie für Tierärzte*, 3rd. ed. Stuttgart, Enke, 1900.

have this peculiarity, namely, that gastrostomy or gastrotomy, which usually give rise to the escape of a considerable amount of gas, run as unfavourable a course as colotomy in horses, where the gas is developed in the large intestine.

Perityphlitis, starting from the vermiform appendix of the cæcum, only occurs with such disastrous frequency in man. The majority of mammals do not possess an appendix, and there are no pathological or anatomical records concerning inflammation of the appendix in such animals (anthropoids and certain rodents) as do possess one.

Congenital stenosis of the rectum or anus, occurring in dogs and swine, and less often in bulls and horses, is of similar surgical import as in man.

Prolapse of the rectum and anus is a frequent occurrence in horses, dogs and other domestic animals.

Intussusception, which is so dangerous to man, is equally so to the animals in which it frequently occurs, namely, cattle, horses and dogs. Volvulus of the left colon in horses is equally fatal. Hernia is caused in animals in the same manner as in man. It may be congenital, owing to a widely open umbilicus or femoral ring, or may be acquired later owing to increased intra-abdominal pressure or subcutaneous injury of the belly-walls by blows from hoofs or horns.

Man only differs in one point from animals. It is only in him that the pull of a fatty mass from without can cause a bulging of the peritoneum, and so lead to hernia.

Umbilical hernia occurs in horses, cattle and dogs; inguinal hernia in bitches and the males of other domestic animals; abdominal hernia in horses and cows; perineal hernia is rare, and is almost entirely confined to dogs, while diaphragmatic hernia is more frequent in horses, and less frequent in dogs, cattle and other domestic animals.

A surgical condition which is peculiar to oxen, but which in them is quite common, is internal hernia, in which the gut is nipped by the spermatic cord, or its peritoneal attachment.

Foreign bodies in the stomach and intestines demand no special notice, as they give rise to the same symptoms as in man, according to their character, and either remain inactive till spontaneously expelled, or else require removal by operation.

Nor is there any difference between man and other animals as regards tumours of the rectum and anus. Here, as elsewhere, fibromata, adenomata, sarcomata and carcinomata may occur, and require removal by the surgeon when they threaten health or life.

Surgery of the Respiratory Organs.—Rhinology is not so advanced as regards animals as it is in man. It is limited to the recognition, and removal, of foreign bodies and tumours (polypi, fibromata, etc.) in the nose.

The so-called rhinoscleroma, which consists of a permanent thickening of the nasal mucous membrane, and the nose itself, following on catarrh, has as yet only been observed in man, and never in animals.

On the other hand, animals suffer from diseases of the frontal sinuses and antrum of Highmore, such as actinomycosis, tumours and accumulations of fluid or pus. They require similar operations to those performed on man. Horses, owing to their activity in the service of man, are specially liable to these and other diseases of the nose, such as necrosis of the nasal bones and violent hæmorrhages.

Conditions calling for surgical interference, such as foreign bodies, new growths or diphtheritic inflammation of the larynx and trachea in animals, differ in no way from the corresponding eventualities in man.

Goitres are not so common as in man, but are occasionally seen, especially in carnivora, less often in horses and cattle; they produce the same symptoms, owing to pressure on the trachea, as in man. The extirpation of the goitre is but seldom undertaken, but when complete gives rise to the same cachexia strumipriva, which Kocher first noted in the patients he had operated upon for goitre.

Accumulations of air or blood in the pleural cavity are due to the same causes in animals as in man; the latter are caused by penetrating wounds of the chest, or by perforation of a bronchus. In these cases and also in penetrating wounds of the thorax, bad treatment may lead to a collection of pus (pyothorax), which, like the effusions of blood (hæmothorax), must be removed by puncture or a cutting operation (horses, dogs, cattle and other animals).

Surgery of the Genito-Urinary Organs.—When the kidney is damaged by trauma veterinary surgeons consider it more economical to order the wounded animal to be slaughtered, whereas in man the surgeon would cut down upon and treat the wounded kidney. Quite recently, Lorge, Rubay and other veterinary surgeons have attempted for the first time to open the kidney from behind for stone, and to close it again after removing the concretion. On the other hand, puncture of the bladder for absolute retention of urine has long been practised. In dogs and swine it is performed suprapubically; in larger animals through the rectum or perineum. In carnivorous animals and swine stones occur composed of urates, oxalate and cystin; in herbivora they are mainly calcium phosphate and triple phosphate; in sheep they consist of a compound of calcium and magnesium phosphate and silicate. Operations are seldom performed for stone in the bladder in domestic animals, even in the case of dogs which suffer frequently from this condition; urethrotomy, however, is done if a stone becomes impacted in the urethra.

Stricture of the urethra is most commonly seen in horses, hypospadias and epispadias in sheep and dogs, and but rarely in other animals. Veterinary surgeons have frequently to treat prolapse and retroversion of the bladder after difficult labour, a phenomenon which occurs in bitches, mares and sows, but never in women. On the other hand, women suffer from prolapse of the uterus and vagina quite as frequently as cows, mares and sows.

Phimosis and paraphimosis are not peculiar to man, but are frequent in certain domestic animals; phimosis is commonest in dogs, and paraphimosis, a still more frequent occurrence, owing to the shape of the penis; it is less frequent in bulls and swine.

As to hypertrophy of the prostate, which torments so many elderly men, we may console ourselves with the thought that certain animals, such as the dog, and less frequently the horse, are similarly afflicted in their old age. Sarcocele, hydrocele, hæmatocele and varicocele also come under the notice of veterinary surgeons in stallions, bulls and rams.

Inflammation of the testis is much more frequent than inflammation of the epididymis in stallions and bulls. Both processes when not metastatic do not usually go on to suppuration in animals, but to resolution and restoration of function.

The larger number of the swellings of the testis, whether tuberculous, myomatous, cystic, sarcomatous or carcinomatous, demand removal by castration, an operation which is daily performed on male domestic animals on purely economic grounds.

The changes in physical and psychical condition which occur as a result of removal of the male and female genital glands have attracted the attention of investigators from the earliest times, and have recently formed the subject of an interesting treatise by Moebius,[1] who holds that these changes are, generally speaking, identical for man and animals. Anatomically, the changes in the sexual organs may first be mentioned. As in man the penis remains small, and the prostate and vesiculæ seminales atrophy, while the mammary glands increase in size, so also in oxen the prostate and vesiculæ disappear at the same time as the teats grow large. The reverse condition was observed by Dr. Roberts in India, where females who had been splayed while young became muscular and masculine in type without any development of the external genitals. Castrated animals usually become fat, just as large fatty cushions usually develop in castrated men and women. The changes in the skin connected with the development of secondary sexual characteristics are still more remarkable, and concern males more than females. The growth of hair which characterises the adult man is absent in eunuchs, or only developed as down to the extent seen in women. The resemblance to the female type is seen in the fact that eunuchs seldom develop an " Adam's apple," a fact recorded by Aristotle.

In castrated cocks the similarity to the hen bird is seen in the absence of wattles and comb, and the scanty growth of tail feathers which remain flattened as they do in hens. Capons are either unable to crow, or can only do so imperfectly. The poor development of the larynx in human eunuchs is the reason why the voice does not change, but remains high pitched. The larynx is intermediate between the male and female in type.

Equally striking are the changes in the bones. According to Moebius, eunuchs are generally tall and slim ; it is not known

[1] Moebius, *Über die Wirkung der Kastration.* Halle, 1905.

whether the pelvis is of the female type, but in animals the phenomena are well known. In the males the bones of the fore part are slighter than those of the hinder, and in bitches which have been splayed the larger species have heavier pelves on the whole, but all the relative measurements down to the conjugate diameter of the outlet are smaller. The skull undergoes striking changes. In eunuchs the circumference of the head is small, and the occipital curve, as Gall showed, is considerably narrower. Corresponding to this, according to L. Hofmann, is the slightly built skull of male animals after gelding. A capon's skull remains small; the skulls of bulls and horses do not develop. Some observations on stags are interesting; if they are gelded early, before the antlers have begun to bud, these do not appear; if later, the antlers remain small, and after atrophy of the testis on either side a unilateral atrophy of the antler also occurs.

Gall has described a remarkable narrowing of the occipital arch in eunuchs. This he considers corresponds to an atrophy of the cerebellum, a view which he has established for animals but not in the case of man. Not only did Vimont find, when carrying out some experiments to test Gall's assertion, that the removal of one testis caused a diminution in the size of the opposite cerebellar hemisphere, but that after double castration the entire brain failed to develop, and more especially the cerebellum. It is clear that the special influence of castration on the cerebellum must both in man and animals lead to corresponding mental changes. As a matter of fact, it is well known that the sexual instinct is absent in castrated men and women and animals, and that they have, moreover, lost all courage and love of fighting.

From the way in which the observations on human castration agree with those on animals, Moebius comes to the conclusion I had already reached in my treatise on *The Double Personality of the Metazoons*, namely, that "to a certain extent each sex contains the developmental potentialities of the other". The genital glands, says Moebius, are not the cause of the secondary sexual characteristics, but only promote them, while hindering the appearance of the secondary characteristics of the other sex.

Surgery of the Organs of Locomotion.—Laceration of the muscles in animals, such as horses, have nothing to distinguish them from those in man. Wry-neck (torticollis) can be produced, as in man, by paralysis, inflammation, dislocation or fracture of the cervical vertebræ, or contractures of the neck muscles. Lacerations of fasciæ and tendons are common in horses as the result of strain; the least frequent is laceration of the Tendo Achillis, which has only been observed in cows. A pathological peculiarity in horses, corresponding to Dupuytren's contraction in man, is the condition which depends on a congenital or acquired contracture of the flexor tendons of the fore-foot. "Galls" on the joints and tendon sheaths are extremely common in horses, and are analogous to cysts and ganglia in man. On the fore-limb they may occur either on the flexor or extensor tendons; tumours on the metacarpus are very laming, still more so are those on the fetlock of the hind-leg.

Dislocations are exactly similar to those in man. Dislocations of the lower jaw occur frequently in carnivora, although they are also met with in horses and swine. Dislocations and separation of vertebræ of the sacroiliac joint and of the symphysis pubis occur in horses, and still more often in cattle. Dislocations of the shoulder-joint are much less frequent in domestic animals than in man, in whom they are the commonest form of dislocation. Owing to its firm fixation by means of ligaments, the so-called fore-arm, the fore-foot and phalanges are still less frequently dislocated; deformities of the phalanges are, however, not uncommon in horses. Of dislocations of the hinder extremity (corresponding to the lower in man), the hip-joint is only commonly dislocated in cattle and other animals; in horses it is less frequent. Dislocations of the knee-joint, knee-cap (horses, cattle and dogs) and of the fetlock are very rare.

In a thesis on the surgical diseases of man attributable to his upright position, P. Albrecht includes spinal curvatures as seldom, or never, met with in animals. It is true that a spine which is supported by four limbs is less easily bent than that of man.

Lordosis, or dropped back, however, is frequent, and can be seen any day in the larger domestic animals; scoliosis and kyphosis, moreover, are by no means unknown in horses and cattle.

There are, however, joint deformities which are absolutely confined to man; these are knock-knee (Genu valgum), bandy legs (Genu varum), and the clubfoot (Pes varus, valgus, equinus, calcaneus and plantaris), (Figs. 208-211).

No animal suffers from these deformities, which depend on the special structure of the human skeleton.

On the other hand, fractures occur both in man and in animals as a result, direct or indirect, of the same daily occurrences. It would take too long either to enumerate them or to mention the animals in which they most commonly occur. Suffice it to say that all known fractures occur from those of

Fig. 208.
Pes varus.

Fig. 209.
Pes valgus.

Fig. 210.
Pes equinus.

Fig. 211.
Calcaneus.

the skull to those of the bones of the extremities, and are followed by the same results as to deformity and shortening, according to the way in which they are treated. The bones of the tail may, however, be fractured, and this is the only point, so far as fractures are concerned, in which man differs from other animals, although it must be remembered that the coccyx may be fractured in man.

Caries and necrosis of the bones is not even mentioned in the large work of Möller and Frick, and appears to be seldom, if ever, noticed in domestic animals. These two diseases, however, much more frequently attack animals in zoological gardens, especially apes and the smaller beasts of prey. It is extremely interesting to find that caries and necrosis may be recognised in the bones of cave bears. Walther found a lumbar vertebra partly destroyed by caries, and two lower jawbones in which exostoses had occurred due to caries arising in the alveoli. He was able to recognise a sequestrum lying within the casing of dead bone in a necrotic humerus from a cave bear.

3. Diseases of the Higher Sense Organs.

The pathology and pathological anatomy of the higher sense organs which has attained the rank of a speciality in the case of human medicine, will now be considered as a kind of adjunct to the foregoing sections on special comparative surgery. Although from the anatomical point of view the higher animals may be said to suffer from the same diseases of the nose and ear as man, they have not, for obvious reasons, been made the objects of similar special studies. With regard to diseases of the nose, the short notice given above must suffice, and the chapters on diseases of the ears are equally short and condensed in most veterinary text-books.

As in man, two forms of inflammation of the external auditory meatus, the acute and the chronic, are known (Otitis externa); they occur most frequently in dogs, less frequently in horses and other animals. The etiology and symptoms are the same as in man; and the papillomata, which form a sequel to the chronic form, require the same treatment when diagnosed. Chronic catarrh of the external ear can be diagnosed in horses, but, according to Möller and Frick, inflammation of the middle ear (Otitis media) and labyrinth (Otitis interna) generally remain untreated and are not recognised till after death. They are the result of Otitis externa, the introduction of foreign bodies, the growth of parasitic organisms or of tuberculosis.

Veterinary ophthalmology alone has become during the last ten years a well-established speciality, owing to the ease with which the eyes of animals can be examined with the ophthalmoscope; far-reaching comparisons with pathological conditions in man have thus been established. Dr. H. Möller has published a clear and well-written text-book on veterinary ophthalmic surgery on which much of what follows here is founded.

Lesions of the cornea are very frequent in all domestic animals, as are their sequelæ, anterior synechiæ, prolapse of the iris, opacities and scars (at any rate in dogs); in dogs and horses superficial and deep inflammations and ulcers are also common. Fistula and staphyloma follow as in man, as the result of perforation. New growths, pterygium and dermoids are not infrequent in horses, dogs and sheep.

The various forms of inflammation of the conjunctiva from simple catarrh to purulent (blenorrhagic) or diphtheritic conjunctivitis, appear with the same symptoms as in man. Blenorrhagic inflammation is often most extensive in cattle, sheep and dogs; the diphtheritic form is confined to fowls, pigeons and other birds, in which primary diphtheria of the throat and nose has occurred.

Diseases of the membrana nictitans are peculiar to animals; wounds occur in horses, cattle and dogs; chronic inflammation, accompanied by thickening, in dogs and swine; fibromata in the larger animals, and prolapse in dogs and swine.

Coloboma also occurs in animals, as a result of disturbances in the normal formation of the fœtal pupil; the pupil may be closed either by posterior synechiæ, or by swelling of the uvea. Inflammation of the iris is very frequent, either primary or secondary, to disease of the ciliary body or choroid.

The causes of acute inflammation of the iris are either traumatism or infection. Iritis often extends to the ciliary body and choroid, and if primarily infective it may lead to a general purulent inflammation of the eye (panophthalmitis).

Night blindness in horses is rather different from that in man; in man it is due to a decrease in central vision, conditioned by a rapid contraction of the visual field when the light is deficient, without any internal inflammation of the eye. In the horse it is due to a periodically recurrent irido-choroiditis of an infectious character, leading to destruction of the retina and blindness in one or both eyes.

As in children so in young domestic animals (dogs and horses) opacity of the lens may occur as a congenital defect. Cataract generally, however, occurs later both in these and in other animals (bears, hyænas, wolves, the smaller felidæ, and other small beasts of prey); it is the result of metabolic disturbances, former inflammation, hæmorrhages into the anterior chamber, or diabetes. The various operations for cataract are also performed on animals.

Glaucoma, which von Græfe showed was due to an abnormal increase in intraocular tension, occurs, according to Möller, in dogs and rabbits, though it is not common. It is characterised, as in man, by the greenish hue of the retinal reflex and the hardness of the eyeball; the ophthalmoscope shows the same hollowing of the optic disc.

The condition known as amaurosis in animals is the result of various diseases of the retina, optic nerve or visual centre in the brain.

Primary inflammation of the retina is seldom seen in animals. In most cases it is secondary to choroiditis. Inflammation at the point where the optic nerve enters the retina can easily be recognised by the ophthalmoscope, as can separation of the retina (dogs and horses), and hæmorrhages, which are frequent as the result of the infections, and of heart failure.

Infectious diseases in horses and cattle also give rise to inflammation of the optic nerve before its entry into the medulla (retrobulbar neuritis).

Diseased conditions of the vitreous body are especially common in horses, and are caused by disease of the choroid or retina. The latter are usually due to wounds of the sclerotic, and less often to inflammation. Dogs, lambs and cows are predisposed to hydrophthalmos, in which the outer covering of the eye extends through a complete sclerochoroidal staphyloma.

The following conditions are similar to those seen in man, and require similar treatment: inflammation of the lacrymal sac (horses and cattle); closure or narrowing of the lacrymal duct (horses, donkeys and mules); fistula (horses, cattle and dogs); wounds and inflammation of the eyelids; ectropia and entropia (dogs).

Swelling of the lids, ptosis and malignant or benign tumours in animals have no special characteristics.

The same lesions and inflammations of the soft parts of the orbit may occur in horses and cattle as the result of work, and in dogs as the result of fighting, and may occasionally result in exophthalmos.

With regard to lesions in the external nerves of the eye, nystagmus has a more serious significance. In man it may be the result of myopia, either congenital or acquired in early life; in this case it leads to no consequences but has very little chance of improvement.

In animals, such as swine, horses and dogs, it is always the result of poisoning or of cerebral disease, and thus demands a cautious prognosis. Squint, on the other hand, has hardly any significance in animals; internal strabismus, due to paralysis of the external recti muscles, is commonest in horses, cows and dogs.

As might be expected, nothing is known of defects of accommodation in animals. With regard to refraction, Matthiessen, Berlin and others have shown that a slight grade of hypermetropia is present in most domestic animals; Berlin estimates it in horses as from one to two diopters, though higher degrees may of course occur. A frequent cause of squint in horses is astigmatism, that is to say, an inequality of the dioptric apparatus in its different diameters; according to Möller, it is usually present in horses and other domestic animals.

4. Pathology of Pregnancy and Parturition.

(a) Diseases of Pregnancy.

Pregnancy in the human being may be unfavourably influenced by abnormal conditions of the uterus which in other mammals are either non-existent or else approximate to the normal. Thus, a uterus unicornis in the human species may have its single horn so much stretched by the growth of the fœtus that the wall is thinned and eventually ruptured. The same thing may take place in the uterus bicornis when a fœtus develops in one-half.

In most carnivora and edentata, and in some rodents, the uterus is divided into two parts by an incomplete septum, and the young lie to the right and left. A human uterus bilocularis, with a septum arising from the fundus, causes a cross position of the fœtus like the uterus bicornis, which is the normal form of uterus in ruminants, pachyderms and ungulates, and in them gives rise to no difficulties during pregnancy.

Acute retroversion due to external forces, or one which is slowly developed, is connected with the upright position and does not occur in animals; nor do anteversion, due to a pendulous abdomen, or the oblique position of the pregnant uterus. As against these purely human abnormalities we may set others which are peculiar to animals. Twisting of the uterus round its long axis due to the pull on the broad ligaments exerted by the growth of the fœtus in utero, occurs in cows, and less frequently in sheep and goats, while it is still less common in horses, swine and dogs. In other cases a hernia of the uterus may occur after rupture of the abdominal muscles, so that the pregnant uterus lies in a sack formed solely of the integument. In bitches hernia of the uterus into the inguinal canal may occur. Prolapse and procidentia of the pregnant uterus may occur in both human beings and animals; the latter condition is frequently associated with prolapse of the vagina. In the human female prolapse and procidentia commonly occur only during the first three months, but in these they are apparently fairly common. Prolapse of the vagina only occurs in multiparæ. From the fourth month onward this untoward event, which is frequently the cause of abortion, becomes less and less common. Among domestic animals, cows, mares and goats are especially liable to prolapse of the vagina. Lesions of the fœtus due to external mechanical influences during pregnancy occur, though not frequently, both in human beings and animals.

Hæmorrhages caused by the presence of innocent or malignant growths are also common to both during this period. Such hæmorrhages are also due in domestic animals, as mares and cows, to apoplexy of the chorionic villi, or to a kind of placenta prævia, when the network of villi belonging to the so-called *Chorion læve* is implanted in the region of the internal os as an accessory placenta.

A single, complete, central or lateral placenta prævia is peculiar to the human species, and is connected with the erect position.

With regard to dropsy of the fœtal membranes, caused by general fœtal œdema in cases of circulatory and renal disease, a difference is to be noted between human beings and animals. In human beings in whom the allantois disappears early, dropsy can only occur in the amnion, while the early obliteration of the urachus causes the urine also to drain into the amniotic cavity. Thus hydramnios is the only condition found in human beings. In the domestic animals, however, dropsy both of the amnion and of the persistent allantois may take place, and the urine drain into the latter sac owing to the urachus remaining open till birth.

Development of the fertilised ovum outside the uterus, either in the ovaries, Fallopian tubes, or in the peritoneal cavity, occurs in animals as in man, though with important differences. In the human subject extra uterine gestation, though rare, is always a true primary condition ; in animals, such as rabbits, hares, swine, dogs, sheep, cattle and horses, besides this there is a false extra-uterine gestation constituting the majority of the cases, due to rupture of the uterus and implantation of the fœtus in the peritoneal cavity, where it may, or may not, undergo further development.

Œdema of the legs and external genitals constitutes one of the most frequent symptoms of pregnancy in the human female. This œdema is often associated with varicose veins, which persist in a slighter degree after parturition. A similar œdema of the hind-legs and udder is common in pregnant mares and cows, but varicose veins are not mentioned in works on veterinary obstetrics, either because they do not occur, or because their presence is concealed by the animal's hair.

Nervous complications of pregnancy peculiar to women are fainting, hysterical convulsions, and eclampsia due to renal disease. It cannot be decided whether pregnant animals, like women, suffer from neuralgic pains of various kinds, as there are no means of recognising such a condition. It is certain, however, that mares and cows often experience false or premature pains while the os uteri is closed and the udders still flaccid ; cows and goats suffer from cramp of the cervix uteri without dilatation of the os, and also from premature pains and distension of the udder as a result of old cicatrices and thickening of the walls of the cervix. As might be expected these premature pains often result in abortion.

In human beings the term abortion is used to mean expulsion of the fœtus during the first three months ; this condition is due either to extreme excitability on the part of the mother, abnormalities of the uterus, such as new growths or displacements, to the occurrence of a menstrual period, or finally to any cause producing death of the fœtus. Habitual abortion is very frequent in women affected with syphilis. In Bartel's work, recently edited by Ploss, the commonest cause of abortion in savage races all over the world is said to be overstraining of the women by hard work, tiring journeys or carrying heavy loads. To this, to the difficulty of rearing children, and often to the sterility of the soil must be added the frequency of artificial abortion in all savage races in America, Asia, Africa and Australia. European observers admit that the same motives for this may exist as are found in civilised peoples, namely, indolence on the part of women, and attempts of erring girls, and wives, to get rid as soon as possible of the evidence of their guilt, in which they may be helped by more experienced women.

Artificial abortion, as practised by savage and civilised peoples, or induced in cases of necessity by medical men, is a special attainment of man which no animal has ever succeeded in reaching.

Natural abortion is much more frequent in animals. Though unusual in the smaller ruminants, and still more unusual in the carnivora and swine, it occurs often enough among the larger domestic animals, such as mares and cows; in the former it is usually between the fourth and ninth month, and in the latter between the third and seventh. Sporadic cases occur as the result of circumstances causing death of the fœtus, such as disease of the placenta, overstrain, and psychical influences (anxiety or terror), or, as the result of eating bad fodder or ergot (in rye, various grasses or reeds), a whole series of animals will abort one after the other; infective material may indeed produce abortion throughout a whole herd or stable.

Artificial abortion, which is not infrequently practised by veterinary surgeons, has but little in common with the pathological variety. It is a measure which is adopted as in human beings when it is rendered necessary by a contracted pelvis or by maternal disease; the principal conditions for inducing premature labour are the extreme asthenia of old mothers, œdema of the fœtal membranes, serious hæmorrhage, or an extreme degree of prolapse of the vagina.

In human beings the term miscarriage is used when the fœtus is not viable and is expelled before the twenty-eighth week; the term premature birth is used when the fœtus is between the twenty-eighth and thirty-eighth week and is capable of survival. The viability of the fœtus in domestic animals must be the ground for diagnosing premature birth.

(b) Pathological Complications of Parturition.

Among savage people the causes preventing birth are reckoned to be weak pains, bad position or want of activity of the fœtus, and disproportion between the size of the child and the mother's genital canal, and magic. This latter, and also the want of activity on the part of the fœtus, are childishly simple ideas, but with these exceptions the views of savage nations are very close to the reality, especially in the entire absence of external aid.

The circumstances hindering birth in civilised people are known to be abnormal size of the fœtus, or of one of its parts; abnormalities in the membranes, umbilical cord or placenta; anomalies in the uterus or external genitals; faulty position of the fœtus; contracted pelvis, and, after delivery, retained placenta.

Abnormal size of the fœtus may hinder parturition both in human beings and in our domestic animals. The abnormality may affect the whole body or only one part. The belly may be excessively large owing to ascites, or the head may be enlarged by hydrocephalus, which in both cases is often a hindrance to birth. But apart from any collection of fluid in the brain, the child's head may have a disproportionately large circumference. In man this may occur in the children of fathers whose heads are very large, and in calves and puppies under similar circumstances.

Deformities and tumours, both in human and animal fœtuses, and curvatures and contractures in the latter, may form a more or less complete obstacle to delivery.

In the vast majority of cases, only one fœtus is developed in the human uterus. The simultaneous presence of more than one fœtus in the uterus, besides causing increased trouble during pregnancy, interferes with parturition, as abnormal positions of

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the fœtus, prolapse of the cord and of the extremities, are more common under these circumstances. Twins, either from one ovum and thus always of the same sex, or from two ova and then generally of different sexes, are fairly common, occurring on an average once in eighty-seven births. Triplets are rare, one in 7,600 births, and quadruplets and quinqueplets are still rarer. Multiple pregnancy is the rule in many mammals, and then it occasions no disturbance at birth. In uniparous mammals, however, the development of twins or triplets is a disturbing factor in parturition just as it is in the case of human beings. Twins occur in sheep fifty-six times in 300 births, in cows once in seventy-five, in mares once in 387. In goats twins are usual.

The condition of the fœtal membranes is of much greater importance to the course of parturition in both human beings and animals. If the membranes are too thin, they rupture too soon for the proper dilatation of the os uteri, and the early escape of the amniotic fluid thus prolongs labour. A like result ensues when the membranes are too thick to rupture spontaneously at the proper time, so that the entry of the fœtal head into the true pelvis is delayed. The amount of amniotic fluid is also of considerable importance; if it is too great, or too small, untoward disturbances of parturition are liable to occur both in man and animals. If the amount is too small, the protruding bag of membranes which is required to dilate the os uteri is only incompletely formed, and after the escape of the little fluid which exists the labour is "dry". If the amount of fluid is too great the fœtus is allowed too much mobility, and various abnormal positions result; when the membranes rupture, the limbs or the umbilical cord may prolapse.

We have already referred to placenta prævia (central or lateral) which is, properly speaking, peculiar to the human race. Abnormalities in the human placental tissues (deposits of fibrin, cysts, inflammatory changes, etc.) appear to be very rare in animals and are only very briefly dealt with in veterinary textbooks. It is impossible at present to say whether complete separation of the placenta, which is very rare in human beings, has ever been known to occur in animals.

Abnormal insertion of the umbilical cord into various parts of the placenta, torsion and knots in the cord, such as occur in the human subject, have no greater effect on the course of parturition when they are observed in animals. The length of the cord is, however, in both cases of more importance. If it is too short the entry of the head into the true pelvis will be delayed, and often there will be a separation of the placenta and consequent hæmorrhage. If it is too long it may, during the period of gestation, become twisted round the neck or other portion of the body of the fœtus, and so delay parturition, or in human beings it may become prolapsed; if the cord cannot be replaced, prolapse constitutes a serious complication, and may lead to the death of the child during parturition. Lacerations of the cord during labour are much more dangerous to the human child than to young animals, unless they are at once ligatured. This difference depends on the behaviour of the umbilical vessels, which in the case of animals become sealed immediately after a laceration, whereas in the case of human beings, unless a ligature is applied, a dangerous hæmorrhage occurs.

It is obvious that both in human beings and animals unusual rigidity of the external os uteri, and superficial or still more deep-seated strictures, will cause serious obstructions to the course of parturition. In women, mares, cows and bitches a narrowing of the vagina or vulva, due to antecedent wounds or inflammation, may cause rupture of the uterus of the neighbouring large blood vessels or the vagina, unless operative assistance is promptly rendered.

In women it may happen in the second or third stage of labour that, if traction is made on the cord while the placenta is still firmly attached, the placental site becomes inverted and dragged through the os, until in the most extreme cases the entire uterus is turned inside out and pulled out through the vulva. In domestic animals similar causes lead to inversion and finally to prolapse of the inverted uterus. In ruminants, with their multiple placentæ, the tendency to prolapse is much greater than in animals with single or widely spread placentæ; "especially as in the first-named animals the fusion of the fœtal and maternal portions of the placenta is much more intimate and the method of its detachment is quite different from that which obtains in the others" (Franck).

The character of the pains during labour is of supreme importance both in human beings and animals. All diminution in their strength, or in the extent to which they affect the uterine tissue, is more or less a hindrance to the course of parturition. Excessive or tetanic contractions are especially disastrous when parturition cannot proceed owing to a faulty position or attitude of the fœtus, and the accoucheur is prevented from seizing it owing to the extreme pressure. If the condition is not relieved lacerations and other important complications may ensue. M. Schmidt reports two cases of laceration of the uterus in lionesses in the Zoological Gardens at Grenoble and Frankfort-on-the-Main. Abnormal contractions of certain sections of the uterus also tend seriously to prolong parturition both in human beings and animals, though not to such a dangerous extent. These contractions occur where the musculature is circularly arranged as at the internal and external os. The delay caused by weak pains can be still more easily understood, whether involving the whole uterus or only a portion thereof. Both in human beings and animals parturition cannot proceed when the musculature is tired out by long and fruitless pains, especially when the position of the fœtus is faulty.

Although in the various factors causing prolonged parturition which have hitherto been described there is a general resemblance between human beings and animals, a marked difference will be noted when we consider the various malpositions of the fœtus in utero: although these malpositions may in both cases be classified as head presentations, breech presentations and transverse presentations. The main difference between human beings and animals is concerned with cephalic presentations, and is due to the different shape of the skull. In human beings the calvarium is especially developed, and this presents most frequently; when the pelvis is normal this presentation has the best prognosis, though it is not quite so good when the head is placed obliquely, when the occiput is rotated backwards, or where the deeper parts are transverse. Face presentations, on the other hand, are among the most unfavourable, as labour is prolonged and the child's life threatened. In animals, on the other hand, face presentations are normal, and presentation of the calvarium one of the worst complications of labour. In human beings, owing to the shortness of the neck, malposition of the head is almost inconceivable, but among the larger domestic animals, such as foals, malpositions of the head are, owing to the length of the neck, very common. A lateral position is especially common, and after that positions in which the head is bent downwards or backwards.

Conditions depending on malposition of the fore-legs are still more complicated; here one or both ankles, or one or both shoulders may present.

Breech presentations both in women and female domestic animals are abnormalities which tend to make labour more difficult. In the former, those in which one or more limbs lie beside the breech may be distinguished, and also those in which the foot or knee comes down before the breech; these may all be again divided into two positions, according as the child's back is turned towards the right or left side of the mother. If the child's back is turned towards the back of the mother, the position must be regarded as abnormal. Breech and footling presentations have been recognised among savage peoples from time immemorial, before any more accurate diagnosis of the presentation could be made.

Among domestic animals besides pure breech presentations there are malpositions of the hind limbs and malpositions of the tail. The position of the young may thus be "lower" (or towards the mother's belly), right or left (towards the mother's corresponding flank), as normally among domestic animals the back is turned towards the back of the mother. Malpositions of the limbs are more serious in animals; in human beings they are short and the joints are but little developed, but in domestic animals the long limbs and powerful joints offer much more resistance to the correcting hand of the accoucheur. It is, indeed, utterly impossible to convert a breech presentation into a head presentation in the case of domestic animals.

If the human fœtus does not present either by the head or the breech, its position must be either transverse or oblique. In the first case the long diameter of the child's trunk is parallel with the transverse diameter of the uterus, and the head may be found in the mother's right or left side; the back, the belly or the right or left flank of the child may be downwards, and, according to the position of the fœtus, one or more extremity may lie on the os uteri, or one of the upper extremities may prolapse.

It is characteristic of human transverse presentations that they do not arise during labour, but are due to various antecedent causes, and that in small and badly developed or macerated fœtuses, the malposition corrects itself, while in all other cases version is possible. The conditions in the case of domestic animals are very different. The transverse position arises during, and as the result of, labour, and is developed from some other position. It is commoner in horses than cattle. The young lie transversely, with the back strongly bent and with one end of the body lower than the other, so that either the back or the belly is turned towards the inlet of the pelvis. Version is possible in small animals, if the size of the genital canal permits; in larger animals version is only possible when one half of the fœtus has been torn away. Oblique positions only differ from transverse positions in degree, and are only met with in the human subject. The long axis of the child's trunk forms an acute angle with the long diameter of the uterus, so that obviously either the head or the breech must lie close to the os uteri. This circumstance renders the oblique position more favourable than the transverse.

But whereas the oblique position is peculiar to human beings, an abnormal position is observed in animals which can never occur in man owing to the upright posture. This is the vertical position of the fœtus, in which one end lies against the mother's belly and the other against her sacrum or lumbar vertebræ, so that it sits or stands in the uterus with either its back or its belly opposite the pelvic inlet.

Considerable differences may thus be demonstrated between the various factors tending to obstruct labour in human beings and those found in animals. The most important difference, however, still remains to be described, *viz.*, the influence of the pelvis on the course of parturition. As regards this, the domestic animals in which the course of parturition can be observed are much more suitably framed from an anatomical point of view than the human female. Not only is the pelvis in animals wide and roomy, but its component parts are more movable than those of woman. The course of labour in mares is rendered much easier by the fact that the only important structure closing in the pelvis is the broad pelvic fascia. In cows the mobility of the sacro-iliac joint and the sacro-lumbar joint is greater than in mares. Labour in sheep and goats is still easier owing to the mobility of the upper sacral vertebræ, which renders possible a considerable widening of the pelvic outlet. In swine difficult labour is very rare, owing to the marked concavity of the sacrum and the extreme mobility of the sacro-lumbar and the sacro-iliac joints. In bitches the false pelvis is more capacious than in any other domestic animal, and the sacro-iliac joint is so movable as to form a regular diarthrosis. In addition to the

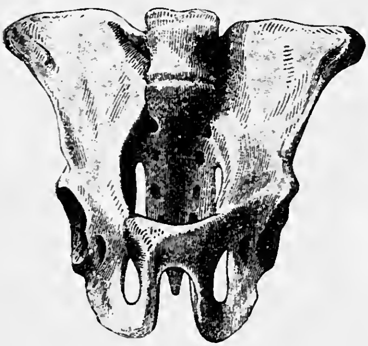

FIG. 212. Robert's pelvis. (Späth.)

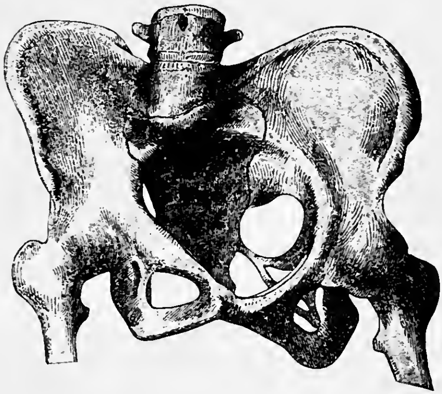

FIG. 213. Nægele's pelvis. (Späth.)

anatomical advantage enjoyed by domestic animals, there is the fact that pathological changes in the pelvis, causing a diminution of the pelvic diameters, are much less common. Franck indeed states that a narrow pelvis in adult animals only exists in a relative sense when the young one or the fœtal head, that is to say, is disproportionately large. The only pelvic deformities with which he is acquainted are those due to fracture of the pelvic bones, exostosis and ankylosis of the joints, such as the sacro-iliac, whereby a pelvis similar to Robert's pelvis may be formed in animals.

As we have seen, primitive peoples do not reckon a contracted pelvis among the hindrances to parturition. According to the universal testimony of experienced and expert travellers, the course of labour is, in the vast majority of cases, a much easier one, as rachitic, or otherwise contracted pelves are all but unknown. Especially favourable conditions obtain among most races of Australasia and Oceania, and the savage peoples of Asia, Africa and America. H. Fritsch makes the following weighty pronouncement on this matter: "It is obvious that uncommunicative savages can always evade troublesome questions by saying that no assistance is ever needful during parturition. Some experience is necessary in order to test the truth of this statement, as any inspection or examination during the act would be entirely impossible. To understand, however, why severe labours are so infrequent among such races, one must remember that very contracted, or absolutely too contracted pelves hardly ever exist. On the one hand, bone diseases (rhachitis) leading to pelvic deformity are unknown, and on the other hand, badly built individuals perish through insufficient nourishment. In the case of a crippled individual, it must not be forgotten that generally a woman is a chattel, and a bad chattel is unlikely to find a bidder at most auctions, especially as women are mainly married in order to be used as labourers. There is also considerable evidence (*e.g.*, Wernich's measurements and weights) showing that the children are remarkably small, have but slightly developed occiputs, very round heads and very soft bones. From all this it may be gathered that difficult labour is a rarity."

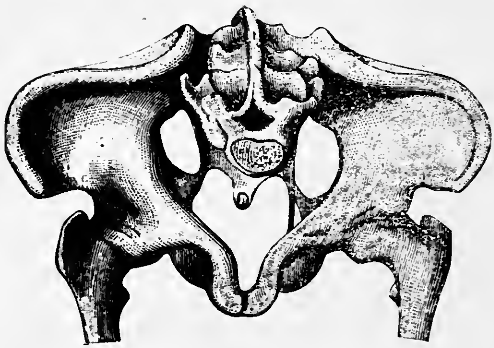

FIG. 214. Osteomalacic pelvis. (Späth.)

If we compare what is taught in our own midwifery text-books as to the influence of the pelvis in prolonging labour with this favourable account, we find a whole list of pelvic deformities, partly congenital and partly acquired later in life. There is the generally contracted pelvis of dwarfs, and the common shortening of the conjugate diameter caused by a too protruding sacral promontory; the funnel-shaped pelvis and the pelvis of male type, which is deeper and narrower transversely than the usual female pelvis.

To these must be added pelvic deformities secondary to some pathological condition. By defective development of the two wings of the sacrum, and ankylosis of both sacro-iliac joints, the pelvis of Robert is produced (Fig. 212); Nægele's pelvis is formed by ankylosis of one sacro-iliac joint and imperfect development of the wing of the sacrum on that side, producing a narrow slanting cavity. Asymmetry of the pelvis, with contraction of one-half, may result from unequal development of the transverse processes of the lower lumbar or first sacral vertebræ; or the pelvis may be narrowed by the excessive growth of certain bony projections (ridges or processes). Two bone diseases, both of them special forms of inflammation, are specially unfavourable to the proper development of the pelvis. Rhachitis produces either a diminution of the conjugate diameter with a normal or increased transverse measurement, or a general decrease in all diameters. Osteomalacia, on the other hand, in which the bones are abnormally soft, causes a change of shape which is due to the pressure of the body-weight from above and on both sides. The promontory of the sacrum and the ilia are forced inwards and the symphysis forwards into a peaked shape. Pelves with ankylosis of the sacro-iliac joints are very rare; deformities due to single or double hip-joint disease (Fig. 215) are more common, whilst commonest of all are those in which the contraction is due to curvature of the spine such as kyphosis or scoliosis (Fig. 216).

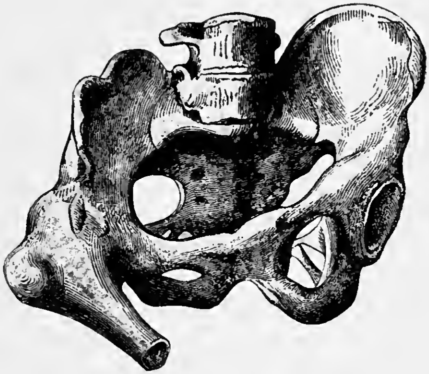
FIG. 215. Pelvis in hip-joint disease. (Späth.)

It is these contracted pelves which easily give rise to more or less deep and extensive tearing of the perineum.

Laceration of the perineum appears to be confined to human beings, at least no mention is made of it in veterinary text-books on obstetrics. There is, however, a still more severe and destructive lesion, which may occur both in human beings and animals, though it is fortunately rare in both, namely, expulsion of the head (or in animals of the head and fore-limbs) through the tissues of the vagina or perineum owing to abnormal rigidity of the external genital opening. Franck records a series of cases occurring in mares in which certain parts of the foals, the head, feet, or both together, were expelled through a laceration in the upper wall of the vagina and the lower wall of the rectum, a condition certainly fatal to the mother unless re-position could be promptly effected.


Fig. 216. Contracted pelvis in lordosis. (Späth.)

Finally, when the fœtus is born the completion of the labour may be delayed both in human beings and animals if the after-birth does not come away properly, and dangerous hæmorrhage occurs.

Retention of the placenta is not uncommon in women, and in some may occur more than once. Among animals it occurs most frequently in cows, less frequently in other ruminants, seldom in horses, and less frequently of all in the multifarious domestic animals.

Removal of the placenta by external manipulation is only possible in human beings. In both human beings and animals it may be seized from within the genital canal, and its removal is followed by contraction of the uterus and cessation of the hæmorrhages.

APPENDIX.

Comparative Therapeutics.

IN the foregoing researches into comparative pathology we have found much that is common to man and animals, and also much that is peculiar and specific for man. The further question now arises whether the attempt to overcome these pathological conditions by corresponding therapeutic measures is absolutely peculiar to man, or whether, and if so to what extent, it may also be observed among animals. In both cases we must distinguish between purely private and individual therapeutics, and those measures which are social in character and extend to others of the same species.

The ancients do not appear to have entertained any doubt as to the power of animals to help themselves. Evidence of this is seen in the most fabulous tales recounted by Aristotle, Pliny, Aelian, etc. According to Pliny, the hippopotamus when it has overeaten itself and feels too plethoric, bleeds itself by driving the sharp end of a broken pipe into a vein. The Egyptian ibis, and the white stork so common in Germany are said to use their beaks as enema tubes; bears when their eyes get weak allow the bees to sting them on the head; swallows use the seeds of the celandine to clear dimness of vision, and does use the fennel-like plant *Seseli libanotis* to ensure easy parturition; ringdoves, fowls, blackbirds and partridges cure the indigestion which recurs every year by means of bay leaves; pigeons and fowls also use the plant Helxine; ducks and other water birds syderis, and cranes marsh reeds, while bears employ the juice of the arum as a laxative.

Numerous examples of how animals cure themselves when poisoned are quoted by the ancients. Thus bears who have swallowed mandrake, eat ants as an antidote; panthers poisoned by an arrow swallow human excrement, and tortoises when bitten by a poisonous snake seek a kind of origanum, while stags poisoned by a spider can cure themselves by eating crayfish. Indeed, as to the treatment of wounds, Pliny states that stags when wounded by arrows only have to eat the leaves of the dictamnus in order to cause the arrow to fall out, and that weasels when wounded in their battles with rats heal their wounds by nibbling rue.

However incredible these tales of the classical authors may appear, we cannot altogether deny the possibility that animals may know of remedies for their illnesses and accidents. Everyday experience tells us that the dog's method of curing indigestion by eating grass is by no means a bad one. It is equally rational in stags, boars and other animals to cool their overheated blood in a cold spring. We are justified then in cautiously inquiring whether more highly organised animals when bitten by a poisoned snake may not seek to stay the further action of the poison by using some familiar plant as an antidote. The mongoose, an ichneumon inhabiting Java, is said by trustworthy travellers of the present day to dig up the bitter root of the ophiorrhiza mungo when bitten by a cobra; he rubs the wound with the juice of this root which has such an invigorating effect that he is soon ready to begin the fight again. In support of this account it may be mentioned that the root of this plant has a reputation all over India as an antidote to snake poison, and natives point out the little mongoose as the origin of their knowledge of the action of this plant. If he could really be healed in this manner the mongoose ought by now to have acquired an immunity against snake poisons, just as the hedgehog, which is said by Lenz and Brehm to be immune to the bite of the adder, has acquired this property as a heritage from many generations of hedgehogs who have become immune owing to many successive snake-bites from which they have been fortunate enough to recover.

The question as to whether wounded animals know how to treat themselves is a less complicated matter. We may see every day how dogs and cats lick freshly made and bleeding wounds, and by this method, vigorously applied, obtain remarkably rapid healing without suppuration. The reports of travellers are unanimous in stating that large animals invariably lick their wounds whenever they can reach them with their tongues. Wounded apes endeavour to staunch the blood by pressing their hand upon the wound; they also try to pull out arrows with their hands, just as they are accustomed to pull out splinters of wood or thorns very successfully when these are accessible. How appropriate, too, is the method of progression adopted by dogs when they have broken one of their legs! When the first pain and agony is over they soon find out how to get about on three legs, and learn how to hold the broken leg that the fracture heals without any shortening to speak of even though no bandage is applied.

The licking of the wound is simply an instinct; the removal of thorns or splinters of wood by apes implies a certain degree of reflection. A still higher degree may be seen in the elephant, which, as Bouchinet states for a fact, having a large leech in his left axilla, removed it very skilfully with a splinter of bamboo. If this tale is really true it shows that a specially highly gifted animal may make for itself a suitable instrument for purposes of surgical aid.

These evidences of the capabilities of the animal mind are of uncommon interest as regards the comprehension of the beginnings of therapeutics; but it is still more interesting to find that the same motives which have led mankind on to the higher developments of the art, obtain among animals, the motives, namely, of sympathy and fellow-feeling for another's pain. Indeed, the fact is beyond dispute that animals can feel sympathy for each other and a desire to go to each other's assistance. I will not now relate the many oft-told instances in which animals have had compassion on those of their kind which through extreme youth or age were unable to help themselves. In Ludwig Büchner's book on the love of life in the animal world, many examples have been collected. We are only concerned here with the help rendered to one another by animals in cases of illness or accident. In the London Zoological Gardens were two baboons who inhabited the same cage, and one of them was bitten in the arm by a dog-faced monkey who lived next him. The wounded ape ran howling into the middle of the cage with his arm held tight against his breast. His comrade went up to him, took him in his arms and continued to soothe him in affectionate tones until he ceased his lamentations. But the mutual helpfulness of animals is not confined to such expressions of sympathy. It is quite touching to see the way in which a dog endeavours to support the broken limb of his comrade; there is also quite a credible story of a white horse who licked a wound made by a seton on the chest of a companion which the latter could not reach owing to his short halter.

In contrast to these actual examples of mutual help, stands the fact that parrots in their antipathy against those who are sick, crippled or wounded, either of their own or some other variety of bird, hunt them down and kill them. In this case, according to Büchner, pity is extinguished by the stronger feeling of abhorrence, and the condition must be regarded as an exception to what is a very general rule among animals—a rule especially well marked among the gregarians. It is certain, says Darwin, that animals living in communities have a feeling of love for one another which is much less marked in those living solitary lives. The feeling of pity, which is shown in various instinctive actions, is taken by Darwin as the explanation of that hereditary impulse which compels social animals to the exercise of mutual helpfulness.

Since instances of neighbourly help are especially to be found in social animals, it is not surprising that these beginnings of therapeutics should be especially observed in the insects which dwell in communities. We know that these inhabitants of the insect commonwealths are endowed with a brain, which, for all its minute size, is of so fine a quality that it has been the wonder of all students of nature. The ants stand highest in the series, and among them examples of the treatment of the sick and wounded have been reported which would seem incredible were they not vouched for by competent observers such as Huber, Forel, Lubbock and others. Ants take in other ants when sick or wounded, provided that they belong to the same species, and that the disease or damage is not too severe. In the latter case they are regarded as hopeless, carried outside the ant-hill and abandoned. But even in this there is, according to the reports of the above-named observers, the greatest difference both in willingness and in dexterity between different individuals. Forel observed a colony of white ants (Formica pratensis) while in the act of changing their place of abode. On the summit of the old nest an obviously sick ant was moving with tottering steps, drooping antennæ and half-closed jaws. Other ants came up to it, stroked it and looked at it in various places and tried gently to drag it inside the nest. Suddenly one of those going out of the nest came up, pushed the others on one side and tried to seize the sick one. After many fruitless attempts it succeeded at last in doubling up its legs and antennæ, and allowed itself to be carried by its neighbour into the new nest. Moggridge saw a still more remarkable instance of the pity felt by one ant (an atta) for another. It dragged the sick one to a little spot of water, immersed it for a few moments and then took it out again with the greatest care to dry in the sun.

To these well-authenticated instances of the treatment of the sick may be added some equally interesting cases of the care of the wounded. Latreille cut off the antennæ of some workers among the yellow ants in order to see what would happen. The mutilated insects ran hither and thither as if mad, without any knowledge of their whereabouts; then some other workers from the same nest came up to them, laid their tongues on the wounded spots and let a drop of moisture fall on them. Latreille observed this with a lens, and clearly saw this process several times repeated. M. de Saint Furgeau remarks that "an ant never meets a wounded comrade of the same species without seizing it and carrying it into the nest". Lubbock's observations, however, are more detailed. He placed a wounded ant on a piece of paper; a previously marked ant passed the wounded one twelve times without taking any notice of it. Three others also ran hither and thither without attending to it, but a fifth picked it up and carried it into the nest.

The foresight of ants even goes so far as to provide for their cripples. An ant born without antennæ, which had never been seen to leave the nest, one day went out while Lubbock was watching, and was immediately attacked by some hostile ants. It lay there, badly wounded, and unable to move, when by chance some other ants from the same nest came by, examined the poor damaged creature, carefully picked it up and carried it into the nest. The same observer knew of a crippled worker in a nest of Formica fusca which was unable to feed itself owing to a contraction of the mouth and a deformity of the antennæ which were rolled up in a spiral. It was, however, taken by its companions on their expeditions, and, thanks to this provident care, lived for several months.

Throughout this work we have tried by means of a critical comparison between man and the other animals to determine what are specifically human characteristics. Now, as we have seen, there is a considerable power of medical self-help in all the more highly organised animals, as well as the power of helping each other seen among those who live in communities, even among the smallest of the small. We shall, therefore, be prepared for the conclusion that both these attainments will be manifested in primæval man whose origin lies among the great class of mammals. Our means of determining the condition of mankind in this respect are, in the first place, our knowledge of the period of childhood in human beings, and in the second, our knowledge of the life of savage peoples at the present time.

Of course the human child can only be considered in regard to this matter when it has outgrown the period of infancy, and has attained to the powers of speech, and of the free use of its limbs. Even then it is in some matters quite helpless and dependent on the goodwill of its surroundings. But it soon begins to feel for others' misfortunes. The sight of its mother's tears makes it unhappy; the cries of its brothers or sisters when in pain call forth sympathetic weeping, and soon the dormant social instinct awakes within it and compels it to take the liveliest interest in the pains of other children or adults. In a few years the child gains some knowledge of what is done by others in these and other cases of internal or external disease, and the desire to follow the example of its elders arises in the heart of the little Samaritan. We need only watch a child at play to notice how it will try to soothe a crying infant with a helpful word, how it will stroke and rub the bruised foot of another who has fallen down, or attempt to staunch the bleeding wound of a third with a handkerchief soaked in cold water.

All this has been learnt from its elders. We must therefore, if we are to find the still remoter origin of therapeutics, find out what the adult man in the savage state can do for internal or external pains. And here we are on the right path, for the unanimous testimony of all travellers and investigators tells us that savages must be looked upon as nothing more than big, simple-minded children. As there are now in existence such tribes as the Xingus in Brazil which, left behind in the march of civilisation, are still living in the Stone Age, we may rightly conclude that the methods of healing now obtaining among these are the same as those which were practised by prehistoric palæolithic man.

The commonest lesions from which savage people suffer are those produced by external injury in the course of hunting or fishing, during their wanderings over hill and dale and their feuds with neighbouring tribes.

Minor injuries are treated by the patients themselves; small wounds, and also those made by snake bites, are sucked and then tied up with leaves and strips of bark. Thorns, stings, splinters of wood and other substances are withdrawn with the finger—simple accomplishments in which primitive man does not differ much from the higher animals, such as apes. But a stage of human therapeutics much more developed than that of the animals may soon be observed. Setting of fractures and dislocations and the opening of the larger abscesses even with the most primitive instruments cannot be done by the patient himself, but require the help of another. This second party was at first the nearest and closest friend, but later with the further growth of social impulses the practice of therapeutics came into the hands of specially skilled persons, the so-called medicine-men; which fact tended more and more to the development of their surgical resources and their knowledge of the medicinal properties of certain plants.

In the following brief account of obstetrics it will be seen that in this department of therapeutics a vast difference is noticeable between man and animals. Mammals, who alone need be considered, have a specific advantage over man in the roomy construction of their pelves, which renders difficult labour one of the rarest events among wild animals. If such a case occurs, however, the female animal is abandoned, as neither herself nor any comrade of the same species can afford her the necessary assistance. "Parturition," says Brehm, "is nearly always rapid and easy, and takes place without the help or sympathy of any other creature." The opening of the membranes and the division of the cord are managed by the mother herself, and Brehm only quotes one doubtful instance in which a domestic cat is said to have bitten through the cord of the kittens of another young cat.

Among even the most primitive men the conditions are quite different. If labour is difficult, all the neighbours assemble to give counsel and help. And when medicine-men have been evolved in a tribe, they step into the breach often with the most astounding hardihood. Bartels mentions an account by an eye-witness of a successfully performed Cæsarian section done by a medicine-man in Uganda (Central Africa) on a primipara, aged twenty years.

The evolution of a certain class of special healers among the members of a tribe is what constitutes the great difference between human and animal therapeutics.

Savage races can understand external wounds and the dangers of parturition, but they are entirely ignorant of all internal disorders, and their ideas as to their causation are pure guess-work. Demons of all kinds, magicians and witches, the evil eye, worms and other creeping things were regarded as the origin of internal disorders. Nor did the medicine-men know what were the exciting causes of disease. They concealed their ignorance by noisy rattling of drums, by exorcisms and spells; but even they understood how to employ water in various ways, and how to prepare powerful drugs from plants known to themselves alone.

Among the civilised peoples of to-day we can still see remnants of the infancy of the nations in that form of medical art which still flourishes quietly among the peasantry. The savage races are now at the same point of development as regards therapeutics as were the forefathers of our own civilised peoples. The most ancient systems employed blood, spittle, urine and even excrement, as drugs; but sympathy also, and the power of the spoken word can be seen deeply ingrained in the old art of the medicine-man. While the popular medicine was thus prolonging its clandestine existence, civilised therapeutics had developed into a special branch of human knowledge. The foundations were laid in the priestly schools of medicine of Egypt and Mesopotamia; in the ancient schools of Greece, and in Alexandria, Byzantium and Rome it developed into a still fuller life; with this development and fruition the mediæval scholiasts were contented, but the Renaissance brought into the realm of therapeutics new life and new developments. Men of undying name entirely reconstructed anatomy and physiology, and laid new foundations for the healing art in the more accurate knowledge of the structure and behaviour of the human body. Chemistry and the microscope became associated as axillary to medicine, and the joyful plaudits of the people accompanied the discoveries of the learned. From the second half of the sixteenth century, and throughout the seventeenth and eighteenth, one can watch the gradual accumulation of therapeutic knowledge and skill, growing like the growth of a crystal. The eighteenth century closed with the highly significant discovery by Jenner of protective vaccination against small-pox, by means of which it at last became possible to quell one of humanity's most terrible plagues. This was, as it were, a foretaste of the many blessings which the nineteenth century, so fertile in discoveries, was to bring to suffering humanity. First the discovery of the cell by Schwann and Schleiden; then the possibility of painless operations by the aid of chloroform; Pasteur's discovery of the minute living things which induce putrefaction and the morbid infection of the body; following on this Lister's antiseptic system for the treatment of wounds; Koch's discovery of the bacillus of cholera and tuberculosis, and the possibility of obtaining pure cultures of micro-organisms; Behring's introduction of the anti-diphtheritic serum, and Röntgen's discovery of the marvellous rays which can pass through solid bodies. Truly we have here, in a single century, such a collection of therapeutic discoveries of prime importance as exceeds those of all like periods put together. Thousands of sick people who would in earlier times have succumbed to their diseases leave the hospitals cured, and still thousands of doctors are hard at work discovering new remedies for stricken man.

If to the many other specific human characteristics we are yet to add another, surely it must lie in the knowledge of the causes of disease, and in this never-resting search for new methods whereby the sufferings of unnumbered sick ones may be alleviated or entirely extinguished.

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110 of bones in body (hyoid, sternum & coccyx reckoned as 1 each) = 223

Skull

Ultimate capacity attained, relatively, man than any other animal.

In anthropoids skull sutures first close in frontal region, in the same / man first at parieto-occipital suture.

In lower animals facial bones continue to grow by the cranium ... plate bones & preponderance of face.

Among men ♀ larger capacity than ♂ (absolute cubic content) of the light & dark ... skull & more ... of forehead are secondary sex characteristics of ♀

Other distinctive characteristics of human skull

① ... direction (...) backward ... of occipital foramen.

② ... breadth of interorbital septum, greater size of ethmoidal cells.

Sutures ... occipitalis sometimes fail to close completely (...) a low race)

Sometimes a depression on the ... region ... in ... of ... & formation of ... p. ...