
Charles
Atwood
Kofoid

OUTLINES

OF

PHYSIOLOGY,

BOTH

COMPARATIVE AND HUMAN;

IN WHICH ARE DESCRIBED THE

MECHANICAL, ANIMAL, VITAL, AND SENSORIAL ORGANS, AND FUNCTIONS;

INCLUDING THOSE OF

RESPIRATION, CIRCULATION, DIGESTION, AUDITION AND VISION, AS THEY EXIST IN THE DIFFERENT ORDERS OF ANIMALS,

FROM THE SPONGE TO MAN.

ALSO,

THE APPLICATION OF THESE PRINCIPLES

TO

MUSCULAR EXERCISE,

AND

FEMALE FASHIONS, AND DEFORMITIES.

ILLUSTRATED BY NUMEROUS ENGRAVINGS.

Intended for the Use of Schools and Heads of Families.

BY J. L. COMSTOCK, M. D.

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PREFACE.

Perhaps the author of the following work cannot do better than to make an extract or two, by way of Preface, from Dr. Dick, "On Mental Illumination and Moral Improvement," in which he has shown the want of, and the advantages to be derived from, a treatise on Comparative and Human Physiology for the instruction of youth. That a work on these subjects is wanted, it is believed every intelligent Instructor is ready to acknowledge; and whether that here offered to the public will serve the required purpose, must now be submitted to the judgment of others.

"It is somewhat unaccountable," says Dr. Dick, "and not a little inconsistent, that while we direct the young to look abroad over the surface of the earth, and survey its mountains, rivers, seas, and continents, and guide their views to the regions of the firmament, where they may contemplate the moons of Jupiter, the rings of Saturn, and thousands of luminaries placed at immeasurable distances,— * * that we should never teach them *to look into themselves*, to consider their own corporeal structures, the numerous parts of which they are composed; the admirable functions they perform; the wisdom and goodness displayed in their mechanism, and the lessons of practical instruction which may be derived from such contemplations."

Again, the same author, speaking of subjects for Natural Theology, enumerates "particularly, the curious and admirable mechanism displayed in the construction of animated beings, from the microscopic animalcula, ten hundred thousand times less than a visible point, to the elephant and the whale—the organs of mastication, deglutition, digestion, and secretion, all differently contrived, according to the structure of the animal, and the aliments on which they feed—the eyes of insects, and the thousands of transparent globules of which they consist—the metamorphoses of caterpillars and other insects, and the peculiar organization adapted to each state of their existence—the numerous beauties, and minute adaptation in the wings, feet, probosces, and feathers, of gnats and other insects—the respiratory apparatus of fishes, and the nice adaptation of their bodies to the watery fluid in which they pass their existence—the construction of birds. their pointed bills to penetrate the air, their flexible tails serving for rudders, the lightness, strength, and tenacity of their feathers, and the whole structure of their bodies adapted to the air in which they fly, and the food by which they are sustained—above all, the wonders of the human frame, the numerous parts of which it is composed; the hundreds of bones, and muscles, the thousands of veins and arteries, glands, nerves, and lymphatics—the heart with its ventricles and auricles, the brain, with its infinity of fibres, the lungs with their millions of vesicles, * * —these and thousands of similar objects, adaptation and contrivances will afford ample scope for expatiating on the power, wisdom, and intelligence of the Almighty Creator, and the benevolent contrivances which appear throughout every part of the universal system."

"One great practical end," says he, "which should always be kept in view in the study of physiology is the invigoration and improvement of the corporeal powers, and functions, the preservation of health, and the prevention of disease."

All these, and many other subjects of a similar nature are noticed in this volume, and if the author has succeeded in adapting his language and manner to the understanding of youth, he cannot but hope that this treatise will be the means of greatly increasing the knowledge of the rising generation, in one of the most interesting and useful departments of natural science; and at the same time of directing their attention, especially that of females, to the preservation of their forms, and their health, by avoiding habits and fashions, which at once deform their persons and ruin their constitutions.

To avoid the necessity of frequently quoting authorities, we subjoin a list of authors which have been consulted in the progress of the more strictly physiological part of this work, the application of these principles towards the sequel, being chiefly the original suggestions of the author.

Among the authors consulted, we are especially indebted to the "Bridgewater Treatise, on Animal and Vegetable Physiology," by Mr. Roget. From this, much matter and many cuts have been taken.

Dr. Ticknor "On the Philosophy of Living," Harpers' Family Library, No. 77, contains a mass of sound and valuable observations on many of the various subjects on which it treats, but was unknown to the author, until too late for him to take much advantage from the matter it contains. Dr. Alcott's little book, "The House I live in," is an original and curious treatise, and is well calculated to arrest the attention of children, and to instruct them with respect to the structure of their bodies.

Dr. Combe's Physiology, No. 77 Harpers' Family Library, is a highly valuable and sufficiently popular work on the subject, and ought to be read by every parent, and school teacher.

The author expected to have inserted at the close of the volume, a short treatise on the peculiar application of Callisthenics, guided by music, as an exciting and proper exercise for young ladies, but have to regret that it was not received in time, and therefore must be deferred until the next edition. It is by Miss C. E. Beecher.

Hartford, Connecticut, July 1836.

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ANIMAL PHYSIOLOGY.

The term physiology signifies "a discourse on Nature," and hence is applicable to an explanation of the laws which govern the growth of vegetables, and the crystalization of minerals, as well as to a discourse on the functions of animal life.

Animal Physiology is divided into two distinct departments, viz., Comparative and Human. Comparative Physiology is a discourse or treatise, on the corporeal functions of the inferior animals. Human Physiology explains the corresponding functions of Man.

In pursuing the subject of Animal Physiology, the student will constantly be reminded that nothing has been left undone, even to the minutest detail, which could in any way advance the welfare and comfort of living existences taken as a whole. On the contrary, he will find that each animal is placed in a situation most congenial to its own organization and capacities, and that it is provided with instruments and endowed with senses and capabilities exactly befitting the condition in which it is placed. The earth worm, for instance, has no use for eyes, since it never voluntarily comes to the light; nor for hands or wings, since these would be worse than useless in the place and manner of its existence. Nor has the fish any use for lungs or

What is the meaning of the term Physiology? How is Animal Physiology divided? What is said of the adaptation of the organs and capacities of animals to their wants?

feet, since its organization prevents it from breathing the air or walking on the earth. On the contrary sight, instruments for rising in the air, and for walking on the earth, are absolutely necessary for the higher orders of animals, otherwise they would be unable to accomplish the ends for which they were created.

The student will also be able to notice, that the Creator has employed the strictest economy with respect to animal organization, every individual being in possession of all the instruments and means with which to accomplish the ends of its creation, but no more. No superfluous organs are bestowed on any, even of the favorites of nature, but always a sufficiency for every destined purpose, both with respect to number and power.

In the details of the habits and physiological functions of some of the lower orders of insects, the pupil will probably often find himself greatly excited by curiosity, but it is hoped that he will not therefore neglect or forget the chief design of this work, which is to bring him to the acknowledgement and adoration of a Great First Cause, by making him acquainted with the mechanism and functions of His animated creation.

What is said with respect to the economy employed in animal organization?

PART I.

MECHANICAL FUNCTIONS.

The lowest orders of the animal creation possess neither bones, nerves, sight, or hearing. Some of them are fixed, while others have the power of locomotion, though they possess neither eyes nor ears to direct them in their movements.

Some of the *medusa* tribes can hardly claim the rank of organized beings, appearing when alive like a transparent jelly, and when dead leaving nothing but a limpid watery fluid into which they dissolve by decomposition.

The *sponges* have no higher place as animal existences, being fixed to the bottom of the sea, and having no sensation and no motion, except that by which they obtain their food.

Many other orders, as the Hydra, Vorticella, and Infusoria, are but little removed from these in organization or capacity. Some of these tribes are so little above vegetables in their organization, that they may be preserved like the seeds of plants. The *Rotifer*, or wheel animal, which lives and moves in water, may be taken out and dried, when it appears like a grain of dust, and may so be kept for any length of time. But if placed in a drop of water it soon shows its vitality by its brisk voluntary motion, and this alternate life and death the little animal passes through any number of times without

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What is said of the senses of the lowest orders of animals? What is said of the medusa? What is said of the sponges? What is said of the rotifer, or wheel animal?

injury. In like manner the *Gordius*, a worm resembling a horse-hair, which inhabits stagnant pools, may be dried, when it has no more signs of life than a piece of wire, and again revived to life by immersion in water. This animal is supposed by many to have derived its existence from a horse-hair accidentally falling into the water. But it is hardly necessary to say that such mistakes call for a more general knowledge of Animal Physiology.

We shall begin our physiological descriptions with the most simple organizations, and gradually passing through those which are more and more complex, finally come to that of our own species.

SPONGE.

The remains of this animal are in such universal use, and consequently so well known as to require no general description. It belongs to an order of animals called *Zoophytes*, which also includes the Corals, the Polypi, and several other races which are only a single grade above vegetables. This order indeed appears to be the connecting link, between the animal and vegetable kingdoms. The term Zoophytes signifies "animated plants."

The Sponges, of which there are manv species, are all marine animals, living at the bottom of the sea, where they are firmly attached to rocks and stones.

These productions in general appearance much more nearly resemble plants than animals; but in their internal organization and structure they differ entirely from vegetables. Their animal nature is clearly shown by chemical analysis, and by the voluntary motion of some of their parts which resembles respiration.

Every part of the surface of a living Sponge presents to the eye two kinds of orifices; the larger having a rounded shape, and generally a little raised on the mar-

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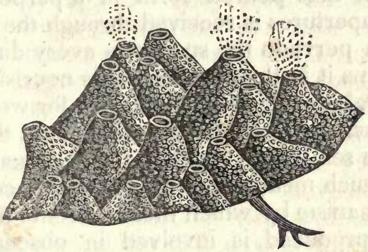
What is said of the gordius? To what order of animals does the sponge belong? What is the meaning of the term zoophytes? How is the animal nature of the sponge indicated? What is said concerning the orifices of the living sponge?

gins; the smaller are much more minute, running in all directions, and constituting what are termed the *pores* of the Sponge.

Fig. 1.



The structure of the living Sponge is shown by fig. 1, where it will be observed that the larger orifices are much more conspicuous than in the dead one, these elevated parts being usually almost obliterated by the death of the animal, and by pressure in packing it for market.

From these orifices, Dr. Grant has discovered, that in the living Sponge there is a constant stream of the fluid in which the animal is immersed. A small piece of living sponge being placed in a watch crystal filled with sea water and the whole placed under a microscope, Dr. Grant perceived some motion among the opaque particles of the fluid. "On moving the watch glass," says he, "so as to bring one of the orifices on the side of the sponge fully into view, I beheld, for the first time, the splendid spectacle of this living fountain, vomiting forth, from a circular cavity, an impetuous torrent of liquid matter, and hurling along, in rapid succession, opaque masses, which were strewed every where around. The beauty and novelty of such a scene in the animal kingdom long arrested my attention, but after twenty-five minutes of constant observation, I was obliged to withdraw my eye from fatigue, without having seen the torrent for one instant change its direction, or diminish, in the slightest degree, the rapidity of its course. I con-

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What was the experiment by which Dr. Grant proved that sponge is an animal?

tinued to watch the same orifice, at short intervals, for five hours, sometimes observing it for a quarter of an hour at a time, but still the stream rolled on with a constant and equal velocity."

The water thus poured forth in a perpetual stream from these apertures is received through the millions of pores which pervade the sponge in every direction, and by this means it is that the animal is nourished. Even fish of several pounds weight will live for weeks, or perhaps months, upon no other nourishment than what is contained in sea water, so that the sustenance of the Sponge by such means presents nothing uncommon.

The mechanism by which these currents of water are constantly produced, is involved in obscurity. It is however supposed to consist of *cilia*, or small hairs lining the inner surfaces of the tubes, the motions of which propel the water through them.

These currents are readily made apparent by placing the living animal in a shallow vessel of sea water, and strewing a little powdered chalk on the surface, the motions of which make that of the water plainly visible, as shown in the figure.

Manner in which the young Sponges are disseminated. In all parts of creation, whether of the vegetable or animal kingdoms, there is provided effectual means for the dissemination of the species. (For an account of the dissemination of the seeds of plants, see the author's Introduction to Botany.) For the distribution of the Sponges the method provided is singularly curious and interesting, and at the same time displays in a most striking manner the care which the Creator has taken to perpetuate his most humble works.

On examining certain parts of the Sponge, which when living and wet, is nearly transparent, there is found a multitude of yellow opaque spots, visible to the naked eye. These, when examined with a microscope

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Whence comes the water which is poured forth from these apertures? How does the sponge obtain its nourishment? By what means is it supposed the currents through the apertures are produced? How are the currents made apparent? In what manner are the young sponges distributed?

are ascertained to be the eggs, or *gemmules* of the future animal. In a few months they enlarge in size, and

Fig. 2.

assume an oval or pear-shaped form, and are covered with cilia, or hairs, as shown by fig. 2. They then become detached from the parent one after another, and float or swim along with the current, always carrying their broad and rounded extremity forward. While thus suspended in the water, the cilia, with which they are covered, are in rapid and perpetual motion, giving them a slow impulse forward. In these movements if they strike against each other, or meet with any other impediment, they avoid the difficulty as other animals do, by turning aside and then proceeding in their former course. In some instances when two of these little animals happen to meet, they adhere to each other, and in a few days no line of distinction can be observed between them, the two being united into one individual, and so continue to grow during the rest of their lives. This union appears to be analagous to that of engrafting in plants, only with respect to the young Sponges it is voluntary.

After leaving the parent, these little animals float about for a day or two, when finding a suitable place, they fix themselves firmly to a stone or rock, and there gradually increase to the adult size, and in their turn send forth their progeny as above described.

These facts of course could only have been ascertained by placing the parent sponge in a vessel of sea water. Many of these observations were made in vessels no larger than watch crystals.

POLYPIFERA.

The term *Polypifera* is the name of the order, and means animals bearing *polypi*. The name *polypus* de-

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In what manner do they move through the water? What is said of the union of two of these animals into one? What does this union appear to be analagous to? What becomes of the young sponges after being detached from their parents? What is the meaning of the term Polypifera?

notes a mass of these animals, and *polype* a single animal.

This order embraces many species of very simple animals, chiefly inhabiting salt water. Some of them are exceedingly minute, while others are several inches in length.

Each of these curious animals is formed of a tube, attached by its lower end to some solid substance, the upper end being surrounded by a number of flexible fibres or arms, called *tentacula*. These tentacula radiate from a common centre, in the midst of which is the mouth of the animal. A single polype is represented by fig. 3. The tentacula are eight in number, but in some species are much more numerous. The arrangement of these, on the margin of the mouths of the animals, bears a considerable resemblance to a flower with radiating petals, as the daisy and aster.

Fig. 3.

Polypi for the most part reside in cells, or tubes, composed of horny or calcarious matter, in the form of sheaths, which enclose the body of the animal, leaving the tentacula and mouths free for action above their margins. Sometimes these tubes are joined together endwise, like the branches of a tree, leaving lateral apertures for the protrusion of the tentacula of each animal, as shown by fig. 4. In this figure each bundle of radiating fibrils along the branches represents the tentacula of a polype.

Fig. 4.

The well known marine substance called *coral* is the product of the labors of certain species of these industrious animals. A great number of species are perpetually employed in the construction of different varieties of this substance. Coral is composed of calcarious particles, with a portion of animal, and occasionally coloring matter elaborated into a solid, or porous form, by these animals.

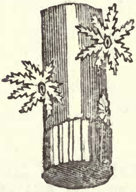
What does polype mean? Polypus? Polypi? Describe a polype? What are tentacula? What common flowers do these animals resemble? What does fig. 4 represent?

Fig. 5.

A branch of red coral is represented by fig. 5, with the little animals at work on it.

Fig. 6 is a part of one of these branches magnified, and showing the tentacula expanded as when the animal is under water; and also in the contracted state, as when the branch is removed from the fluid.

Fig. 6.



These structures are fixed permanently to stones or rocks at the bottom of the ocean, which in warm climates are often covered with them to a great extent.

It has been ascertained that these fixed zoophytes are multiplied like the sponge, by gemmules, in the manner similar to that already described.

The mechanism by which some species of polypi produce a constant current of water towards their mouths is so curious that we should not do justice to this subject without describing it.

When the tentacula are expanded, small particles in the water may be observed constantly tending towards the mouths of these animals. This motion of the water is not produced by the motion of the tentacula themselves, but is the effect of the rapid vibration of minute cilia placed along their sides.

In the species called *Flustra Carbacea*, the tentacula in each polype are twenty-two in number, and along the lateral margins of each, there is a single row of cilia extending from the base to the termination. This animal is represented in the posture of forming the current by fig. 7. Fig. 8 is a portion of a tentacula highly magnified, to show the cilia, and the manner in which the current is produced. From the positions in which the cilia stand, it will be observed that their mo-

Fig. 7.

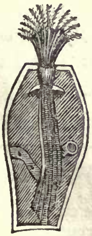


Fig. 8.

tions are ascending on the one side, and descending on the other. By these contrary motions the water would be carried around the tentacula in a longitudinal direction, provided it was detached. But many of them being placed around the mouth of the polype, with the motions of the cilia on the outside ascending, and those on the inside descending, it is obvious that the effect is to produce a perpetual current of the fluid to the mouth of the animal, and as the polype subsists on minute insects, and particles of decomposing matter which it takes from the water, this wonderful mechanism is evidently designed to bring food to its mouth.

The vibrations of these cilia, when the animal is vigorous, are too rapid to be distinguished by the eye, even when assisted by a microscope; and it is only when it becomes languid, and the motions diminished, that they can be seen. But the effect can be discovered by the naked eye, by the motions of floating particles in the water.

HYDRA.

To the Zoophytic order belong another tribe of animals called *Hydra*, which on some accounts are the most singular and curious productions of nature. This animal consists of a stomach with tentacula for catching its food, and nothing more. It exhibits not a trace of either brain, nerves, or organs of sense of any kind; nor is there any parts corresponding to lungs, heart, arteries, or veins, or any other vessels whatever, all those organs so essential to the existence of other animals being entirely wanting.

Mr. Trembley, of Geneva, who watched the actions of these animals with unwearied patience for days together, has given the following curious account of what he discovered.

What ornamental substance is made by polypi? What is composition of coral? In what manner are polypi multiplied? Explain fig. 7 and 8. In what manner do polypi produce a constant current of water towards their mouths? What purpose does this current answer to the animal? What parts pertaining to other animals are wanting in the hydra?

The Hydra are fresh water animals of very diminutive size, and are generally fixed to some solid body, as a stick or leaf, by the tail, though they have the power of detaching themselves and of moving slowly through the water. They are carnivorous animals, and though they do not chase their prey, they devour all kinds of living creatures coming within reach of their tentacula, which they can manage. Worms longer than themselves they devour, by first doubling them together by means of their long arms.

Fig. 9.

A Hydra in the act of gorging a worm of twice its own size is seen at fig. 9. The poor worm is completely entangled within the folds of the tentacula, while the voracious animal, with expanded mouth is absorbing its juices, so as to bring it within the capacity of himself.

It sometimes happens that when two of these animals have siezed the same worm by different ends, a violent struggle ensues between them, and the stronger, having gained the victory, not only swallows the object of contention, but his antagonist along with it.

Fig. 10.

Fig. 10 represents such a case, the tail of the swallowed animal protruding from the mouth of the victor. But the former soon extricates himself from this dilemma, without having suffered the least injury, and indeed is often the gainer, by retaining a portion of the object of contention to himself.

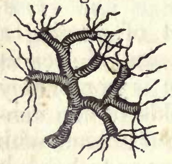
But the most singular, and indeed, astonishing facts which Mr. Trembley ascertained with respect to these animals, are, that they *have the power of repairing all sorts of injuries and mutilations inflicted on them, and of still digesting their food, and of recovering a good degree of health after being turned wrong side out.*

If their tentacula be clipped off they soon grow again. If the animal be cut in two, across the middle, there will sprout forth a new head from one part, and a new tail from the other, together with such portions of the body in each case as were wanted to make a good and

What is said of the power of the hydra to reproduce mutilations?

complete animal. If the head of the Hydra and a portion of the body be divided by a longitudinal section, the animal is thereby the gainer, for the divided parts form two heads instead of one, with complete sets of tentacula for each mouth, and thus he can enjoy the satisfaction of eating with two mouths at the same time. If the head be split into half a dozen parts, each part will form a new head with mouth and tentacula to match, the whole being united to one body. Fig. 11 represents a seven headed monster, the result of several mutilations and divisions of one of these protean creatures.

Fig. 11.



Sometimes of its own accord a Hydra will split in two parts lengthwise, each division becoming independent of the other, and growing to the same size, and attaining the same organs as the original animal.

Mr. Trembley also found that any portion of one Hydra might be engrafted on another, in the same manner that pieces of India rubber may be joined, that is, by cutting their surfaces and pressing them together. By this means they would unite and become a compound animal. Thus many heads may be united to one body, or many bodies to one head; and so on the contrary when one Hydra is introduced into the mouth of another so that their heads are kept in contact, for a time, they unite and become one individual animal.

Even the figures of other animals, as quadrupeds, or man, might be constructed in this manner, though every where covered with moving tentacula.

PENNATULÆ.

Another form under which polypi exist, is that called *Pennatula*. This is called *sea pen*, from its re-

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How may parts of these animals be engrafted upon each other? Give some account of the pennatulæ.

Fig. 12.

Fig. 13.

semblance to a quill. It consists of a calcareous stem, the upper end of which has a series of branches on each side, resembling the filaments of a feather, and in the end of each of which resides an animal, the whole being represented by fig. 12. Some of the polypi are seen magnified in fig. 13.

These animals are not fixed like those we have described, but float along with the currents of the ocean, having little or perhaps no power of locomotion, though the movements of their tentacula are sufficient to prevent their sinking, and to enable them to rise slowly in the water.

The Pennatulæ must be considered as a mass of distinct animals aggregated together to form, in many respects, one individual. In Botany the class *Syngenesia* presents many distinct flowers assembled together to form a single compound individual, as the Thistle and Dandelion, each individual being on the same receptacle, and supported by the same stem. So far, therefore, as aggregation is concerned, there is a strict analogy between a compound flower and the Pennatulæ. But while each individual of the Syngenesian flowers receives its nourishment through the same stem, the corresponding part of the compound animal, which is a common stomach, receives its nourishment through hundreds of mouths, so that here the analogy fails.

In the Pennatulæ each mouth leads into a separate stomach, whence the food, after digestion, passes into several channels, which proceed in different directions from the cavity of each stomach, dividing into many branches, and being distributed over all the surrounding portions of flesh. These branches communicate with similar channels proceeding from the neighboring stom-

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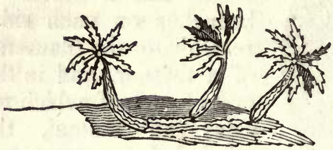
What is said of the stomach of the pinnatulæ?

achs; so that the food which has been taken in by one of the mouths, contributes to the general nourishment of the whole mass of aggregated polypi. These curious facts were discovered by Cuvier, and are represented by fig. 14, where the stomachs of the three polypi, with their tentacula spread out, are seen communicating at their lower extremities with a canal, which thus becomes a common stomach to the whole colony.

Fig. 14.



INFUSORIA.

The Infusory insects, or Infusoria, were so named from the circumstance that they always appear during the warm seasons, in water in which vegetable or animal substances have been infused. Hence they exist in stagnant ditches and pools of water, every where during the summer and autumn. These animals are generally too minute to be distinguished by the naked eye, and therefore it is to microscopic observations that we owe our knowledge of their existence and habits.

Former writers on natural history have called these animalcula, *monads*, and have regarded them as occupying the very lowest rank of animal creation. Some have even expressed doubts whether they really belong to the animal kingdom; but would rather consider them as *molecules*, or the elementary particles of organic beings, separated from each other by chemical decomposition, but retaining the power of voluntary motion.

The Infusoria, during the last century, have been the object of very laborious microscopical research; no naturalist considering himself accomplished until he had spent a considerable portion of time in observing the motions and studying the characters of these animated particles. Many theories, conjectures, and disputes

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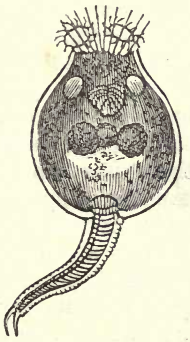
Whence do the infusoria derive their name? What was the former name for infusoria?

arose in consequence of such observations; some contending that Monads were merely living globules without animal organization, but capable of uniting into animated masses, and thus of forming the flesh and blood of organized creatures. According to this doctrine, all other animals, including us, human beings, are nothing more than great congregations of Monads. That great naturalist, Buffon, was the author of this hypothesis, and therefore it is hardly necessary to say that it had many profound advocates. It would neither interest nor instruct the student in physiology to give a detail of other opinions concerning these living motes, since the more perfect microscopes of later philosophers have shown that these animals are regularly and carefully organized, having not only a stomach, but such other organs as fit them for their station in life.

Wheel Animal.—The *Rotifera*, or wheel animalcula, is one of the Infusoria race, though larger than the monad. Fig. 15. represents an animal of this order, magnified 380 times its natural size. Its name is derived from the apparatus which it possesses for creating a circular current in the water. The organs by which this effect is produced are two in number, and are seen at the top of the figure. They are situated on the head, but do not surround the mouth, like the tentacula of the polypi. They consist of circular disks, the margins of which are fringed with rows of cilia, bearing a resemblance to a crown wheel in machinery. These wheels appear to be incessantly revolving, and generally in one direction, giving to the fluid a rotary impulse, which carries it around in a continual vortex. The constancy of this motion would seem to indicate that it is as necessary to the life of the animal as respiration is to the higher orders; the revolu-

Fig. 15.



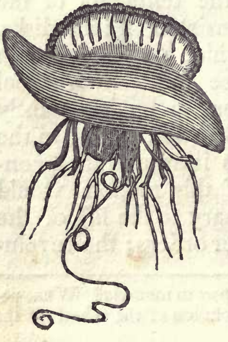
What was the opinion of Buffon with respect to monads? What peculiarity do the rotifera exhibit? Is the revolution of the wheel of the rotifera real, or only apparent?

tions never ceasing so long as the animal is alive. This motion, when considered merely with respect to the mechanism by which it is produced, cannot but excite intense curiosity; for we have no analogy in the organization of any other animal with which to compare it, nor from all we know on the subject should we believe it possible that a circular motion of a part of an animal could be continued for any length of time in the same direction. What animal or other substance will withstand perpetual twisting in one direction? and yet if there is no deception with respect to the revolutions of these wheels, one would be led to suppose such a substance. The appearance is undoubtedly that of a constant revolution of the wheel itself, but recent observers, however, believe it to be only apparent, and the deception to be caused by a peculiar and exceedingly rapid motion of the cilia on the margin of the wheels.

Physalia, or Portuguese Man-of-War.—This animal greatly excels in size those we have heretofore described, but scarcely ranks above them in organization; its powers of motion being merely such as to enable it to rise and sink in the water.

It consists of a large air bladder, of perhaps a quart in capacity, which floats on the surface of the ocean, and which serves it as a sail. Below this there is a bundle of tentacula, with a mouth and stomach, the whole appearing more like an inorganic mass than a living creature, fig. 16. These animals are very abundant in most parts of the Atlantic ocean, where they appear at a little distance like so many large soap bubbles floating along before the wind, only that they present the most vivid hues of color. "Nothing, it is said, can exceed the beauty of the spectacle presented by a numerous fleet of these animals quietly sailing on the smooth surface of a tropical sea. Whenever the surface is ruffled by the slightest wind, they suddenly

Fig. 16.



absorb the air from their viscicles, and thus, becoming specifically heavier than the water, immediately disappear by sinking into the depths of the ocean. By what process they effect the absorption and reproduction of the air in their bubbles, yet remains to be discovered."

Echinus.—The shell, or skeleton of this animal is well known under the name of *sea urchin*, or *sea egg*, and is represented by fig. 17. Its form is spheroidal, resembling that of an orange. On the outside there are a great number of tubercles arranged in double lines in beautiful symmetry, from the mouth downwards, and forming meridian lines from one pole of the sphere to the other. Each of these are little balls, smooth, and polished on the outside, and which serve for the articulation of the bases of the spine, with which, when alive, this animal is covered. When examined by a magnifier, it will be seen that the end of the spine has a socket exactly fitting this ball, thus forming the ball and socket joint, which has a universal motion. The head of the spine is furnished with a capsular ligament to keep it in place, and around which are sets of radiating muscular fibres, by which motion in all directions is given it.

Fig. 17.

The shell is constructed of calcareous matter, and is composed of oblong six sided plates, accurately fitting each other, and arranged in rows like a mosaic pavement, as seen by fig. 18. There is a wonderful provision by which the globular shell of the Echinus is enlarged according to the wants of the internal animal, for some species grow from the size of a pins' head, to six or eight inches in diameter. This is accomplished by dividing the shell into a great number of six sided

Fig. 18.

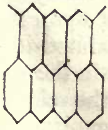


Fig. 19.

How are the spines of the echinus fitted to its shell? What motion have these spines? In what manner is the house of the echinus enlarged?

pieces, as seen by the above figure, and of allowing constant additions to be made to the margins of these pieces. In this manner it is obvious that the whole structure would be enlarged without changing the shape. Fig. 19 shows the appearance of these plates when magnified.

By employing his spines as feet, or levers, this animal is capable of making considerable progress along the bottom of the sea.

MOLLUSCA.

The *Mollusca*, as the name signifies, are animals with soft bodies. They have neither bones, nor hard parts corresponding to the bones of the higher orders of animals. This order includes all those animals which live in calcareous habitations, constructed by themselves, and so far as they are popularly known, are called *shell fish*, as the Oyster, Muscle, and Clam.

The shells of the Mollusca are formed either of one or of several pieces, which are called *valves*. Those of one piece are called *univalves*, those consisting of two pieces are termed *bivalves*, and those of more than two pieces are *multivalves*.

This order presents a vast number, and variety of individuals, many of which have been minutely examined, and arranged into species, genera, and orders, forming a distinct object of study, entitled the science of CONCHOLOGY. It is proper, however, to state, that this science is not founded on the physiology of the animals which inhabit these shells, but on the forms and peculiarities of the shells themselves. This arose, originally, from the necessity of the case, for in a great many instances the shell is readily obtained, being cast upon the sea shore, empty, while the animal which inhabited it is never seen, because while alive it lived only in the unfathomable depths of the ocean. But could the classification have been founded on the animal organization, it is obvious that this method would be practicable only to a few, since the animals could not be preserved for

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What does the term mollusca signify? What are molluscous animals?

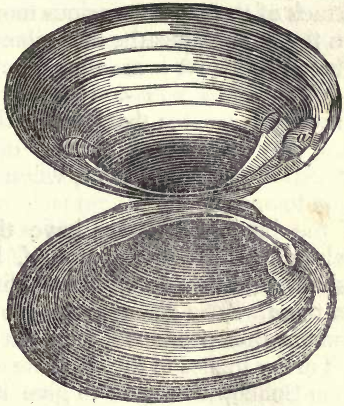
any length of time. Besides, it being the object of the conchologist to collect, arrange, and preserve some of the greatest beauties which nature has presented to us, in the form of shells, this object could be effected only by an arrangement founded on the shells themselves.

Without going further into the general subject of this order, we shall examine a few individuals as types of their general organization, so far as this is known.

ACEPHALA.

This term means without head, and common examples exist in the *Muscle*, *Oyster*, and *Scollop*. These are *bivalve* shells, the two valves being united at the back by a hinge, and connected by teeth which lock into each other. Besides these, the two shells are connected by

Fig. 20.



means of a strong ligament in form of a short pillar, a b, represented in fig. 20, which are the two valves of a species of *Unio*, or fresh water Clam. These ligaments are very distinct in the common species of *Venus*, called *Round Clam*, seen in all the fish markets of the Atlantic states. These ligaments hold the two valves together with great force, so that when the animal is alive it is difficult to separate them without a knife.

There is also in all bivalve shells, a cartilage, generally of a dark color, situated between the two valves at the hinge, the office of which is to force them asunder.

Now as the nourishment of the animal requires that the shell should be kept open to a small distance for the admission of the water, and as its safety might require it to be closed suddenly, provision is made for this action, by a strong muscle passing from one of the valves to the other, and by which they are instantly brought together at the will of the animal.

Thus we see that the Creator has furnished these animals with every comfort and convenience which it would be possible for them to enjoy in the situation in which they are placed. A pair of hard shells to protect them—a cartilage, answering as a spring to keep these shells a little open, to admit the water from which they obtain food and air—a ligament, to prevent the shells from opening too widely, in which case the sand and mud would destroy the animal—and a muscle by which he can in an instant close his doors, and become proof against the attack of the most voracious monsters of the deep. When the animal dies the muscular force ceases, but the cartilage retains for some time its elasticity, and the ligament continues its adhesion to the valves, and from these circumstances it is that we find the shells cast upon the shore, only open to a certain distance, until after the destruction of the ligament, when the cartilage throws them quite open.

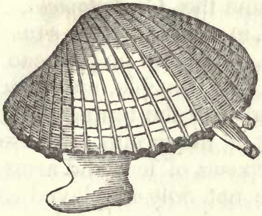
Several of the bivalve Mollusca have the power of giving themselves a considerable motion, by suddenly closing their shells, and thus forcibly expelling the water from between them. The reaction of the fluid on the temporary current thus produced, may often be seen to throw the shell many inches in the opposite direction.

The common Scollop contrives to give itself motion, even on the shore, by suddenly and forcibly closing its valves; one of which, striking against some impediment, as a pebble, acts as a spring, and thus throws it to a little distance. It is said that when left by the tide, they often reach the water in this way.

In bivalve shells, when the animal is alive, how are the shells kept open? What prevents them from opening too widely? How are the shells suddenly brought together? Why are bivalve shells generally found only partly open on the shore? In what manner do some of these animals give themselves a sudden motion in the water? How is it said the scollop contrives to move on the shore?

The Cardium.—Other bivalves are furnished with an instrument shaped somewhat like a foot and leg, with which they give themselves a slow, but continued motion through the sand. The form of this instrument in the *Cardium* or cocle, is shown by fig. 21. This organ is a hard mass of muscular fibres, woven together in a very complex manner, and capable of motion in every direction. By retracting, and then forcing this instrument forward, a contrary motion is given the shell, for the same reason that a boatman, in shallow water, pushes his craft along with an oar from the stern. With his foot the Cardium also contrives to bury himself to any depth he chooses in the sand or mud. For this purpose the leg is elongated, and by a sort of vermicular motion is forced deep into the sand; then turning up the toe, and forming it into a kind of hook, the animal, by an alternate retraction and elongation of the leg, raises and depresses the shell, and by the resistance of the sand on the hook gradually draws the whole downwards. By a reverse of this motion, that is, by first drawing up the foot, and then pushing it downwards against the sand, the shell is again forced towards the surface. In this manner does the Cardium bury itself in the sand, in the course of a minute or two, to avoid danger, and as quickly emerges from its hiding place when the danger is past.

Fig. 21.



With an instrument similar to that belonging to the Cardium, many species of bivalve mollusca move along on the sandy bottoms of the water in which they live, with greater or less facility. In nearly every still pond, or river, the furrows left by the passage of Unios, or fresh water clams, may be seen running in every direction, and made in this manner.

In what manner does the cardium move? How does the cardium bury itself in the sand?

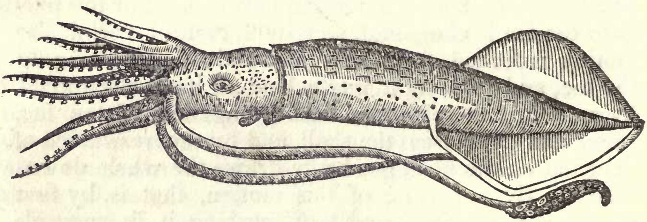
CEPHALOPODA.

Among the mollusca, next to the acephala, in the order of organic developement, come the *Cephalopoda*, a name which signifies *head-footed*, in allusion to the situation of the organs of locomotion, which are on the head.

These parts consist of many long, flexible, muscular legs, or fleshy processes, situated like the tentacula of the polypi, around the opening of the mouth. These members answer the double purposes of legs and arms, of feet and hands, for they are not only employed as organs of locomotion, but as those of prehension also.

The Cuttle Fish.—One of these most singular animals is represented by fig. 22, being one of the *Sepiæ*, or Cuttle fish tribe, called *Loligo*, or Calamary.

Fig. 22.



In addition to the prehensile powers of these tentacula, by which they grasp objects with great force, by twining around them, they also have the power of adhesion by means of suckers, in the form of tubercles placed along their inner sides, as shown in the figure.

"So great is the force" says Mr. Roget "with which the tentacula of the Cuttle fish adhere to bodies by means of this apparatus, that while their muscular fibres continue contracted, it is easier to tear away the substance of the limb, than to release it from its attachments. Even in the dead animal," he continues, "I have found that the suckers retain considerable power of adhesion to any smooth surface to which they may be applied."

What is the meaning of the term cephalopoda? Why is this term applied to certain animals? Give some description of the cuttle fish.

Besides the tentacula, the Cuttle fish is furnished with a pair of arms, with the ends expanded and also furnished with suckers. These long members are employed as cables, and the suckers as anchors, by which these animals fix themselves firmly to rocks during violent agitations of the sea, and without which they would undoubtedly sometimes be dashed to death against the rocky shores. These long arms are not employed by the animal in swimming, the short ones being used as oars for the purpose of impelling this singular creature, not forward but backward, for in this manner do all the Cuttle fish tribe swim. Some of them are 15 or 20 feet long.

ARTICULATA.

The animals now to be noticed are articulated, or are provided with joints, by means of which their hard and inflexible parts become the instruments of motion. Hence this division includes animals having joints, whether large or small, and by which they are at once distinguished from the mollusca, where nothing analagous to articulation exists. This division contains a vast assemblage of living beings, including the Insects, Fishes, and Quadrupeds. The limits of this work will however allow an account of the physiology of only a few of the most curious and important.

CRUSTACEA.

The *Crustacea* are animals encased in a compact, crusty frame-work, composed chiefly of carbonate of lime, as the Lobster, and Crab.

The joints of Crustaceous animals are constructed in the most admirable manner, by which in most cases every part of the limb can be moved in all directions. They have either three or four pairs of legs, each of which is divided into five pieces, by as many joints. On each side of the head there is a long, and often very

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Why are certain animals denominated articulata? What races of animals are articulated? What are the crustacea? What parts of these animals are called antennae?

delicately formed instruments called *antennæ*, or feelers. These, in the Lobster are many inches in length, and composed of a great number of rings, articulated to each other in a most beautiful manner, and furnished with minute muscles on the inside, so as to give them motions in all possible directions, at the will of the animal. Some naturalists have supposed that these are not merely the organs of feeling, but that they might also serve for that of hearing, or smelling also.

As the coverings of the Crustacea are composed of hard unyielding substances, it is obvious that the animal within must be restrained in its growth, unless some means were provided by which it could relieve itself from such confinement, and accordingly, as nature every where provides for the comfort and perpetuity of the lowest, as well as the highest of her works, so in the case before us, the animal has the power of casting off its old covering when it becomes too small, the same being soon after replaced by a new one, of ample dimensions.

The pocess of casting the Shell.—These animals cast their shells once a year; and the manner in which the Lobster, as an example, draws himself out of his old case, his condition afterwards, and the incipient formation of the new shell, has been particularly investigated by the celebrated Reaumur.

The Lobster, for some time before the process begins, becomes exceedingly restless, undoubtedly from the pain excited by the pressure of its shell, and thus the poor animal is under the necessity of making violent efforts to relieve itself. By this means the shell is burst open along the chest, between the insertion of the legs. The claws are the first parts withdrawn from their sheaths, and next the feet, both of which seem to require much muscular exertion; the head next throws off its case, together with the many jointed antennæ, and the two eyes are disengaged from their horny pedicels. In this operation, not only the complex apparatus of the

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What provision has nature made for the growth of the crustacea? In what manner does the lobster cast off its crusty covering?

jaws, but even the horny cuticle and teeth of the stomach, are all cast off along with the shell; and last of all the tail is extricated. The whole process is not accomplished without long continued, violent, and painful efforts. Sometimes the legs are lacerated, or even torn off in attempting to withdraw them from the shell, and not unfrequently in the younger animal, death follows before, or soon after, its accomplishment. Even under the most favorable circumstances, the denuded animal is left in the most languid and helpless condition, the limbs being so soft, and pliant as by the utmost exertion, to be scarcely able to draw the body along.

The flesh is not, however, left entirely without defence, for before the old shell is cast away, preparations have commenced for a new one; the membrane surrounding the entire animal, and which by the addition of new matter becomes the future shell, having already acquired some density. As soon as the old shell is cast off, this membrane which was flabby and wrinkled, becomes tense by the expansion, or sudden growth of the animal, so that the new shell is much larger than the old one. The process of hardening, and thickening now proceeds rapidly, and the animal soon acquires the perfect use of its limbs, with the addition of about one fifth of its former weight.

The Lobster, like some species of polypi, already described, when it happens to loose a limb, soon acquires a new one in its place. Possibly the instinct of the animal has taught it this fact, for when caught by one of the claws, it will sometimes by a sudden jerk break the limb off at the first joint, or at its junction with the trunk, at which place it appears that the new limb grows with the greatest facility.

With respect to the growth of the new claw, Reaumur observed that the wound left by the old one soon becomes covered by a delicate white membrane, with a convex surface. This is gradually pushed forward, becoming thinner as it is stretched, until it gives way, and exposes the little new claw in the soft state. The new part now enlarges rapidly, and in a few days, acquires a shell as hard as the old one. It however does not attain the size of the preceeding claw, or its mate, and this is the reason why we often see, both Lobsters and Crabs, with one of these parts much smaller than the other.

INSECTS.

This division of animals derives its name from the Latin *insecto*, which signifies "to cut," because most of them appear nearly divided by an incision through the middle.

The natural history of this class of animals affords a highly interesting, useful and curious field of inquiry. It is a subject, in which it appears to us, the most incurious can hardly avoid to take more or less interest, since its objects are so common and so diversified in appearance, as to have forced themselves, more or less, on the notice of every one who has his perfect senses.

Insects have organs of locomotion, sensation, sight and taste, and many of them are endowed with the most wonderful instincts; but they have neither heart, arteries nor lungs, though some of them have parts analagous to the two latter organs.

Changes in the Forms of Insects.—Most Insects begin their lives in the form of larvæ, or worms, the power of flight being reserved until after having passed through several preparatory changes, they attain their perfect state. These changes are termed *metamorphoses*, and are most conveniently seen, in the *Lepidopterous*, or Butterfly tribes.

Beginning with the hatching of the egg, laid by the Butterfly, the following changes take place, before a Butterfly is again produced. Most of these eggs are no larger than mustard seeds, and are attached to the leaves of plants on which the future larva, or caterpillar is to feed. In this the Butterfly is directed by that most mysterious property, called instinct, and by which she never fails to place her eggs on such plants as are the most proper food for her future progeny. Thus some

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What is said of the lobster acquiring a new claw in place of one destroyed? Whence is the term *insect* derived? What organs have insects? In what form do insects begin their lives?

species place their eggs on nettles, others on the parsnip, others on the cabbage, &c., and it is found that if the caterpillars produced, are transferred from one of these plants to the other, they in most cases die of starvation, or improper food, being unable to partake of any other, except that on which they are found.

The young caterpillar is at first exceedingly small, being often less than a line in length. As they enlarge in size their skins, being at first somewhat elastic, are stretched so as to accommodate their growth. But this part growing more firm with age, finally refuses to yield any further to the growth of the animal. It is then cast off in the following manner. The worm fastens the old skin to the side of a leaf, and then breaks through that part which covers the head, and liberating its fore feet, gradually draws the body out, the skin remaining stationary. But before this is done, a new skin has been prepared underneath, more capacious than the former, and which again for a time allows the insect to grow. This, however, in its turn becomes too small; or rather the caterpillar becomes again too large for its skin, and the same process is repeated four or five times before the full size is attained.

When the larva is fully grown, and therefore when there is no further necessity for a new skin, it makes a much more decided and important change than those it had before undergone; for although it had thrown off coat after coat, it still had become nothing more than a worm. But now it not only strips itself of the caterpillar's skin for the last time, but so changes its form as to have no appearance of what it was before. It is wrapped in a shroud of skin, presenting no vestige of its former legs, mouth, or any other member. It is fixed in its place by a rope of silk, or wound up in a cocoon of the same material, and presents, in either case, scarcely any signs of life. In this condition it is said to be in its *pupa*, or *chrysalis* state.

What is said of the different plants on which the butterfly lays her eggs? What change takes place when the larva passes to the chrysalis?

The Silk Worm.—Of the silk worm, Fig. 24, represents the full grown caterpillar, and Fig. 25 the chrysalis which it produces, the latter being deprived of its cocoon in order to show its form and size.

Fig. 24.

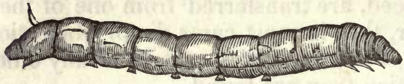
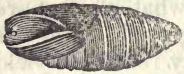


Fig. 25.



The chrysalis remains in this state for various lengths of time, depending on the species to which it belongs, or on the warmth to which it is exposed. Some Insects continue in this state for years, while others emerge and become perfect in a week, or two. During this time the organs which are to serve them in their future, and more elevated career, are preparing; although very little change can be observed in the size, or appearance of the chrysalis.

When the time arrives that these several organs are completely formed, and the butterfly is ready to assume its rank among the beautiful and lively inhabitants of the air, then it is that the insect bursts the shroud in which it has so long been enclosed, and comes forth in form and colors so beautiful, and in spirits, so joyous and sportive, as amply to compensate for its inglorious, and degraded origin.

Fig. 26.

Our Insect has now arrived to its *imago*, perfect, or butterfly state, the Moth, of the Silk Worm being representes by Fig. 26.

Through these several changes do all the butterflies, and a great proportion of the Insects, properly so called, pass. Some of them enjoy their perfect state only for a short time, a few hours; while others continue to display their beauties, and wanton among the sweets of the

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How long do insects remain in the chrysalis state?

garden for weeks or months. In all cases they deposite eggs for a future race, before their final exit.

The Moth, or as it is more commonly called the Butterfly, of the silk worm, has, like all other Insects, six legs. The wings are four, of a greyish white color, with two transverse undulated bands across them. They are far from being beautiful when compared with most others of the same race, and are also entirely void of that sportive vivacity, so common to most other species.

METAMORPHOSES OF INSECTS.

The subject of Insect metamorphos has excited curiosity, and has been the object of inquiry and investigation among naturalists and philosophers in all ages of the world. Having given a detail of the changes which take place during this process in a single species, we are now prepared to pursue this wonderful subject more at large, and to shew the variety and difference of circumstances which attend the same changes in other species.

Messrs. Kirby and Spence, in one of the best works ever written on Insects, introduce the subject of their metamorphoses in the following manner. "Were a naturalist to announce to the world the discovery of an animal, which, for the first five years of its life existed in the form of a serpent, which then, penetrating into the earth, and weaving a shroud of pure silk of the finest texture, contracted itself within this covering into a body without external mouth or limbs, and resembling more than any thing else an Egyptian mummy; and which, lastly, after remaining in this state, without food, and without motion, for three years longer, should, at the end of that period, burst its silken cerements, struggle through its earthy covering, and start into day a winged bird—what think you would be the sensation excited by this intelligence? After the first doubts of its truth were dispelled, what astonishment would succeed! Among the learned what surmises, what inves-

What is said of the time which the chrysalids of insects remain in the torpid state?

tigations! Among the vulgar what eager curiosity, what amazement."

In the same spirit, Swammardam, who spent most of his life in making observations on Insects, observes on the same subject: "This history is so extraordinary, so amazing in all its circumstances, that it might very well pass for a romance, were it not built upon the most firm foundations of truth."

With respect to the size and appearance of the caterpillars and of the chrysalids they form, as well as the situations in which they are placed, and the time of remaining in the torpid state, there are nearly as many varieties as there are species of Insects. Some larvæ descend deep into the ground before they assume the torpid state, and there remain three or four years before they acquire wings. Others weave small cocoons, and having thus covered themselves in beds of silk, then change to chrysalids. These are sometimes constructed in the earth, and sometimes attached to the sides of fences, or the side of any vessel in which the worm is confined. If confined in a glass vessel the observer may witness the whole process of weaving the cocoon, and of casting off the old skin, by which the chrysalis becomes apparent.

The positions in which the larvæ place themselves in order to undergo this change, are also extremely various. One species suspends itself to a leaf with its head downwards, being only fixed by the tail; another passes a rope of silk around its neck, and thus hangs in an oblique position; while others are simply glued in a horizontal position, in any convenient place.

Larva which feeds on the parsnip.—There is a common larva which may be seen feeding on the leaves of parsnips in the autumn, and which every one has noticed on account of its handsome appearance, and the fetid odor which it emits on being disturbed. The color is greenish yellow, with bands of velvety black, and when full grown it is nearly two inches long. The younger ones of this caterpillar would at first be taken for a different

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What is said of the positions in which chrysalids are placed?

species, being dotted, or sprinkled, with yellow and black, instead of having the colors well defined. If the young naturalist will take a sprig of the parsley, with one of these on it, and put the whole into a glass jar, or other place of confinement, taking care to water the plant, he will soon find it to be identical with the large ones.

This larva is remarkable for having on the back of the neck, an instrument composed of two fleshy horns, branching from a common stem somewhat like the letter Y. This organ appears to be similar in some respects to the horns of snails, and is capable of similar movements, being completely retractile. When the animal is irritated these horns are projected, and it appears from the observation of Reaumur, that this organ secretes an acid liquor, which emits the unpleasant smell, and which every one who has touched one of these worms cannot but have perceived. Reaumur supposes that this acid is a means of defence against the attacks of the ichneumon, a small fly which deposits its eggs in the flesh of the larvæ of various insects.

This larva, when spinning the silken cord by which it is to be supported in the chrysalis state invariably fixes it around the neck at the junction of the fifth and sixth segments, where there is a cavity in which it is kept from sliding backwards or forwards. This cord appears to pass under the skin of the chrysalis, but on examination with a magnifier, it will be seen, only almost concealed in a deep channel. The larva and its chrysalis, both of the natural size, are represented by Fig. 27 and 28; the latter being suspended by the cord in the manner described.

Fig. 27.

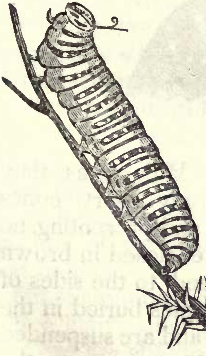
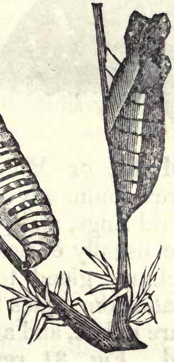


Fig. 28.



Difference in the Chrysalids of Butterflies and Moths. There are differences between the chrysalids of butterflies and moths, and also between these species of Insects, which it is proper to point out at this place. The chrysalids of Butterflies are naked, that is, they are not covered with cocoons, but are attached to trees, or other substances, by silken cords, passing around the neck, (Fig. 28,) or are attached by the tip, and hang suspended as represented by Fig. 29. They are also angular. The antennæ of Butterflies are club-shaped, that is, they are thickest towards the tip, or end in a bulb, as seen by Fig. 30.

Fig. 29.

Fig. 30.

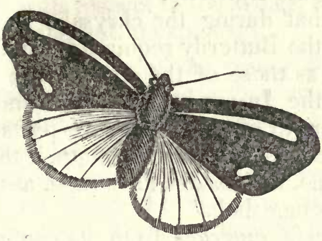
The chrysalids of the Moths, or Millers, as they are sometimes called, are commonly short cones composed of several rings, and presenting no angles. They are usually enclosed in brown silk cocoons, sometimes glued to the sides of trees, or fences, and sometimes buried in the ground. A few are naked, and are suspended by the small end. Fig. 31 represents the most common form. Both forms of chrysalids are occasionally dotted with spots exactly resembling gold.

Fig. 31.

What difference is there between the chrysalis of a butterfly and a moth? What is the difference between the antennæ of these insects?

The antennæ of Moths are somewhat sword-shaped, tapering from the insertion to the point, and are sometimes fringed, Fig. 32.

Fig. 32.



The Butterflies are *diurnal* insects, flying only in the day. The Moths are *nocturnal*, seldom flying except at night, or after sun set. Some of the small species are, however, occasionally seen by day.

Some of this tribe, called *Hawk Moths*, have a proboscis, or tongue several inches long, by means of which they pump the honey from the nectaries of flowers. Both Butterflies and Moths, are furnished with four wings, six legs, a proboscis, and suck honey as their chief aliment.

Change from the Chrysalis to the Butterfly.—Swammardam, one of the oldest and best authorities on the anatomy of larvæ, demonstrated that even before the time when the caterpillar changes into the chrysalis, all the parts of a butterfly may be discovered within its skin. His directions for observing this phenomenon are, to take a full grown caterpillar, and having tied it to a thread, put it into boiling water, and take it out soon after; thus its external skin will separate, and may be easily drawn off from the Butterfly, which is contained folded up in it. This done, it is clearly and distinctly seen, that within this skin of the caterpillar, a perfect and real Butterfly was hidden.

On examining certain chrysalids, which are covered with a light colored shroud, and consequently translucent, we are able to discovert he eyes of the Butterfly, as well as its wings, which are of small size and folded upon the sides. There may also be observed several slender ribs or divisions, arising from the head, and

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What ist he difference in their time of flying? What is said of the existence of the butterfly within the skin of the larva? What is said of the butterfly in the chrysalis?

which on more minute examination may be seen to consist of the two filaments of the tongue, or proboscis, the legs, and the antennæ of the Butterfly.

It appears therefore, that during the chrysalis state, the future organs which the Butterfly requires are in the progress of perfection, as those of the chicken are in the egg, and that when the Insect has remained under this form, a sufficient length of time for these parts to gain a proper degree of consistence and strength, it then bursts open the membrane, and makes its escape, as the young quail does from its egg-shell.

Just before the Butterfly emerges from its confinement, it is easy to see, in some chrysalids, the form of the legs, antennæ, and tongue, and even the color of the wings. The extremities of the legs may be seen to move, the wings to enlarge, and finally the whole insect to struggle as if determined no longer to submit to confinement. After a few such efforts, the membrane of the chrysalis gives way in a longitudinal rent down the back, where a suture may be observed, undoubtedly for this purpose. The rent then extends over the head, and down the breast, and after various efforts and contortions, the butterfly finally disengages itself entirely from its covering, leaving it divided into several sections, as represented by Fig. 33. But the Insect though now disengaged from its prison, has not yet attained its full perfection, for besides being exceedingly weak, so as hardly to be able to crawl, its wings are folded and doubled together in such a manner as to make them appear like pieces of wet paper, as shown by Fig. 34. The spots and markings are also indistinct, as though their wet condition had made the colors run into each other. But they expand with such rapidity, that, according to Swammardam, "the naked eye cannot trace their unfolding, for, from reaching scarce half the length of the body, they acquire, O miracle of miracles! in the short space of about half a quarter of an hour, their full extent, and

Fig. 33.

Fig. 34.

bigness." The colorings peculiar to each species also become defined and perfect as the wings expand.

The means employed to effect a change so wonderful with respect to the wings, and in so short a time, has not been left unexplained.

The Wings of the young Butterfly, how expanded.—The wings of Butterflies are composed of two fine membranes between which are little veins or ribs resembling those of the leaves of some plants. These may be seen by the naked eye, when the scales, or dust which colors the wings is rubbed off, and are called *nervures*. They are hollow tubes, having a communication at the insertion of the wing with the body of the Insect. Into these, the young Butterfly forces a quantity of air, and perhaps also a fluid, and by the distention of which, the folds and wrinkles of the soft and wet wings are in a few moments obliterated. The nervures, and also the fully developed wings are shown by Fig. 35.

Fig. 35.

These when compared with Fig. 34, will show the change produced by the means above described in "half a quarter of an hour," and at the sight of which Swammardam could not help exclaiming, O! miracle of miracles! The whole process, indeed, from the hatching of the egg, to the perfection of the Butterfly, though not a miracle, because the whole is in the ordinary course of nature, must ever be considered among the most wonderful se-

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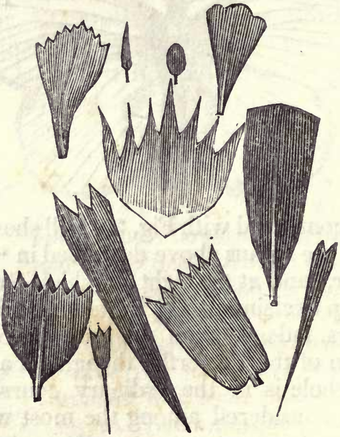
In what manner does the butterfly make its escape from the chrysalis? Is the insect perfect when thus disengaged? In what manner are the new wings of the butterfly unfolded and distended?

ries of natural phenomena which man has been allowed to witness. Who can study such traits of nature, without acknowledging the care, design, and wisdom of the Creator to be displayed in them in a most striking and wonderful degree.

Wing Scales of Butterflies.—The soft down which covers the wings of Butterflies and Moths, which appears like the finest dust, and by which all the splendid variety of colors are given to these insects, is found when magnified, to consist, of scales, or feathers, of different, but regular forms. It is from these scales that the name of this genus, *Lepidoptera*, "scaly-winged," is given.

According to some naturalists, these minute parts should be considered rather as feathers than as scales, since they are affixed to the wings by minute quills. But others consider them as scales from their being composed of merely membranous plates, having nothing in common with feathers excepting perhaps, the manner in which they are attached. The reader may have the

Fig. 36.



opportunity of deciding this matter for himself, by consulting Fig. 36, where the forms of a number of these parts are shown, highly magnified. The number of these on the wings of the larger Butterflies, must amount to millions, since Leuwenhoeck, the best observer on such subjects, found more than 400,000, of them on the wings of the silk worm Moth, which is comparatively a small Insect.

The construction and arrangement of the parts of these scales are very regular and beautiful, their surfaces being striated with parallel, and equidistant lines, the distinct visibility of which, in those from the *Pontia brassica* or cabbage Butterfly, is considered as affording an excellent test of the goodness of microscopes.

The forms of these scales as seen by the adjoining figures, are exceedingly various, as also their sizes, when magnified by the same power. These differences of form occur not only in the different species, but also on different parts of the wings and body of the same Insect; for the surface of the body generally, as well as the legs, and in some species the antennæ are more or less covered with these scales. These forms are indeed so various on different parts of the same Insect, that in the works of that distinguished naturalist, Lyonet, there are six quarto plates nearly covered with the delineations of different forms of these scales found on a Moth of the silk worm tribe, the *Bombyx cossus.*

The arrangement of these scales upon the wings are in regular transverse lines, the ends of one row lying over the basis of the next, like the shingles on the roof of a house. When these are removed from both sides of the wings, of a Butterfly it will be seen that these parts are exceedingly thin, and transparent like the wings of the dragon fly and bee.

Red drops emitted by Butterflies.—Several species of Butterflies just after the time of changing from the chrysalis to the perfect state, or perhaps at that of emerging from their place of confinement, emit several drops of a red fluid, resembling blood in appearance. When a great number of these insects have been produced at

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Whence does the genus to which the butterfly belongs derive its name? What is said with respect to down on the wings being feathers? What is said of these scales with respect to their being a test of the goodness of microscopes? What is said of the different forms of these scales? How are they arranged on the wings of the insect?

the same time, and place, as sometimes happens, the people have been struck with terror and dismay, taking these drops for the effects of a shower of blood, which of course could portend nothing less than some direful calamity to the country. The author of this volume, last October, obtained a specimen of these bloody drops, from the *Papilio urticæ*, the caterpillar of which was taken from the common nettle, and underwent the metamorphoses in confinement. The red drops happening to fall on a piece of oil cloth carpet, were cut out and preserved. They are of a deep red and do not fade by keeping. In consequence of this circumstance, the author's attention was excited to the subject and he threw together the following remarks and facts, which were offered as a little contribution to "The Hartford Natural History Society."

Ancient showers of Blood explained by facts, in the Natural History of the Butterfly.—It is well known to the general reader, that various authors have described showers of blood as falling from the heavens, and that such phenomena have been considered the miraculous, precursors of some extraordinary, or direful event. Thus Ovid has commemorated such an occurrence among the other prodigies which attended the violent death of the great Roman dictator.

> "With threatning signs the lowering skies were filled,
> And sanguine drops from murky clouds distilled."

Such occurrences are alluded to by several other ancient writers, both Greek, and Roman. Homer speaks of showers of blood which fell before his time, and also one or two, of which it would appear that he was an eye witness. Such phenomena he declares indicate the direct and violent encroachmentof the gods on the established laws of nature. Cicero also alludes to such events, and was the first to doubt their preternatural origin; but in his attempts to account for them on natural principles, he involves suppositions not less difficult to explain than the phenomenon itself, even without reference to its real cause.

Dion Cassius, who flourished in the third century, mentions a shower of blood which fell in Egypt in the time of Octavian. This he considers a very rare and extraordinary occurrence, not however, it would seem, because it was of blood, but because, as he states, it fell in a country where showers of any kind are unknown.

Stowe, the old British Chronicler also speaks of several cases of what he calls *blood-rain.* "In the days of Rivalla," says he, "it rained bloud three days, and then a great mortalitie caused almost desolation." Again, "in the time of Brithricus of the bloud of Cerdicus, who was king of the West Saxons for seventeen years, it rained bloud, which falling on mens' clothes appeared like crosses." Nor does Hollingshed fail to record some scraps of the same history. He relates that in the fifth century, "at Yorke it rained bloud," and that in the seventh, "corne, as it was gathered in the herveste-time, appeared bloudie." From Batmans' "Doome" we find that in 1553, it was deemed among the forewarnings of the deaths of Charles, and Philip, Dukes of Brunswick, that "there were drops of bloude upon herbs and trees."

In the days of Nero it is said that blood-rain fell in such quantities as to tinge some rivers of a red color. It is likewise recorded by historians that the phenomenon, or miracle of falling blood, either seen on the leaves of plants, or on stones, or fences, has occurred at various times and places, ever since the Christian Era. But after having quoted the above authorities, it will be needless to specify others to establish the general fact of such records. It will therefore be sufficient to state that two instances of bloody rain are recorded to have fallen in the tenth century; one in the eleventh; two in the twelfth ; one in the thirteenth; two in the fourteenth ; one in the fifteenth ; and five in the sixteenth.

Thus, although it appears that almost from the earliest times of history, it has been understood and believed that showers of blood actually falling from the air, were not uncommon, still no one as we shall see directly, until about the beginning of the seventeenth century, undertook any serious investigations for the purpose of accounting for phenomena so extraordinary.

It is most probable this neglect of inquiry arose from a superstitious dread of interfering with so sacred a subject; for it was generally believed that such showers undoubtedly prognosticated some direful event, and hence they were received as miraculous warnings, or special interpositions of providence in the affairs of men. Under such a belief, we can hardly wonder that few or none could be found, who were so bold, or perhaps wicked, as to attempt to account for such occurrences on natural principles. Such conduct would have been a virtual denial of the miracle itself, or at least a fool hardy attempt to explain the acknowledged special communications of heaven by a reference to the ordinary laws of nature.

It is true that in the time of Hippocrates, a learned doctor named Garceus, declared it as his opinion, that blood-rain, was common rain boiled by the heat of the sun, but with this exception, we find no expressions of doubt with respect to the miracle, or at least no attempt to solve the mystery, from the time of Cicero to that of the celebrated naturalist Reaumur, in the beginning of the seventeenth century.

Before we proceed to the explanation, it may be proper to remark, that so far as we know, all the ancient accounts of bloody rain, fail entirely with respect to the detail of attending circumstances. We are not informed whether such showers fell from thick clouds, accompanied with lightning and thunder. Whether they fell by night or by day, or indeed whether the red drops were ever *seen* to descend, or whether they were first discovered on the leaves of plants, and on stones and fences. Hence we may fairly conclude that the fall of bloody showers have only been inferred from appearances on, or near the ground.

It is now known that there are several species of Butterfly which emit red drops, immediately after their emergence from the chrysalis, as the Papilio Io, or the peacock Butterfly; the Papilio urticæ, and several others.

The report of Reaumur to which we have before alluded, and which accounts satisfactorily for these bloody showers, is as follows. In the beginning of July 1608, the people of Aix la Chapelle, were in the utmost alarm from what they thought a shower of blood, that had fallen in the suburbs, and some miles around the place.

M. de Peiresc, a philosopher, who among other kinds of knowledge, had not neglected that of the operations and economy of Insects, was consulted on the subject. He found the walls of a church-yard near the place, and the walls of several small villages in the neighborhood to be spotted with large drops of a blood colored lqiuid. A little before this time this gentleman had happened to pick up a large and beautiful chrysalis which he had carefully laid in a box. Immediately after its transformation into the Butterfly state, he remarked that it had left a large drop of a blood colored liquid in the bottom of the box. The red stains on the walls, and the stones near the highways, and on the leaves of plants in the fields, were found to be perfectly similar to that left on the bottom of the box. M. de Peiresc hesitated no longer to pronounce, that all the blood colored stains wherever they appeared, proceeded from the same cause. The prodigious number of Butterflies which he at the same time saw flying in the air confirmed his original idea. He likewise observed that the drops of miraculous rain were never found in the middle of the town, but that they appeared only in places bordering upon the country; and that they never fell upon the tops of houses, or upon walls more elevated than the height to which Butterflies generally rise. What the investigator of these facts saw himself, he showed to many persons of knowledge, or curiosity, and finally established as an incontestible fact, that the pretended drops of blood were in reality nothing more than drops of red liquid deposited by these Butterflies. It is also deserving of remark, that all the showers of blood that have been recorded to have happened, took place in the warm seasons of the year, when Butterflies are most numerous.

And now who will deny the practical use of Entomology, when these simple facts have been the means of delivering the world from the thraldom of superstitious fear, which from time immemorial has been consequent upon the belief in miraculous showers of blood. When Newton demonstrated that the comets, instead of wandering in any direction and without order, were confined to regular orbits, and therefore that we of the earth,

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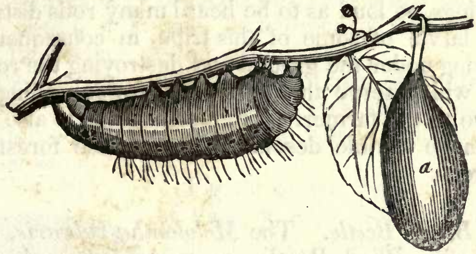
had nothing to fear from them, Astronomy was hailed as the noblest and most useful of sciences on this very account; and yet Astronomy in that instance did nothing more for the world than Entomology has done in the case before us.

Tusseh Silk Worm.—Before we leave the Lepidopterous Insects, we will describe a species of Silk Worm found in India, which although it is not domesticated like the common one of Europe and America, the *Bombyx mori*, still appears from time immemorial to have furnished the natives with an abundance of an inferior kind of silk for common uses. It is called the Tusseh Silk Worm, and is found in abundance in many parts of Bengal and the adjoining provinces, and the cocoons are reeled and wove into a coarse, dark colored, but most durable fabric called Tusseh doothies, much worn by the Brahmins, and other classes of Hindoos.

This Silk Worm, whether from want of skill, or from the wild habits of the Moths, is unknown, has never been reared in the usual manner of other worms; the natives therefore every year, at the proper time, go into the jungles and find the young worms on the limbs of certain trees, which they cut off and convey to other trees of the same kinds near their habitations. These are known by the native names of asseen, and byers trees, and these trees are guarded day and night, in order to prevent birds and bats from destroying the young caterpillars. In two or three weeks, these worms acquire nearly their full size, being monsters of four inches in length, and three in circumference; their colors are of a light green, with a yellowish stripe on each side, the sixth and seventh rings being marked with an oblong golden spot. From the back issue a few long, coarse, distinct hairs, with others of a smaller size scattered over the body, Fig. 37.

When these worms are ready to spin their cocoons in which they change to the chrysalis state, they begin by attaching glutinous filaments to a leaf as a foundation, and afterwards spin a strong cord by which the future cocoon is suspended to a twig for additional security. The cocoon is of an oval form and firm texture, as represented by Fig. 37 *a*. The chrysalis remains in the

Fig. 37.



torpid state for nine months, when it discharges from the mouth a quantity of corrosive liquor, which softens the upper end of the cocoon, and the moth makes its escape.

These Insects are of enormous size, the largest measuring with the wings spread, six, or even eight inches across. They are exceedingly vigorous on the wing, and fly to great distances. The natives often catch, and mark them, and then let them fly; the marks of the different districts being known, it is said they are frequently caught more than a hundred miles distant from the places where they were marked.

The wings of these insects are of a uniform yellowish brown, with one round transparent spot in each of the fore wings. They live from six to twelve days, deposite their eggs and die.

BEETLES.

The Beetles belong to the Linnæan order *Coleoptera*, which word signifies "wing-sheathed," so called, because these insects are provided with hard wing cases, with which they cover, when at rest, their proper wings. These cases are called *elytra*, and when shut together, form a longitudinal suture along the back. A great

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To what order of insects do the beetles belong? What is the meaning of the term coleoptera? What are the wing cases of these insects called?

variety of this tribe are known under the common appellation of *bugs*. Most of them fly only in the night, and some of the larger, make a deep toned sound with their wings, so loud as to be heard many rods distant.

The larvæ of some of this tribe, in consequence of their living under the ground and destroying the roots of plants, which serve them for food, are exceedingly destructive to the farmer. The perfect insects also sometimes make terrible desolation among the forest, and other trees.

The Blind Beetle. The *Melolontha vulgaris*, called also Chafer, Blind Beetle, or more commonly Cockchafer, is one of these insects.

Fig. 38.

The larva of this beetle is known to farmers under the name of the *White worm*, and is represented by Fig. 38. The eggs of these worms are deposited in the ground by the parent insect, and when first hatched are of very small size. As they grow, they change their skins several times, and at the end of four years during which time they remain in the earth, they acquire the size represented, having six legs, armed with strong claws, and a reddish head. During its subterranean residence, it lives on the roots of grass, sometimes committing the most deplorable ravages. When their numbers are great they cut off all the roots of the grass in the richest meadows, leaving the turf entirely detached and dead, so that it may be rolled up by the hands like a carpet without the aid of a turfing knife. Underneath, the soil appears pulverized, and turned into a soft mould like the prepared bed of a garden. In this, the worms are seen coiled up and lying on their backs, generally almost motionless.

Some years since a poor farmer in Norwich, England, suffered so much from these worms as to destroy all his hopes, and the authority of that city out of compassion, voted him 25 pounds to assist him under such a calamity. This man and his servant testified, that they had gathered eighty bushels of these obnoxious creatures, but still his farm for the season was destroyed.

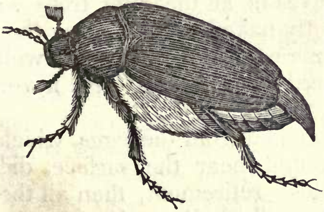
At the close of the fourth year these larva construct for themselves large oval cocoons, having first descended to the depth, it is said, sometimes of five or six feet below the surface of the ground.

These cocoons are of an oval form, of considerable bulk, and are constructed with a good deal of ingenuity, and reference to comfort, being wove of silk and lined with the same.

Fig. 39.

Fig. 39 shows the section of one of these cases with the worm in it. The covering of this chrysalis is so thin and transparent that all parts of the Insect may be seen through it. In the month of February the perfect Insect rends its envelope, and emerges from it, though still several feet under ground. It is now yellowish, soft, and weak, but gradually acquires strength and firmness, and begins slowly to make its way towards the surface. This however, it does not reach until May, when it is not uncommon to find these yellowish bugs, as they are called, just under the surface, and about which time they assume their new and elevated condition as inhabitants of the air.

Fig. 40.



The Cock-chafer, is a strong Insect of a yellowish brown color; antennæ largely club-shaped; feet armed with sharp claws, and the body somewhat hairy. Fig. 40 represents this Insect of the natural size.

During the day these Beetles remain motionless, sometimes concealing themselves under the bark of trees and about fences; but on the setting of the sun they issue forth from their hiding places to feed on the leaves of various trees, and sometimes their numbers are such as to do as much mischief in their perfect state, as they did when in that of the larvæ, devastating whole forests in such a manner as not to leave a green leaf behind them.

Devastations committed by this Beetle. In the Philosophical Transactions, for the year 1697, there is an account of the appearance of these insects in certain parts of Ireland, and the ravages they committed there. "Multitudes," says this statement, "appeared among the trees and hedges in the day time, hanging by the boughs in clusters, like bees, when they swarm. In this posture they continued, with little or no motion during the heat of the sun; but towards evening they would all disperse, and fly about with a strange humming noise, like the beating of distant drums, and in such vast numbers that they darkened the air for the space of two or three square miles. Persons travelling on the roads, or abroad in the fields, found it very uneasy to make their way through them, they would so beat, and knock themselves against their faces in their flight, and with such force as to make the place smart, and leave a mark behind them. In a short time after their coming, they had so entirely eaten up, and destroyed all the leaves on the trees for some miles around, that the whole country though in the middle of summer, was left as bare as in the depth of winter; and the noise they made in gnawing the leaves made a sound resembling the sawing of timber. They also came into the gardens and destroyed the buds, blossoms, and leaves of all the fruit trees so that they left them perfectly naked: nay, many that were more delicate than the rest, lost their sap, as well as leaves, and quite withered away, so that they never recovered again.

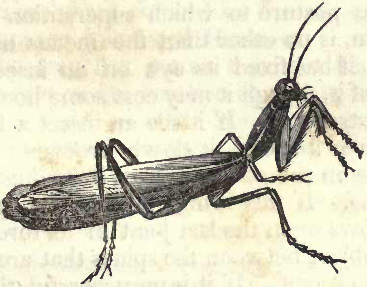
Their numerous young hatched from the eggs, which they had lodged under ground, near the surface, did still more harm in that close retirement, than all the flying swarms of their parents had done abroad; for this destructive brood lying under ground, ate up the roots of corn and grass, and thus consumed the support of both man and beast." Many other instances of similar devastations are recorded to have been committed by these insects in different parts of the world.

MANTIS.

There is a Hemipterous, or half-winged Insect of very singular manners and habits called the *Orator Mantis,* and sometimes the *Praying Mantis,* from the position in which it is usually found. This Insect is of considerable size; the clytra, or wing cases are of a bright green color, and on each of the wings there is a black spot.

The common posture of the Mantis is that of resting on its hind legs, and erecting its fore feet, holding them, close together and giving them a quick motion, as if, as some say, it was in the act of praying, Fig. 41. Hence

Fig. 41.



among certain people, this creature has been held in great veneration from time immemorial. It has been supposed to tell fortunes; forewarn of evils, and to do many other things, according to the vividness of superstitious imaginations. Dr. Moufet, who wrote a work in folio, on insects, in the sixteenth century, very seriously tells us of this insect, "that they are called Mantes, that is, fortune tellers, either because by their coming they do show the spring to be at hand, so Anacreon, the poet sang; or else they foretel death, or famine, as Cælius, the scholiast of Theocritus, writes; or, lastly, because it always holds up its fore feet like hands praying, as it were, after the manner of their diviners, who, in that gesture, did pour out their supplications to their gods. So divine a creature is this esteemed, that if a child asks the way to such a place, she will stretch out one of her feet, and show him the right way, and seldom, or never misses. As she resembleth these diviners in the elevation of her hands, so also, in likeness of motion, for they do not sport themselves as others do, nor leap, nor play, but walking softly, she returns again modestly, and shows forth a kind of mature gravity." This is only the position of the Mantis, that it takes to catch its prey.

The praying position, and soft modesty of this insect, which charity and superstition thus metamorphosed into kindness and virtue, by a more attentive examination of its habits, prove to be nothing more than cunning devices to secure its prey, being one of the most cruel and voracious of all the Insect tribes. The patience of the Mantis, says Bingley, in waiting for its prey, is remarkable, and the posture to which superstition has attributed devotion, is no other than the means used to catch it. When it has fixed its eye on an insect, it rarely loses sight of it, though it may cost some hours to accomplish its destruction. If it see an insect a little beyond its reach, over its head, it slowly erects its long thorax, then resting on the posterior legs, it gradually raises the anterior also. If this brings it near enough to the insect, it throws open the last joint of its fore paws, and snaps the object between the spines that are set in rows on the second joint. If it is unsuccessful, the paws are not retracted, but still held forth waiting for the victim to come again within its reach. Should the insect go far from the spot, the Mantis flies, or crawls after it, slowly, like a cat.

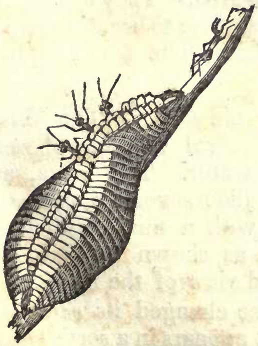
Observations of Roesel.—Roesel, the naturalist, desiring to study the character and habits of this curious creature, put some of the eggs into a glass case until they hatched. The young ones, immediately displayed the most savage disposition towards each other, but Roesel supplying them with flies, which they tore in pieces and devoured with avidity, he in this way saved some of his brood for a time. But notwithstanding he supplied them well with insects, they continued to devour each other apparently through wantonness. Despairing at last of rearing any of them to the winged state, he seperated them into small companies, under different glasses hoping in this way to render them more pacific. But still the strongest in each little community, with the same savage disposition as before, tore in pieces the weaker.

Finally, he put a pair of these insects, full grown, into a glass case, and having taken the precaution of first supplying them with food, watched their actions. But no sooner did they espy each other, than they stood stiff and motionless, each eyeing the other with an air of the sternest defiance. In this posture did they remain for many minutes, when the whole frame of each became violently agitated; their necks were elevated, their wings expanded, and in this state they rushed towards each other with the utmost fury, and hewed away with their sharp sabre-like fore feet, like, says Rœsel, a couple of infuriated Hussars.

Barrow, the traveller, states that the Chinese keep these insects in separate bamboo canes, for the purpose of seeing them fight, as other people do game cocks; and that in the summer months, scarcely a boy is seen in the streets, without a cage of these ferocious warriors. A practice as barbarous with respect to these animals, as it is humiliating to human beings.

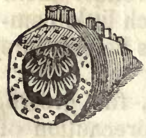
Follicle of the Mantis. The case, or sort of follicle, which the Mantis constructs to contain her eggs is not the least curious thing belonging to this famous insect. This case is about two inches long, of a yellow color, of a texture like parchment, and curiously reticulated, or waved on the outside. The shape is that of a double cone united at their bases. It is fixed to the stalk of some plant, as seen by Fig. 42.

Fig. 42.



Along one side there is a kind of suture through which the young escape as they are hatched, the figure showing some of them in this act.

Fig. 43.



The eggs are very numerous, and are arranged in rows as seen by fig. 43, which is a transverse section of 42. One of these follicles being sent to Rœsel, he observed that a double row of egg-like bodies sprouted up in close contact with each other in a furrow, which divides the egg case longitudinally; these little eminences soon became animated, for out of them he perceived the little Mantes struggling to escape. As soon as one had succeeded in freeing itself from the egg, it ran off with the agility of an ant, which it resembled in form and nimbleness.

MUSQUETO.

The general appearance and habits of the Musqueto are too well known to need description. It belongs to the order Diptera, that is, double winged, these tribes having only two wings, of which, the common house-fly is another example.

The Gnat and Musqueto belong to the same species, the latter being only a large variety of the former. The larvæ of these insects in the warm season, are common in all stagnant pools, and ditches. Even a small vessel of water, if allowed to stand still, will soon exhibit these little beings, diving and swimming about in all directions, generally with their head downwards. They are, however, obliged often to rise to the surface to breathe, being furnished with a small cylindrical tube for this purpose.

Changes of the Musqueto in the water.—The Musqueto undergoes several metamorphoses before it leaves the water. The larva, at first is composed of nine segments, each of which is furnished with a number of fine cilia on both sides, as shown by Fig. 44, which is a magnified view of the insect.

Fig. 44.

After having thrice changed its skin, as it increases in size, it appears in a sort of lenticular, or bean-like form, as shown by Fig. 45. In this state, it is still capable of moving briskly through the water, in the manner

Fig. 45.

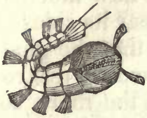
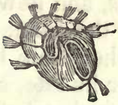


Fig. 46.



of the lobster, that is, by alternately contracting and expanding the body, and striking the fluid with its fins and tail, as shown by Fig. 46.

In this stage of its progress, it takes no food, having neither mouth nor organs of digestion; but a plentiful supply of air seems to be indispensable, and hence it floats on the surface of the water, and only descends when disturbed. In every stagnant pool, thousands of them may be seen, at the proper season, in this state of repose. Their respiratory organs are two ear-like processes shown by the adjoining figures, and these are kept above the surface of the water until another change is about to ensue.

Musqueto leaving the water.—When the Musqueto is about to emerge, and to take the station and form of a perfect being, it stretches out its body at full length on the surface of the water, and then by some secret mechanism, puffs up its skin, so as to split it open at the head. As soon as this fissure is sufficiently large for the purpose, the insect, in perfect form, appears. And, now the condition of the little adventurer is critical, and perilous in the extreme, for, from being an aquatic, it is suddenly transformed into an air-breather; and after having spent all his past life as a sailor, he is in a twinkling turned landsman, perhaps far from the shore, and having no other boat but his own skin, with neither oar nor sail, for he has no use of either leg or wing. If at this juncture a little breeze comes on, it proves a most dreadful hurricane to the poor animal, for if a drop of

Fig. 47.

water gets into the case, which has now become a canoe, it inevitably sinks and carries the insect down with it. This hazardous situation is shown by Fig. 47, which exhibits a magnified picture of the Musqueto just taking its departure into its new element. Reaumur, who saw every thing which nature exhibits with respect to this insect, speaks of the peril of this moment in the following language: "When the observer perceives how much the prow of the little bark sinks, and how near its sides are to the water, he forgets for the moment, that the gnat is an insect, which at any other time he would destroy; nay, he becomes anxious for its fate, and the more so if the slightest breeze plays on the surface of the water: the least agitation of the air being sufficient to waft the creature with swiftness from place to place, and to make it spin round and round. Its body, folded in its wings, bears a greater proportion to the little skiff, than the largest mass of sail to a ship: it is impossible not to dread lest the insect should be wrecked; once laid on its side, on the water, there is no escape. Generally, however, all terminates favorably, and the danger is over in a minute."

STRUCTURE OF INSECTS.

Having detailed the steps by which nature produces a perfect Insect from the egg, and shown also how these natural processes vary in several different orders and species, it is now proper to say something of the structure of these beings, in order to show by what means they perform the functions of life.

Insects, as we have seen, and as common observation evinces, vary exceedingly in their forms, habits and dispositions, and they must consequently vary in respect to their structure, since each species must be furnished with organs, and instruments by which it is precisely adapted to the situation and condition in which it is placed. But although there is so much variety in their appearance, all Insects consist of only three principal parts, viz, the *head*, *trunk* and *abdomen*.

In order to illustrate this subject, we will take one of the Beetle tribe, and divide it into sections, and by means of plans show the names and uses of the several parts. The Insect here represented, is the *Carabus sycophanta*,

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What are the principal sections of an insect?

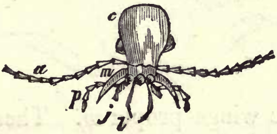
Fig. 48, and may stand as a type of all the other Beetles,

Fig. 48.

since they do not differ in their structures. This specimen is of the natural size, but the sections are somewhat magnified, that the smaller parts may be more distinctly seen.

The head *c*, Fig. 49, contains the principal enlargement of the nervous system, or the brain, the *scull* or *cranium* being usually the hardest part of the insect. To the head are attached the antennæ, and instruments of mastication. The latter are much more complicated in Insects than in larger animals. Those which divide their food, have a double set of jaws, called *mandibles* and *maxillæ*, besides which, there are four other moveable pieces called *palpi*, and *labial palpi*. The mandibles or upper jaws, *m*, cut the food; the lower, or proper jaws, *j*, masticate it; the palpi, *p*, and the labial palpi, *l*, appear to be instruments of sense by which the insect judges of the quality of its food. The motions of all these parts are horizontal, and not vertical as with us, and other animals having incumbent maxillæ. To obtain an idea of the motions and uses of these parts, it is only necessary to watch an insect for a few moments while feeding.

Fig. 49.



The *trunk*, or *thorax* is composed of three parts, con-

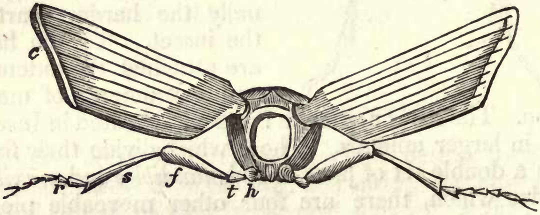
What are the jaws of insects called? What other pieces belong to the mouths of insects? What are the uses of the mandibles and proper jaws? What are the uses of the palpi?

sisting of the three segments, figures 50, 51 and 52. The first is called the *Prothorax*, Fig. 50, to which is

Fig. 50.

connected the first pair of legs. The second, Fig. 51, is called the *Mesothorax*, and gives origin to the second

Fig. 51.



pair of legs and the first pair of wings, or the *elytra c.*

The third section is the *Metathorax*, Fig. 52. This part sustains the third pair of legs and the second pair

Fig. 52.

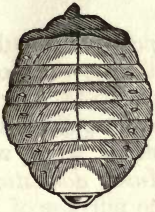
of wings, or the wings proper *w*. These two last seg-

How many sections is the trunk of an insect composed of? On what principle are the limbs of insects named? What are the names of the different parts of one of these limbs, and what are their relative situations?

ments are closely united, but the natural distinction between them is marked by a transverse line.

The third principal division is the abdomen, Fig. 53.

Fig. 53.



This, in the instance before us, is composed of six complete, and three imperfect segments, but these segments vary in number in different insects from three or four, to twelve or more. These segments all have a ligamentous connection with each other, allowing free motion in all directions.

The limbs of Insects, are named from their supposed analogy to corresponding parts in the higher order of animals. Thus the *haunch, h,* corresponds to the hip bone of quadrupeds; the *trochanter, t,* to the head of the thigh bone; the *femur, f,* to the thigh bone itself; the *tibia, s,* to the bones of the leg; and the *tarsus, r,* to those of the foot.

It is perhaps unnecessary in a work like the present, to give a detailed account of the peculiar mechanism, motions and uses of each of these parts. The limbs of Insects down to the feet, may be considered as acting in a manner analagous to our own. The feet have peculiarities to which there is no analogy in other animals, and which therefore must receive further notice.

The legs of most Insects diverge, so as to reach considerably beyond their bodies on each side, thus giving them a firmer support, by throwing the centre of gravity far within the base. When the legs are very long, the Insect therefore, appears rather suspended, than supported by them, contrary to what obtains in quadrupeds and man, where the feet are immediately below the points where the legs are connected with the body.

In Insects, the last joint of the tarsus is generally terminated by a claw, sometimes single, and sometimes double, and by which the foot is fastened in walking to any surface which is in the least degree rough, or unequal. By these hooks insects also suspend themselves on perpendicular surfaces, or with their backs downwards, this being from the mechanism of these parts, the

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By what means do insects walk on rough surfaces?

most easy position they can take. The Beetle tribe, and the Grass-hoppers, are furnished with this apparatus. They cannot climb up smooth surfaces, as a polished door, or a pane of glass, their hooks being useless, without some degree of roughness.

Some Insects walk by Atmospheric pressure.—Other Insects are furnished with a curious, and somewhat complicated apparatus, by which they are enabled to walk not only upon rough, but also upon the smoothest surfaces, even with their backs downwards. It is well known, that the common house fly, (*Musca domestica,*) prefers this position to all others, for the purpose of repose. Hence we may infer, that this is the easiest position the Insect can take, and therefore the one which requires the least muscular exertion.

There has been much diversity of opinion among naturalists, by what means, these Insects are able thus to suspend themselves on surfaces entirely smooth, with so much ease as to prefer this position for sleeping. Dr. Derham in his Physico-Theology, speaking on this subject, says, "that divers flies and other Insects, besides their sharp hooked nails, have also skinny palms to their feet, to enable them to stick on glass and other smooth bodies by means of the pressure of the atmosphere, after the manner I have seen boys carry heavy stones with only a wet piece of leather clapped on the top of the stone." This theory acquired additional weight, or rather was confirmed in the opinions of most entomologists by the elaborate and celebrated experiments of Sir Everard Home, in which he was assisted by the microscopic observations, and drawings of M. Bauer.

Mr. Roget, in his Animal and Vegetable Physiology, one of the most recently published "Bridgwater Treatises," has given the following description of this curious mechanism.

Mechanism of the Foot of the house Fly.—In the house Fly, that part of the last joint of the tarsus, which

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Why cannot they walk on smooth surfaces?

is immediately under the root of the claw, has two suckers appended to it by a narrow, funnel-shaped neck, moveable by muscles in all directions. These suckers are shown in Fig. 54, which represents the under side of the foot of the blue bottle Fly, (*Musca vomitoria*,) with the suckers expanded. The sucking part of the apparatus consists of a membrane capable of contraction, and extension, and the edges of which are serrated, so as to fit them for the closest application to any kind of surface. In the Horse Fly each foot is furnished with three suckers.

Fig. 54.

Mechanism in the Saw Fly.—In the yellow Saw Fly, (*Cimbex lutea*,) there are four suckers, of which one is placed upon the under surface of each of the first joints

Fig. 55.

of the toes, Fig. 55. All the feet of this insect are thus provided. Both of these figures are highly magnified.

The mode in which these suckers operate may be distinctly seen, by observing with a magnifying glass, the actions of a large blue bottle Fly in the inside of a glass tumbler. A Fly, by the application of this apparatus will remain suspended from the ceiling with his back downwards, for any length of time, without the least exertion; for the weight of the body pulling against the suckers, serves to make them adhere stronger, for the same reason that a boy's leather sucker adheres more forcibly in lifting a large stone, than a small one. For this reason it is, that house Flies prefer the ceiling to an upper surface, as a place of rest.

In what manner is it said the house fly adheres to the under surfaces of smooth bodies?

Doubts concerning this mechanism.—Notwithstanding it would thus appear, that there could be no doubt with respect to the manner in which Flies are enabled to adhere to smooth surfaces, yet some entomologists still doubt whether the feet of these Insects really contain any organs which adhere by suction. If Flies adhere by the pressure of the atmosphere, then, if the atmosphere be removed, it is said, they would be unable to walk on a smooth perpendicular surface. To demonstrate this, house Flies were put into the glass receiver of an air-pump, and the air exhausted, when it is said, "it was demonstrated to the entire satisfaction of several intelligent gentlemen present, that the house Fly, while it retains its vital powers unimpaired, can, not only traverse the upright sides, but even the interior of the dome of an *exhausted* receiver, and that the cause of its relaxing its hold, and ultimately falling from the station it occupied, was a diminution of muscular force, attributable to impeded respiration." In consequence of such experiments, it has been proposed to account for the phenomena observed, by the secretion of an adhesive matter with which the foot of the Fly, or the hairs on it are embued. The advocates for this mode say, that they have facts on this subject, which are quite inexplicable except on the supposition that an adhesive secretion is emitted by the instruments employed in climbing. We are however, rather inclined to the belief that these Insects adhere by the pressure of the atmosphere as was so clearly shown by the observations of Sir E. Home.

INGENUITY OF INSECTS.

There are some traits in the characters and habits of certain Insects, which appear so much like the cunning, ingenuity and contrivance of the higher order of animals, that we cannot see why they have not an equal

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What experiment seems to make it doubtful whether flies adhere by the pressure of the atmosphere? What is the conclusion of the author with respect to the means by which flies adhere to smooth surfaces? What is meant by the ingenuity of insects?

claim to those attributes. We do not here allude to that instinctive endowment, which guides the different species to deposite their eggs in places where the young when hatched, perhaps many months afterwards, will immediately find the aliment best adapted to their condition; nor to that apparent foreknowledge with respect to time, by which there is a precise adaptation in the state of the plant to the want of the young larva; for these are mysteries of which we can say nothing, except that they are the means which the Creator has taken to perpetuate his works.

By the ingenuity of Insects, we mean that endowment by which they plan and execute, various structures for convenience, or comfort, and which are varied according to circumstances; and also the devices which they employ for the purposes of entrapping, or escaping each other.

Ingenuity of Spiders.—Thus one species of Spider constructs her net for catching game, in a place where he thinks such flies as best suit her appetite are most likely to come; and being sensible that her presence is frightful to those insects which she would make her victims, she takes the precaution to conceal herself with far more cunning than the cat, or even the tiger. The Spider having finished its game net, next goes to work to make a place of ambush, where it can repose in comfort, until some poor fly not seeing the trap, gets entangled in it. The place of ambush is some sly crevice at a distance from the net. In this it constructs a tube of silk, the entrance of which is no larger than absolutely necessary, and is often entirely concealed from external view. This is constructed somewhat like a sack with a small mouth, the interior being enlarged, so that the inmate can stretch out its limbs, and turn around with facility. But that the cunning Insect may not be under the necessity of watching continually at the mouth of its ambuscade, it carries a cord from some convenient part of it to the net, and having carefully fastened both ends, retires to wait the result of its craftiness. The least motion of the game net, instantly brings the owner to the mouth of its ambuscade, the news being conveyed by the cord stretched between them. If it proves to be some luckless fly, which has caused the alarm, the voracious spider mounts the cord, and in another instant, may be seen tying the legs, and wings of its victim, with the utmost eagerness and art, so as to prevent the possibility of escape. Having thus secured its prey, it sucks its blood at leisure, and then retires and waits for another haul.

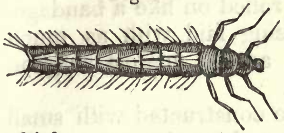
If craftiness, ingenuity and contrivance are not exhibited in such proceedings as these, we know not where to find them in the animal kingdom. Any one by watching a common house Spider, may convince himself of the truth of our statement.

The ingenuity with which spiders contrive to escape when surrounded by water, is sometimes highly curious and interesting. Mr. Kirby placed a large field spider upon a stick about a foot long set in a vessel of water. After fastening its thread, at the top of the stick, it crept down the side until it came to the water, then immediately swinging from the stick which was slightly bent, it climbed again to the top. This it repeated many times, still finding its retreat cut off, and no means of escaping in that manner. At length it let itself down from the top of the stick, not by a single thread, but by two, each distant from the other about the twelfth of an inch, guided as usual by one of its hind feet, one of the threads being apparently smaller than the other. When it had suffered itself to descend nearly to the surface of the water, it stopped short, and by some means not apparent, broke off close to the spinners, the smallest thread, which still adhering to the top of the stick, floated in the air, and was so light as to be moved by the slightest breath. This thread catching on an object at a little distance, the spider employed it as a bridge to make its escape.

But the ingenuity and resources of this tribe of insects are so well known, that we will not multiply more instances.

Ingenuity of the Caddis worm.—A little insect, or worm, common in fresh water brooks, called the *Caddis worm*, and well known to anglers, builds for itself a house, or tube, in which it lives, of most singular, and curious workmanship.

Fig. 56.



The body of this insect is composed of nine sections, the sides of which are fringed with cilia, or paddles. The legs are six, all situated near the head, as shown by Fig. 56, which represents the creature naked, or without its case.

It may be observed that this worm, though it is entirely aquatic, is still not well adapted to swimming. Its six legs all close together are specifically heavier than water, and its long body beset only with a few hairs, would appear better fitted to crawl than to swim. But apparently as a compensation for these defects, the Great Author of nature has endowed it with a degree of instinctive knowledge, by means of which, it is able to avoid the evils which would otherwise arise from its construction.

The Caddis worm constructs for itself a tube or habitation, by means of such materials as it can most easily

Fig. 57.

obtain, and which are fitted to its purpose. Leaves, straws, bits of wood, and shells are employed according to the taste, or convenience of the builder. Fig. 57, shows one of these cases made of a few pieces of leaves, so arranged as somewhat to imitate a Spanish mantle, the head and feet of the insect protruding at the upper end. This, like all the other forms which it constructs is lined with a kind of silk on the inside, and it is by means of the same substance that the different pieces of which these curious habitations are made and fastened together.

Fig. 58.

By Fig. 58 is shown the worm covered by a couple of pieces of semicylindrical, hollow bark, cemented together. Happening to find two such pieces suitable for the purpose, it has been saved the labor of joining more, as most of its brethren have done.

Fig. 59.

Fig. 59 representsts another of these *geniuses* enveloped in a riband, made of pieces of leaves joined together, and rolled on like a bandage, the folds being laid with as much regard to symmetry and skill, as the neatest surgeon displays in dressing a limb.

Sometimes these mantles are constructed with small

Fig. 60.

shells cemented together, as seen by Fig. 60. These shells are commonly empty, but it seems the builder does not always wait for this, sometimes employing living snails, when their sizes happen to suit his wants.

It appears that this insect, when out of its case, can do little more than crawl along the bottom of the brook, where it lives. But when clothed in the manner represented, it floats along near the surface, or sinks towards the bottom at pleasure ; generally retaining the perpendicular position, but changing it to the horizontal, or turning the head downwards, at will. These different positions, as well as some motion in any direction, the insect gains by using its feet as paddles, these parts being always out of the case and free.

But the most wonderful point in this history is the judgment involved in the selection of materials, which when united to the body of the insect will exactly counterpoise the whole, so that it neither rises to the surface, nor sinks to the bottom, but may be made to do either by the small degree of force exerted by the feet.

A vast number of instances might be selected of the ingenuity, craft, and seeming discretion of the Insect tribes, especially of the bee, ant, spider, and wasp, but for these, we must refer the reader to works on Entomology.

What is said to be the most wonderful point in the history of the caddis worm ?

PART II.

VERTEBRATED ANIMALS.

VERTEBRA, signifies "back bone," and the animals which come next to the Insects in the scale of organization, are called *Vertebrated*, that is, they have back bones.

The animals we have heretofore examined consist of those which have no hard parts as the Polypi, or those covered with shells as the Mollusca, or with a crust as the Crustacea, or such as pass from the soft, to a more consistent state as the Insecta.

None of these animals possess an internal solid framework to support, and connect the softer parts, this kind of structure being reserved for animals of the higher orders and more complex organizations.

"If," says Roget, "it be pleasing to trace the footsteps of nature in constructions so infinitely varied as those of the lower animals, and to follow the gradations of ascent from the Zoophyte to the winged insect, which exhibits the greatest perfection compatible with the restricted dimensions of that class of beings, still more interesting must be the study of those more elaborate efforts of creative power, which are displayed on a wider field in the higher orders of the animal kingdom. In the various tribes of beings which are now to come before us, we find nature proceeding to display more

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What are vertebrated animals? How are the vertebrated animals especially distinguished from those we have already examined?

refined developements in her system of organization; resorting to new models of structure on a scale of greater magnitude than before; devising new plans of economy, calculated for more extended periods of duration; and adopting new arrangements of organs, fitted for the exercise of a higher order of faculties.

The result of these more elaborate constructions is seen in the vast series of *Vertebrated Animals*, which comprises a well-marked division in Zoology, comprehending all the larger species that exist on the globe, in whatever climate or element, they may be found; and including man himself, placed, as he unquestionably is, at the summit of the scale, the undisputed Lord of the creation."

"A remarkable affinity of structure prevails throughout the whole of this extensive assemblage of beings. Whatever may be the size, or external form of these animals, whatever the activity, or sluggishness of their movements, whether inhabitants of the land or water, or the air, a striking similitude may be traced in the disposition of their vital organs, and in the construction of their solid frame works or skeletons, which sustains and protects their fabric. The Quadruped, the Bird, the Tortoise, the Serpent, the Fish, however they may differ in subordinate details of organization, yet are constructed upon one uniform principle, and appear like varied copies from the same original model. In no instance do they present structures, which are altogether isolated, or can be regarded as the results of separate and independent formations."

Animals resist both heat and cold.—But although there is a general analogy with respect to the skeletons of all vertebrated animals, and a general similitude in the disposition and construction of their vital parts, still there is a striking and wonderful difference in the effects produced by the action of these parts, especially vital action, on the animal, and particularly on its temperature; for while the

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What is said concerning the affinity of structure, which exists among all animals with back bones? What is said of the different effects of vital action on different vertebrated animals?

fishes, properly so called, partake the temperature of the water in which they live, even to the point of freezing; air breathing animals have the power of resisting both heat and cold, and of preserving nearly the same temperature, whatever that may be in which they are placed.

It is perhaps true, that to a certain degree, all animals, and even trees, resist both heat and cold so long as the vital principle remains active. But in the lower orders of animals, this power is exceedingly feeble when compared with that, which endows Quadrupeds and Man.

Thus eels become as cold to the touch as the ice in which they may be preserved, and yet the vital principle remains, since these creatures may be thus kept in a torpid state, probably for any length of time, and then again revived to life and activity. It is well known also, that the gold fish may be frozen with the water in its vase, and yet by a slow application of heat, become as lively as ever, in the course of half an hour. In these cases, and many others which will be mentioned hereafter, life is suspended, but its principle yet remains, and although such animals do not preserve their temperature like those of the higher orders, they are still endowed with a much greater tenacity of life, for with a few exceptions, when a warm blooded animal becomes cold, the vital principle is not merely suspended, but is extinct, and death ensues.

The power of man, and also of quadrupeds and birds, to resist changes of temperature, is indeed surprising. With respect to the power of animals to resist low degrees of temperature, every one who resides in a cold climate has seen abundance of natural examples. The turkey, for instance, will sleep comfortably, perched on a high tree, entirely exposed to the northern blast, when the thermometer is 30 degrees below zero. Allowing the temperature of the bird to be 100 degrees, which is not above the truth, then there

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What is said about the freezing of eels and fish? What animals have the greatest tenacity of life, cold or warm blooded? What difference sometimes exists between the temperature of the turkey and the air in which he is?

is a difference of 130 degrees, between that of the atmosphere and that of the turkey. But the Black-cap-titmouse, a little bird which passes its winters with us is a much more extraordinary instance of the same kind, on account of its diminutive size. This bird as it flies, does not probably weigh more than half an ounce, and yet small as it is, the vital action with which it is endowed, is sufficient to maintain its temperature, 130 or 140 degrees, above that in which it is placed, and this difference so far from inducing torpor, seems from the cheerful and lively appearance of the little animal, to be a temperature most agreeable to it.

On the contrary, it is found by accurate experiments, that the animal system is capable of resisting degrees of heat in a much greater proportion above its own temperature, than these are below.

Origin of the experiments on the power of Man to resist heat.—A circumstance which happened in France, in the year 1760, first led philosophers to make experiments on the power of the human system to resist high temperatures. Some gentlemen having occasion to use a public oven for certain experiments on the day in which bread had been baked in it, and wishing to ascertain its temperature, a girl, one of the attendants at the bakery, offered to go in, and mark the height of the mercury with a pencil. The girl smiled at the hesitation of the gentlemen to allow her to do so, and going into the oven, marked the temperature at 260° of Fahrenheit. Notwithstanding the anxiety they felt for this young salamander, she declared to their astonishment, that she felt no inconvenience from the heat, and insisted on staying longer, and having remained ten minutes, the thermometer then was found to stand at 288°, that is, 76° above the heat of boiling water, and 190° above the ordinary temperature of the human system, which is 98°.

Experiments of Sir Charles Blagden and Dr. Fordyce.—The publication of these facts excited general

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What circumstance first led philosophers to make experiments on the power of the human system to resist heat? How much higher was the temperature of the oven than that of the ordinary human system?

attention, and several philosophers made experiments on their own persons with a view of testing and explaining such a singular phenomenon. Of these experiments, probably the most accurate and decisive, and certainly the most famous, were those of Sir Charles Blagden and Dr. Fordyce. The room where these celebrated experiments were made was heated by flues, there being neither chimney nor any other aperture where the heat might escape.

In the first experiment, Sir Charles went in, with wooden shoes on his feet, the heat being a little above that of boiling water. The first impression is described as exceedingly disagreeable, but in a few minutes all this uneasiness was removed by the breaking forth of a profuse perspiration. Having staid twelve minutes, he came out with a sense of fatigue, but nothing more, the thermometer then standing at 220°.

It was afterwards found that the temperature of 260° could be endured for a short time, without much difficulty. But the most curious part of these experiments were the sensations produced by touching their own persons on some vital part, or touching each other, and also objects in the room. Every piece of metal about their persons, as their watch chains, became intolerably hot; small quantities of water placed in metallic vessels, boiled in a few minutes. Though the air of the room was 260°, it could be taken into the lungs with impunity, but the boiling water in which the thermometer indicated only 212°, scalded the finger as usual. Eggs and beef-steak suspended in wire nets, were completely done in from five to fifteen minutes, and still the gentlemen were able to remain in the room. But notwithstanding dead matter became heated to the temperature of the air, as was expected, the persons of the gentlemen never rose higher than about 101°, or at most 102°, as indicated by the thermometer, with the bulb placed on the tongue, or under the arm.

The hands being at a distance from the vital parts, were heated to a much higher degree, so that when the

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What were the degrees of heat to which Sir C. Blagden and Dr. Fordyce exposed themselves?

gentlemen touched any part near the seat of life, as the tongue or side, it felt nearly as cold as a piece of ice under ordinary circumstances. Thus though these persons were in a temperature of 260°, and even in some experiments as high as 264°, the heat of their bodies never rose higher than 102°, making a difference of 160°, between them and the air in which they were placed.

In what manner the heat is carried off.—If we look for the means which nature displays to carry away the superabundant heat to which the system is exposed, we shall find that perspiration is the most obvious, though not the only one to which we can refer. The boiling water, in the rooms in which these experiments were made, as is the case every where at the surface of the earth, never exceeded 212 degrees, the remaining heat being carried off by the steam rising from its surface. In like manner the gentlemen state, that within a few moments after entering the heated room, their persons were covered with a profuse perspiration, which continued as long as they staid. But besides this cause, the operation of heated air on the system is not so great as might be expected in consequence of its being so highly rarified, and expanded, that comparatively few particles come in contact with the surface of the body. It has been found also, that the quantity of oxygen consumed by the lungs, (which is the source of animal heat,) during these experiments, is much less than ordinary, most probably owing to the rarity of the air.

It appears that these are the several causes which conspire to keep the temperature of the animal system nearly the same as ordinary, when exposed to high degrees of heat.

STRUCTURE OF THE BONY, OR OSSEOUS FABRIC.

The framework of all vertebrated animals is made of bone, the appearance of which we need not describe.

What are the means employed by nature to resist high degrees of heat? Why is the temperature of boiling water stationary at 212°?

The composition of bone is chiefly *phosphate of lime*, cemented into a solid form by animal matter. On exposure to heat, bone becomes black, in consequence of the conversion of this animal matter into charcoal. In the mean time the oil contained in the cavities takes fire, and all the combustible materials of which the bone is composed are consumed. It now becomes white and porous, having by the process lost about half its weight. What remains, being as it were the skeleton of perfect bone, is phosphate of lime deprived of its animal cement. It is now so brittle as to be broken by a light blow, or even ground to powder in a mortar. On breaking the bone across, we are now able to discover the cavities which contained the oily matter, and probably also some of those which contained the animal cement.

On the contrary, by steeping a bone in a quantity of acid, sufficiently diluted to prevent its action on the animal matter, we may deprive it of its phosphate of lime, and preserve this matter entire. The substance remaining after the solid matter has been dissolved, retains the exact form of the bone, but is soft, flexible, and elastic; and is resolvable into a jelly, by boiling. This substance is very nourishing, and is that which forms the soup made from bones.

The different mechanical purposes for which the bones of the living system are employed, require that they should be of a great variety of forms. Thus the spine, or principal support of all the vertebrata, requiring motion in all directions, is made up of a great number of pieces, joined together by a layer of cartilage between each two, which by its elasticity allows of the required motions. The wrist and ankle are also composed of many pieces each, also allowing of general motion. On the contrary, the limbs acting as a system of levers, connected by joints, are composed of solid, firm pieces, generally of a cylindrical form, and of considerable length,

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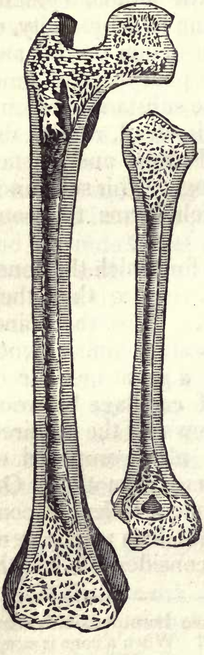
What is the composition of bone? Why does burning bone become black? Why does burned bone become white? When a bone is steeped in acid, what part of its composition is destroyed? What is the appearance, and what the consistence of the bone, when the phosphate of lime is destroyed? What is said of the different forms of bones?

having motion only at the points of connection. Levers of various kinds, most artificially and beautifully combined, are found in the limbs of quadrupeds, the wings of birds, and the fins of fishes. The construction of these bones combine strength and lightness to an admirable degree, being hollow cylinders, with the enlarged ends porous.

All the long bones of quadrupeds, birds, and man, are made on this principle. When we come to the physiology of the birds, we shall find a wonderful provision in that particular class to ensure lightness, the bones being thin cylindrical tubes filled with air.

In the corresponding bones of quadrupeds, the interior is filled with an oily substance called *marrow*, which is entire and undivided along the shaft, or smallest part of the cylinder, but is contained in pores towards the two extremities, where there is a spongy expansion of bony matter, for the purpose of strengthening the enlarged size of the bone at these parts. Fig. 61 represents a longitudinal section of the femur, or human thigh bone, showing the dense, solid substance of the external parts, and the cavernous and spongy structure of the interior. Fig. 62 shows a similar section of the humerus, or bone of the arm which joins the shoulder. It is said by mechanical philosophers, who have made experiments on this subject, that it would have been impossible to have otherwise formed with the same quantity of solid matter, a lever so strong, and yet so light, as that presented by the long bones of the quadrupeds and man.

Fig. 61 and 62.



What is said of the construction of bones which are used as levers? Give a description of the structure of the two bones shown by Fig. 61 and 62. What is said of the mechanical strength of the long bones?

FORMATION AND GROWTH OF BONE.

In the earlier stages of animal growth, there is formed in those parts of the system which are ultimately to be supplied with bone, a cartilaginous pattern in miniature, of the bone itself. This cartilage is semi-hard, somewhat tenacious, and translucent. When the bone begins actually to form, the cartilage becomes absorbed at the centre of the piece, and a few ossific particles are deposited in its place. As the process goes on, cartilage continues to be taken up and bone formed in its room, from the centre towards the circumference, or extremities, until the whole becomes ossified.

In the cylindrical bones the process begins in the middle of the cylinder, forming a ring there, which increases in both directions, until the whole becomes bone. Several of the bones of animals, particularly those of the skull, are not completely formed until the animal is of considerable age.

The heads of the bones are formed independently of the shafts, being separate pieces with a thin layer of cartilage between them. Afterwards these parts unite, the cartilage being replaced by bone ; but this does not happen in our species, until the age of fifteen or eighteen years.

The bones are well supplied with blood vessels, which enter about the middle of the long bones, and penetrating the central cavity, pass both upwards and downwards, supplying the substance of the bone with small branches, and giving off some very delicate arteries which secrete the marrow. It is the arteries which thus pass into the bones, giving off the most delicate fibres through every part of its substance, that secrete, and form the bone itself.

Every bone is surrounded by a thin membrane, called the *periosteum*, from which pass into the external, and most solid part of the bone, thousands of fine blood vessels by which this part was formed, and is still

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In what manner is it said bones are formed ? Are the long bones of young animals formed of one, or several pieces ? Are the solid parts of bones supplied with blood vessels or not ? What is the membrane which surrounds the bones called ? What vessels deposite, or secrete bone ?

nourished, as is proved by the fact, that the destruction of the periosteum, causes the death and decay of the part over which it was placed.

SPINE OF THE VERTEBRATA.

The word *spine* signifies a thorn; this part of the skeleton being so called, because each piece of which the back bone is formed, has a projecting process outward, making as a whole that prominent ridge so well known as the spine in various animals. Thus by common consent, and long usage, a column made up of many pieces, is not only named after a sharp pointed instrument, but is spoken of as a single bone.

This column, in the human species, consists of twenty-four distinct bones, named *vertebræ*, from the Latin *vertere*, to turn, because this part of the skeleton has motion in every direction.

Of these twenty-four pieces, five belong to the loins, twelve to the back, and seven to the neck. The whole spinal column is represented by Fig. 63, of which the pieces above 2, and below 1, belong to the neck and loins; while those between, belong to the back.

Fig. 63.

The spine is the foundation, or chief mechanical support of the whole skeleton; and not only so, as giving protection to the spinal cord, which in one sense is a part of the brain, being a continuation of its substance, but is a very essential part with respect to the nervous system.

A single vertebra is shown by Fig. 64, where the lower part, or body, which is somewhat radiated on the surface, is that by which it is joined to its fellow. The elongation *s* is called the *spinous process;* and is that which, when the whole are in place, forms the ridge of the spine, or back. Besides this, there is another projection, *t*, on each side of the base of the

Fig. 64.

arch, on which the spinous processes are situated. These are called the *transverse processes* of the vertebræ. The arch formed by the united bases of these processes, and a groove in the body of the vertebræ, form the canal through which the spinal marrow passes. This aperture through a single vertebra, is obvious in the adjoining figure. When all are united, they form a continuous canal with solid walls, for the protection of that most important part of the animal system next to the brain, the spinal marrow.

The spine is the great central beam of the whole fabric of the skeleton. To this part all the other bones are connected by muscles, and joints, the whole being thus combined into a general frame work. It is the common axis of all the motions of the limbs, by furnishing fixed points for the attachment of all the larger muscles.

No where has the mechanical art of the Great Architect of Nature, been more skillfully displayed, than in the construction of this part of our frames. Had the spine been made of a single rigid piece, it would be liable to fracture by blows which it now withstands with impunity; and besides, such a construction would have deprived us of a great variety of motions, which are now so important to us in the business and comforts of life.

Between the bodies of each bone there is an elastic cartilage, allowing of a little motion in all directions; and this slight flexure at each part, being multiplied through the whole column, admits of sufficient motion for all our purposes.

In addition to the cartilaginous connection, the spinal bones are bound together by strong ligaments and mus-

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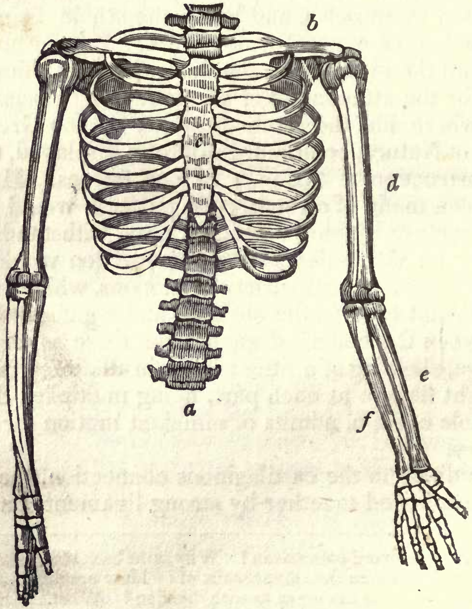
What does the word spine mean? Why is the back bone called spine? How many bones does the spine consist of? How are these bones divided, and what names are given to each division? What is said of the mechanical importance of the spine? What very important part does the spine protect? Which is the spinous, and which the transverse processes of the spine? What most important portion of the system is protected by the spine? What is said of the importance of the spine, as connected with the other parts of the bony fabric? What would have been the consequences, had the spine been formed of a single piece? How are the several pieces of the spine connected together?

cles, passing from one process to the other, through the whole line, thus combining the twenty-four pieces into one entire, and firm column.

It is by the action of these muscles, thus passing longitudinally along the spine, that we are enabled to bend it backwards and forwards, or from right to left. Thus the back is made hollow, or bent backwards, when the muscles attached to the spinal processes are contracted; and when those attached to the transverse processes are contracted on the one side, and relaxed on the other, then the column is bent from the right towards the left, or the contrary, as the case may be.

Fig. 65.



The connection of the spine of the human frame with the ribs and arms, is shown by Fig. 65. The ribs are

How is the spinal column made to bend backwards, or from right to left?

generally twelve in number on each side, though in some instances they are found to be thirteen, and more rarely only eleven. They are distinguished into *true* and *false* ribs. The seven upper ones, which are articulated, or joined to the sternum, *c*, are called *true* ribs, while the five lower ones, which are not immediately attached to the sternum, or breast bone, but to a cartilage connected with it, are called the *false* ribs. The other extremities of the ribs are articulated by small heads to the vertebræ, and secured by a ligament, so as to allow of a small motion upwards and downwards, but in no other direction.

The use of the ribs is to give form to the thorax, to cover and defend the lungs and heart, which are situated within them; and also to assist in breathing, by their alternate elevation and depression.

The *sternum*, *c*, or breast bone, it is well known is situated in front of the thorax. In young people this bone is in several parts, united by cartilages; but as we advance in life these cartilages ossify, or are changed into bone. Its shape is oblong, and its external surface convex. To its edges are immediately articulated the seven upper ribs.

The *clavicle*, *b*, has its name from the Latin *clavis*, which appears to come from *clando*, to shut, this bone resembling in shape an ancient key. It is usually called the *collar bone*, and is placed at the upper part of the breast, or root of the neck, extending across from the tip of the shoulder to the upper part of the sternum. It is a round bone, curved somewhat into the shape of the italic *S*. It supports, and maintains the shoulder in its proper place, and prevents it from falling forwards towards the breast. Its outer end is firmly fixed to the upper part of the *scapula*, or shoulder blade. Animals which employ their fore feet as hands, are furnished with this bone, as the monkey tribe and squirrels; while

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What is the number of ribs in the human skeleton? How are they distinguished? To what part are the seven upper ribs articulated in front? How are the anterior ends of the five lower ribs secured? How are the posterior ends of all the ribs secured? What are the uses of the ribs? What is said of the sternum? Whence is the name clavicle? What is the common name of this bone? To what parts is the clavicle articulated? What animals besides man have this bone?

those which make no such use of their feet, are without it, as the horse and sheep.

The bones of the arm are the *humerus, d,* and the *radius* and *ulna, e* and *f.*

The humerus is a long cylindrical bone, with its upper end articulated to the scapula, forming the shoulder joint. At the point of articulation, the extremity is enlarged into a round, smooth head, which is admitted into the glenoid, or shallow cavity of the scapula, where it is strongly secured by ligaments, but in such a manner as to allow it motion in all directions.

At its lower extremity the humerus is gradually expanded, for the articulation of the two bones of the fore arm, the radius and ulna, both of which are connected with this bone at their upper extremities, forming the elbow joint.

The mechanism of the elbow joint, as well as the action of the muscles on the radius and ulna, together with the mechanism and wonderful powers of the hand, will be reserved for another place, while we proceed to an account of the spines of other vertebrated animals.

The whole number of bones in the human species, amount to 240.

Unity of design manifested in the constitution of the Spines of Vertebrated Animals.—It is a truth as wonderful as it is instructive, which the study of nature developes, that although the Creator had Almighty power and Infinite wisdom, and might therefore have varied his plans and executed his designs in an infinite number of ways, in the construction of the different races of animals, that we still find an economy of design, and a unity of plan in the general construction of the frame work, or foundations of the grand divisions of animals which prevails throughout all the orders, or sub-divisions, however different the destinies, or habits of the distinct races may be from each other. Reasoning and judging on this subject as we do with respect to the arts of man,

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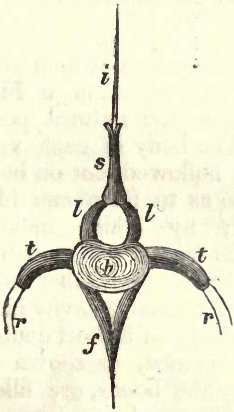
What are the bones of the arm called? What joint is formed by the articulation of the head of the humerus? What bones are articulated with the lower end of the humerus? What is said of the unity of design, as exhibited in the spines of various animals?

we should be led to suppose that the frame work of our own species had first been constructed, and that the corresponding parts of other animals had been varied from this, only so far as their means of existence, habits, or the element in which they were destined to live, made it absolutely necessary.

We have already stated that the spine is the main column, or most substantial part of the skeleton of vertebrated animals, and we have described and figured this part as it exists in our own frames. We will now show the unity of design which exists in the construction of the animal kingdom, by comparing the spines of other animals with that belonging to the human frame.

Mechanical elements in the Vertebræ.—The number of elements, or mechanical parts which enter into the composition of the Vertebræ of different animals is shown by Fig. 66. This does not represent the precise form of any vertebra, but is meant to combine the elements of the corresponding parts as existing in vertebrated animals generally. The first part is the *nucleus* or *body* of the vertebra *b*, which is present in all the species. Next in importance is the bony plates, or *leaves* as they are called *l*, *l*, which proceed from the sides of the body, and embrace the spinal marrow, which runs through the aperture between them as shown in the figure. Another essential element is the *spinous process s*, which unites the two plates, and thus completes the superior arch, of which it may be considered as the key-stone for the protection of the spinal cord. Then come the two *transverse processes t*, *t*, which extend outwards, towards the sides, and with which the ribs *r*, *r*, are generally connected. These

Fig. 66.



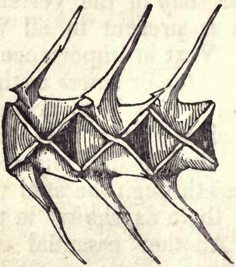
Explain Fig. 66. Point out the parts that are essential to a vertebra.

are the six parts which comparative anatomists consider the elements of the vertebræ, and which are found in most vertebrated animals, however various in form, size, or habits, they may be. In some cases however, in addition to these, there is the process *f*, bifid at the base, and forming a spine at the lower surface of the vertebra, or opposite to the spinous process. This structure is common in the Fishes. The aperture formed by the bifurcation of this process admits the passage of a large artery.

As our plan will not allow an extension of this part of our subject to the different orders of the vertebrata, we will omit any illustration from the quadrupeds, as being most nearly allied to man in the scale of organization, and therefore most likely to present similar spines; and since illustrations the most remote from man in the scale of being, will tend most clearly to show a unity of plan in the construction of the whole, we will give examples from some of the lower orders of vertebrated animals.

Vertebræ of Fish.—Fig 67 represents a section of a part of the spine of a Fish standing in the natural position. The body of each vertebra is hollowed out on both sides, so as to form cup like cavities; by which means, when the two convex cavities are applied to each other as in the living animal, a cavity having the shape of a short double cone is formed, as shown in the figure. These cavities left by the bones, are filled with a gelatinous substance, which is nearly incompressible, and which appears to serve as a kind of pivot for the motions of the joint. By dividing a spine in the centre, these parts are seen, as shown in the figure.

Fig. 67.



A single vertebra is represented by Fig. 68, for the

Explain Fig. 67. What is the difference between the vertebræ of quadrupeds and fishes?

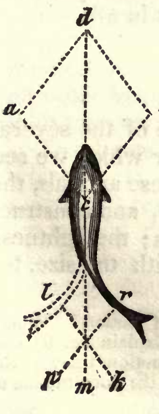
Fig. 68.

purpose of showing the peculiarity of this part in the Fish, and which forms one of the elements of Fig. 66, which is marked *f*.

In the vertebræ of the Fishes, therefore, we see two spinous processes *f*, *f*, standing opposite to each other, the one above and the other below the body, while the transverse processes are wanting. These are the points of difference between the spines of this class of animals, and those of the land vertebrata.

The design of this difference will immediately become obvious, if we stop for a moment to inquire what sort of motion in the spine, is best calculated to impel the fish through the element where it lives. The spines of the vertebræ, standing in a vertical position, when the fish is in its usual posture, all vertical motions, or flexures of the spinal column upwards and downwards, is entirely prevented, the motions being limited to flexures from side to side. Now since the fish moves through the water, on the same principle that a boat is propelled by what is called *sculling*, that is, by a single oar moved backwards and forwards in the stern, it is plain that any compound flexure of the spine would rather retard, than facilitate its progress.

Fig. 69.



Locomotion of Fishes.—The manner in which fishes give themselves progressive motion through the water, will be understood by Fig. 69. Suppose that the tail is curved to the right as shown in the figure, and in this situation the muscles on the left side act suddenly, so as to bring the fish into a straight line, then the re-action of the water against the motion of the tail in the direction of *r*, *p*, would give the whole body an impulse contrary to that of the re-action, and the centre of gravity *c*, would move in the direction of *c*, *b*, which is parallel to *p*, *r*. This impulse is not destroyed by the next flexure of the tail in the contrary direction, because the principal force exerted by the muscles has already been exerted in the motion from *r* to *m*, in bringing the tail in a straight line with the body; and the force which carries it on to *l*, is much weaker, and therefore occasions but a feeble re-action of the water. When the tail has come to *l*, a similar action of the muscles, on the other side will give an impulse in the direction of *k*, *l*, and a motion of the whole fish in the same direction, that is in the line *c*, *a*. The flexures, and consequent re-action of the tail being repeated in quick succession, the fish moves forwards in the diagonal of *c*, *d*, intermediate between the direction of the two forces.

By bending the whole body almost to a circle, and then suddenly straightning it, fishes are able to leap out of the water, or to ascend a perpendicular cataract of considerable height.

Did the plan of this little work allow an extension of the subject of this section, it could be shown that the spines of the frog, tortoise, birds, and indeed, all other vertebrated animals present a striking similarity in their structures, and that their forms, lengths, and peculiarities are deviations from the general plan we have described, only so far as is necessary to adapt them to the general organization of the animals to which they belong. However ignorant any one may be of anatomy, he will generally distinguish the back bone of any animal without mistake, so great is the similarity in all.

STRUCTURE OF BIRDS.

In no class of animals is the structure of the several parts, so obviously adapted to the uses for which we see them employed as in the Birds. In these animals, the frame of the skeleton, the figure, position, and construction of the wings, the size of the muscles; the lightness of the whole system when compared with the size, to-

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In what directions does the spine of a fish allow of motion? Would any other motion assist the fish in its progress? Explain fig. 69, and show in what manner the fish gains progressive motion through the water? What is said of the peculiar adaptation of the construction of birds to the element in which they move?

gether with the positions and strength of the quills, and feathers, all have a direct and beautiful relation to the properties of the element, in which they are intended to move.

In no part of Creation, therefore, do we see more direct and positive marks of design in the Great Author of Nature, than in the adaptation of means to specific ends, than in the construction of Birds.

What is particularly striking in the skeletons of these animals when compared with others, is the vast size of the sternum, or breast bone as seen at *f*, Fig. 70. This bone not only covers the whole chest to a considerable depth on each side, but extends back nearly to the insertion of the legs. Its lower part forms a deep perpendicular crest, shaped, it is well known, like the keel of a ship, the whole being remarkably thin and light, when compared with the extent of its surface. The design of this great developement is obviously to furnish an extensive surface for the attachment of the pectoral muscles to be employed in the motions of the wings. In many Birds these muscles outweigh all the others of the body put together, and it is owing to their great power that the eagle and other birds have such amazing strength of wing, as to carry animals heavier than themselves, and that the Swan sometimes breaks a man's leg by a single flap of his pinion.

But in addition to the general appearance of lightness which the bones of Birds present, the cylindrical ones are hollow tubes filled with air. In this they differ from all other living bones, those of other animals being filled with marrow.

The lungs of Birds are placed on the ribs, between which their substance also projects. They are of a compact texture, and so bound down to their places among the ribs, as to have no expansive and contractile motion, like those of other animals; hence respiration in this order is carried on by alternately enlarging and contracting the cavity of the chest, as will be

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For what purpose is the breast bone peculiarly large in the birds? With what substance are the bones of birds filled? In what manner is respiration carried on in birds?

explained in another place. The air not only circulates through the lungs by this means, but also penetrates the cavities of the bones through vessels constructed for this purpose. In Birds not formed for extensive flight, this provision, however, is much less extensive than in others. Thus in the domestic fowl, the humerus, or first bone of the wing is the only one filled with air. But in the Eagle and other tribes which spend much of their lives in the air, nearly all the bones are hollow, and are filled with the element in which they live. The air thus admitted becomes considerably rarified by the temperature of the Bird, by which provision the whole body is rendered considerably lighter than it otherwise would have been.

In all this we cannot but observe a wonderful adaptation in the construction of the animal to its habits, and the element in which it lives.

Structure of the Back Bones of Birds and Fishes.—In the structure of the two classes of vertebrata, the Birds and Fishes, we may trace remarkable differences, which are obviously dependent on the adaptation of each to the elements in which they are respectively destined to live. In the Fish, the chest, and all the viscera are placed as far forward as possible; the respiratory organs, which are the gills, and the heart being also close to the head. Thus the bulk and consequently the centre of gravity, being placed near the head, the tail is left light and flexible for the purpose of motion. In the Fish, the neck, or rather that portion usually occupied by the neck in the other classes, disappears, its place being filled with those parts usually found in the chests of other animals.

In the Birds, on the contrary, the viscera are placed as far back as possible, and a long flexible neck is contained between the trunk, and head, so as to place them at a considerable distance asunder. In Fish, progressive motion is effected by the tail, the impulse being given by its horizontal flexures from one side to the other. In

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What difference is there in the different kinds of birds with respect to the quantity of air contained in their bones? What remarkable difference is there, between the construction of birds and that of fishes?

the Birds, the instruments of motion are fixed to the fore part of the trunk, the impulse being given by the vertical, or up and down action of the wings at the same instant. In the Fish, the spine is flexible, especially towards the tail, while in the Bird this part is rigid through the body, having motion only in that part which forms the neck.

Birds change the centre of gravity.—It is by means of the neck, that the Bird is enabled to change its centre of gravity according to circumstances. In the act of flying, this centre must be between the articulations of the wings; while in resting on its legs, it must be between the feet. Had not Birds the power of adjusting the centre of gravity, they could neither fly with precision through the air, nor rest secure on their feet.

Fig. 70.

Skeleton of a Swan.—The skeleton of a Swan represented by Fig. 70, will not only serve to show in what manner these changes with respect to the centre of gravity are effected, but also how nearly the bones of Birds correspond with our own. The neck of this Bird is composed of twenty-three bones, most of them so articulated together as to allow of free motion in all directions. By extending this part in a straight line, the bird, while flying, moves the centre of gravity so as to bring it to some point between the insertions of the wings, whereas, while the Swan is floating on the water, or resting on the feet, the neck is thrown backwards and curved into the form of the letter S, by which the equilibrium of the whole system is preserved by throwing the centre of gravity between the feet. On the same principle all other Birds are enabled to preserve their equilibria in any position they choose to take.

Comparison between the bones of Men and Birds.—We have already shown that there is a general similitude in the skeletons of all the Vertebrated animals, and especially in their spines. At first view it would hardly be thought that there could be much similarity between the bones of a Bird, and those of a Man, and yet on a closer examination we shall find that the general principles of structure are the very same, and not only so, that some of the individual bones approximate each other in form. Thus the *humerus*, of which *a*, Fig. 70, is the head, has a general form like that of our own species. It is flattened in the same manner at the lower extremity for the articulation of the two bones, the *radius* and *ulna*. The two latter bones, *b*, with which the humerus forming the elbow joint, are also the same in number, and somewhat similar in shape to those forming the corresponding part of the human skeleton. The *carpus*, or wrist, *c*, consists of only two bones, the one articulated with the radius, the other with the ulna. These move together as one piece. The *metacarpus*, or hand *d*, also consists of two bones, but these are united so closely as to form only one in effect and use. Below these, at *e*, there is a little projecting bone which may be considered as a rudimental thumb.

The prehensive organ in Birds being the bill, and as nature never furnishes any organs but such as are absolutely necessary, so the terminations of the wings of Birds, instead of being furnished with bones and muscles which have the prehensile power, like the hand, are only provided with such as are fitted for the insertion of quills.

PART III.

ANIMAL FUNCTIONS.

THE *Vital functions*, or actions, of animals are such as are immediately essential to life, as the circulation of the blood, respiration, secretion, and absorption. Without these the animal cannot exist. The *animal functions* are those which support and renovate the system, and without which the vital functions could not long be maintained, as digestion, nutrition, and the formation of chyle. These are not immediately essential to life, but may be suspended for a time. The *mechanical functions* are such as depend on the will, as the action of the muscles, whether employed for the purposes of swimming, flying, or walking. The instruments by which mechanical action is effected have been the chief subjects of the

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What are the vital functions of animals? What are the animal functions? What are the mechanical functions?

foregoing pages, and we shall now proceed to treat of the animal functions, reserving for future consideration the action of the human muscles, which can be most properly noticed when we come to speak of Physical Education.

SOURCES OF NUTRITION.

The nutrition which nature has provided for the various tribes of animals, is derived, entirely, from two sources, namely, from the animal and vegetable kingdoms. But as the carnivorous tribes derive their food from those which are herbivorous, the nourishment of all is ultimately derived from the earth itself.

Vegetable food.—The economy of nature, is no where more wonderfully manifest than in the adaptation of animals to the consumption of every kind of nutrition, there being hardly any organized substance which does not furnish food for some living creature. The succulent parts of vegetables are not only the chief source of nourishment of the greater proportion of the larger animals, but also serve the same purpose to myriads of insects. Many tribes of birds likewise, live on vegetables, but insects become the food of the larger number, while not a few are strictly carnivorous. But while these substances are the common food of the most numerous races, even the hardest parts of vegetables, and the most poisonous plants serve the same purpose to certain other tribes. The larvæ of various insects live by eating their way through the diseased portions of timber logs; while the Nettle, the Deadly Night-shade, the Henbane, and other acrid and poisonous plants, afford wholesome food to several species. Some live on fruits and seeds, and others on the juices which they pump from succulent plants.

Animal food.—But while a vast number of tribes thus subsist on the fruits of the ground, these in their turn become the prey of at least as great a number of

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Whence do animals derive their nutrition? What is said of the extent to which vegetables serve as the food of animals?

carnivorous animals. Every part and portion, of the earth's surface; every tree, every building, every room in which we live, and even the atmosphere which we breathe, contain a greater or less number of beings, which are perpetually on the alert to procure victims for their voracious appetites. From the spider, which "taketh hold with her hand and liveth in king's palaces," to the lion which prowls over the deserts of Africa, there is an uninterrupted series of Carnivora, ready to suck the blood of any living thing they can master.

We can see, and shudder at beholding the formidable arms of the lion, and tiger, and can observe the murderous disposition of the cat. But there are thousands of insects which lie in wait for their prey, and which emulate the feline race in their savage dispositions, which fall under the observation of none except naturalists. Many of these when only a few hours old, begin to hunt for their prey, and continue during their lives, to subsist only by war and bloodshed. Many of them are cannibals, devouring their own kind, or even their own families, without hesitation, when other food does not come in the way. Nor are many of the inhabitants of the water, whether fresh or salt, less predacious in their dispositions. From the larvæ that is contented with the stagnant pool by the road side, to the shark that roams through the wide ocean, there exists a continued series of animals, not less rapacious in their dispositions, and even more voracious in their habits, than the corresponding series which inhabit the land.

Many of the carnivorous tribes insist upon killing their own food, and will touch nothing which they find already dead; while others are too indolent to live by the chase, and are contented to devour any thing that once had life, in whatever state they may find it.

In the absence of the larger animals, myriads of insects are ever ready, in the warmer seasons, to devour any dead animal, no matter in whatever place it may be found.

So strongly was Linnæus impressed with the immensity of the scale on which the work of demolition was

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What is said of carnivorous animals, and their food?

carried on by insects, that he used to maintain that the carcass of a horse would not be devoured by a single lion, as soon as it would by three green flesh flies, (*Musca vomitoria*,) and their immediate progeny: for it is known that one such fly will lay 20,000 eggs, which in the course of a single day will produce larvæ, each of which will devour so much food, as in another day to increase its weight two hundred times; and each of these 20,000 in the course of a few days more, will produce a third generation equally numerous.

Relation between the organization of Animals and their food.—Thus we see that one race of animals is destined to become the food of others, and these again are in their turn consigned to the same fate from their more powerful enemies. Each kind, whether they subsist on vegetables or flesh, are so organized as to digest the food which their appetites crave. The peaceful cow and sheep are contented with cropping the blades of grass from the field, because their organs of nutrition are fitted for the digestion of this kind of food and no other. But the lion, the tiger, and all other carnivorous animals are organized only for the digestion of flesh, and can no more live upon herbs, than the cows and sheep can subsist upon each other. Hence the Creator has provided these animals with claws to secure their prey, and cutting teeth to tear and divide it; and since this is the only mode by which such animals can live, we are no more at liberty to treat these races with cruelty because they tear other animals in pieces, than we have to mal-treat the cow because she crops the herbage of the field.

Man Omnivorous.—But while one class of the animal kingdom, are herbivorous, and another carnivorous, from their structure, the lord of the creation, has a stomach, and a general organization, which so far as food is concerned, embraces both these classes, and hence Man

What is said of cruelty towards the predacious animals? How may animals be divided with respect to their subsistence?

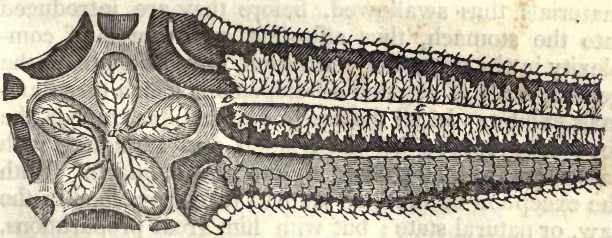
may be called, as he strictly is, the *omnivorous*, or *all-eating* animal.

ANIMAL NUTRITION.

When we examine the structure of the very lowest orders of animal existences, we find, that whatever other parts may be wanting, whether they be eyes, or ears, or nerves, or brain, or organs of locomotion, two parts are always present, to wit, a mouth and a stomach. Without these no animal can exist, for however complex the organization, in other respects, may be, nothing can compensate for the organs of nutrition. From the account we have given of the structure of the Hydra, it would appear that nearly every other part usually constituting an animal may be dispensed with, except these; and that some of the Polypi consist of little or nothing more than a throat and organ of digestion.

Some animals have several stomachs.—Some of the polypi tribes have at least four stomachs, and the *Asteria* or star-fish a very common inhabitant of our sea shores, has ten distinct digestive organs.

Fig. 71.



The mouth of this animal, *a*, is situated in a depression at the centre of the under surface, and leads into a capacious sack or bag, placed immediately above it, when the animal lies with the mouth downwards which

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What is said of the necessity of a mouth and stomach to each animal? What is said of the number of stomachs possessed by some animals?

is the natural position. From this central sack, there proceeds ten prolongatives, or canals, which occupy in pairs, the centre of each ray, or division of the body, of which there are five to each star-fish. These prolongations, or stomach subdivide into numerous ramifications on each side, as shown by Fig. 71, *c c*, which represents one ray of the Asteria, laid open from the upper side. Each ray has two stomachs, such as are here shown, making ten for every animal.

Increased complexity in the Stomach of the higher orders.—We shall not consider it necessary to describe the apparatus for digestion belonging to the different grades of animals as they ascend in the scale of organization. It will be sufficient for our purpose to state that the operations preparatory to the introduction of food into the stomach, increase in some proportion to the complexity of the animal organization. Thus the hydra takes its food into the stomach in precisely the same state that it happens to come to the mouth, and the fish, snake, frog, and many other tribes swallow their aliment in an entire state. Neither have the birds any organs for mastication, so that in common with them, they take their food in an undivided state. But the birds are furnished with an apparatus for grinding the materials thus swallowed, before they are introduced into the stomach, thus affording an example of complexity in the organs of nutritition, proportionate to the general scale of organic developement which these animals exhibit. In all the warm blooded quadrupeds, the food is prepared by mastication and admixture with saliva, before its introduction into the stomach. With the exception of man, all animals take their food in the raw, or natural state ; but with him great preparations, and often very pernicious ones, are made to suit the aliment to his pampered taste, before the act of mastication commences.

Man eats nearly every digestible thing.—Man being an all-eating animal, there hardly exists an article which can be digested, in the sea, on the land, or in the air, that he has not in some way or other contrived to render palatable, or at least to convert by the science of cookery, into something he can take into his stomach.

The most active ingredients in the vegetable and animal kingdoms, and even slow poisons, are in common use as condiments, for what otherwise would be wholesome food; and notwithstanding man is the most anxious of all animals to procure long life, and is perpetually inventing new and improved methods to prolong his earthly existence, yet in practice no animal shows so little wisdom on that very point for which he is so anxious, as the Lord of Creation. All the inferior animals are taught either by instinct or experience to avoid deleterious aliment, and to select such food as is most congenial, and wholesome, and in the wild state most animals would starve rather than touch the food which man prepares for himself. Indeed, no being which the Creator has brought into existence, except the dog and the swine, could long exist on the scientific compounds which man has invented to gratify the artificial cravings of his omnivorous appetite. These animals having been, from time immemorial subjected to human power, the one his companion, and the other the object of his cravings, have finally like their masters, acquired indiscriminate appetites. But notwithstanding the pernicious effects of luxurious indulgence, it will be shown, in another place, that man requires a variety of nutriment.

GRINDING OF FOOD.

Animals which are furnished with jaws and teeth, prepare their food for the stomach by *mastication*. But there are several tribes which are not provided with such an apparatus, and which, as they take solid food, require some internal means of breaking it in pieces, before it enters the stomach. All the birds which live on seeds, as well as the lobster and crab are provided with an apparatus for this purpose.

The part which performs this office in the birds is well known under the name of *gizzard*. That which performs the same functions in the lobster is very different in its construction, though equally efficacious in its operations.

Grinding apparatus of the Lobster.—This part in the Lobster is represented by Fig. 72, which shows the inside of the stomach, together with the triturating machinery at its entrance. There is a cartilaginous frame work, in which the hard calcareous bodies marked *a*, *b*, and *c*, are implanted. These have the form, and perform the office of teeth. The tooth *a*, is situated in the middle of this frame; it has a conical rounded shape, and is smaller than the others. *b* and *c*, are of the same size and shape.

Fig. 72.

When these three teeth are brought together by the action of the surrounding muscles, they exactly fit into each other, and are capable by the motion which is given them, of completely pulverizing the small shells of mollusca, which have been introduced into the cavity of the stomach as food.

Grinding apparatus of Birds.—But the internal machinery for grinding is larger, and more completely formed in the granivorous, or grain-eating birds than in any other animal. In carnivorous birds, as the owl and eagle, this part is entirely wanting, but is found in all the tribes which live on the seeds of vegetables as the Hen, Goose, Pigeon, Swan, &c. In proper with the ancient notion, that "every part helps a part," the grinding faces of the gizzard are dried, ground, and taken to help digestion, to this day.

This organ, called the *gizzard*, has in its structure and mode of action some analogy to the corn-mill. It consists of two powerful muscles of a hemispherical shape with their flat sides applied to each other, and their edges united by a strong tendon which leaves an oval, vacant

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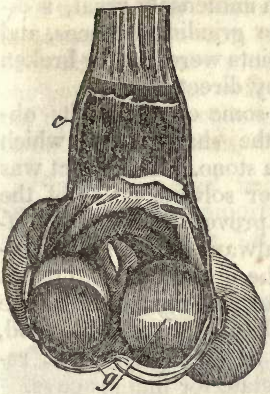
Describe the triturating machine in the stomach of the lobster. What tribes of birds are furnished with gizzards?

Fig. 73.



space between their surfaces. This mechanism is shown by Fig. 73, which represents the gizzard of a swan laid open so as to display the two grinding faces *g*. These surfaces are covered with a dense horny substance, which, when brought together and made to move backwards and forwards, are capable of crushing the hardest seeds, and of reducing them to powder. To assist in this operation, many birds swallow small stones which mixing with the grain, facilitate the process.

In most birds with gizzards, there is a part called the *crop* ,represented and laid open and empty at *c*, in which the food is collected and softened by heat and moisture, before it enters the gizzard. This part therefore, acts as the hopper to the mill, and from it only a few grains are admitted at a time, as they are ground and pass on to the digestive organ, or proper stomach.

The gizzards of birds have been the subjects of numerous, and elaborate experiments, by various physiologists. Those of Spallanzani were the best conducted, and are the most celebrated. He introduced balls of glass into the gizzard of a turkey, and found that they were ground to powder. Tin tubes were also flattened and bent into various shapes by the powerful action of its muscles ; and even the points of needles and lancets, set in balls of lead were worn, or broken off, while the grinding part itself, appeared to have suffered not the least injury.

These results at the time they were made and published, struck all philosophers with wonder and amazement, and calculations were soberly made in order to estimate the actual power required in the muscles of the gizzard to perform such feats.

But the celebrated John Hunter having instituted further inquiries, found that the pressure of the two faces, instead of being perpendicular, as was supposed, is lateral, and at the same time somewhat circular, so that the power it exerts, though immensely great, is directed nearly in the plane of the grinding surfaces, and thus, that the sharp edges and points were bent or broken by a grinding motion, and not by direct force.

But this does not account for some of the results observed in the appearance of the sharp points which were worn off as if rubbed on a stone. This effect was at first attributed to the acrid, or solvent juices of the organ; but as was afterwards proved, is really the effect of the pebbles which are always found in the gizzards of birds, when they can be obtained. No doubt now exists among naturalists, but that these pebbles are absolutely necessary to the perfect digestion of the food, the action of the gizzard alone being insufficient to reduce its contents to the proper state for that process.

After the food has been prepared by the gizzard it passes on to the stomach, where by a process to be hereafter described, digestion and assimilation is performed.

ORGANS OF NUTRITION AND VITALITY IN THE MAMMALIA.

The *Mammalia* include the highest orders of organic developement, in the animal kingdom, embracing as the term signifies, all such animals as nurse their young, as the human species, the quadrupeds, quadrumanna, or monkey, and whale.

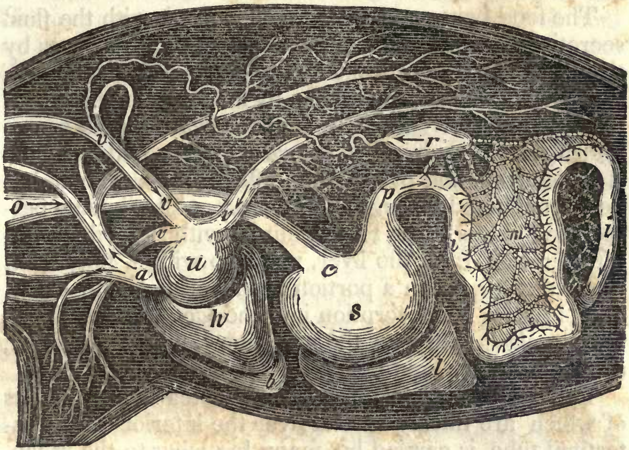
These animals are provided with a complication of organs, all of which are more or less subservient to the process of digestion, for without this process, none of the other functions could long be sustained. The heart and arteries would in a short time cease to act, unless they were supplied with blood, and the blood being formed of chyle, would cease to be produced, if the process of digestion by which the chyle is elaborated, should be suspended, or destroyed. With the cessation of arterial action, the functions of the brain and nerves would fail, and thus life itself would become extinct.

What animals does the class mammalia include? What other functions depend on that of digestion? If the action of the heart and brain should cease, how would digestion be effected? What is said of the dependence of these functions on each other?

And so in its turn, the process of digestion would cease with the want of action in the heart, and brain, so that all these functions are performed as it were in a circle, each one being dependent on the other. In one view, each of these functions may be considered as subservient to the other, while in another view, each is seen to be entirely dependent on the other.

Plan of the most important Viscera.—A connected view of the most important visceral, and vital organs are represented by Fig. 74. This is a side view, showing

Fig. 74.



the natural situation of the parts as they are placed in quadrupeds, but may be considered as applying to the human species without any material change.

In the explanation of this view we will begin with the passage of the food to the stomach. The *esophagus o*, is a muscular tube leading from the mouth to the stomach, and through which the food passes, to the latter organ. Of the *stomach s*—*c*, is the part nearest the heart, and is called the *cardia*, or *cardiac* portion, while the opposite part is termed *pylorus*. This leads to the intestinal tube marked *i*, *i*. The *mesentery m*, connects the latter part with the back, the use of which will be explained directly. The enlargement *r*, is the *recepta-*

cle of the chyle, and from which there proceeds a tube *t*, called the *thoracic duct*, which conveys the chyle to the circulation. *l*, is a portion of the *liver*. That portion of the heart *h*, which is marked *u*, is called the *auricle*, while the cavity *h*, is called the *ventricle*. *a*, is the *aorta*, which is the trunk of the largest artery, and *v*, *v*, *v*, are the large *veins* which convey the blood to the heart. The part *b*, is a portion of the lungs.

Having pointed out the different parts, we will next explain in few words, the different processes by which food is changed into blood, and also the course of the blood in its circulation.

The food being masticated, and mixed with the fluid secretions of the mouth, is then collected into a mass by the muscles of the cheeks and tongue, and swallowed, being carried along the tube *o* by its contractions, down to the stomach *s*. There it is mixed with a fluid secretion of the stomach, called the *gastric juice*, and by which it is dissolved, and prepared to afford chyle after it has been conducted through the pylorus. After having passed the pylorus *p*, the food is mixed with the bile, a bitter secretion from the liver, and also with a fluid from the *pancreas*, when a portion is elaborated into chyle, and is ready for absorption into the *lacteals*, which are the vessels spread over the mesentery, like a net work, as shown by the figure.

The chyle being taken up by the lacteals, the mouths of which are thickly spread over the interior of the intestinal tube, is carried by many branches to the receptacle of the chyle *r*, from which it is conveyed by the thoracie duct, *t*, to one of the large veins under the arm, called the *subclavian vein*, and by this vein to the heart. It thus gains admittance to the general circulation of the blood, and by a process which we cannot explain, becomes blood itself.

It is by means of a constant reception of chyle into the circulation, that the quantity of blood continues undiminished; and that the arteries are enabled to furnish the

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Explain Fig. 74, and point out the name and situation of each part, as designated by the letters. In what part of the system is the chyle thrown into the circulation?

glands in all parts of the system, with the purple fluid, from which all the various secretions are produced. By these processes, vegetable, as well as animal matter, is converted into flesh.

It is through the routine we have described, from the mouth, to the subclavian vein, that the system is renovated, and the exhaustion consequent upon the exercise of all its numerous functions, is constantly repaired, and the whole system kept in vigor and health. Not a particle of nourishment can be added to the circulation, until the food has been changed into chyle; nor is there any other organ by which the chyle can be conveyed to the blood, except the thoracic duct; hence our lives constantly depend on a little stream of chyle, about the size of a crow quill, which enters a vein under the arm pit. Without this source of renovation, the mass of blood would soon become deficient in quantity and quality; there would be no remedy for exhaustion, no source of muscular power, and we should soon fall away and die of inanition, without the hope of a remedy.

Circulation of the Blood.—The blood is brought from all parts of the system by the veins, which are constantly enlarging by communications with each other, as they approach the heart. The veins *v v*, Fig. 74, are called the *ascending* and *descending venæ cavæ*. These convey the blood to the right auricle of the heart, *u*. When the auricle is full, it contracts, and sends the blood to the right ventricle *h*. From the right ventricle, it is thrown by the strong contraction of the heart, to the lungs, where it is exposed to the influence of the atmosphere. It is then brought to the left auricle of the heart, which contracting, throws it into the left ventricle, the action of which forces it through the aorta, to all parts of the system, to be returned again to the right auricle by the veins, as before.

This however, is only a general account of the circulation; a more particular one being reserved, until we come to treat of the circulation in different orders of animals.

What is said of the importance of the chyle to the living system?

MASTICATION.

This word comes from the Latin *mastico*, which signifies *to chew*. Chewing is one of the natural functions of animals, the object of which is, to divide the food into minute pieces, and thus to prepare it for passing through the esophagus into the stomach, to undergo the process of digestion.

While the food is masticating, it is at the same time intermixing with a fluid called *saliva*, which is prepared by glands situated around the mouth, and into the cavity of which it is poured through small ducts, coming from the glands by which it is secreted. The action of the muscles concerned in mastication, serve to stimulate these glands; in consequence of which they afford a larger quantity of the fluid at the time when it is most necessary. The same action also facilitates the passage of the saliva into the mouth.

If the mouth had been constructed without this provision for moistening the food, it is obvious that dry, absorbent substances, could not have been swallowed; since it is absolutely necessary, as our experience teaches, to reduce such substances to a soft pulpy mass, before they can be forced through the esophagus.

There is a great difference in the form, structure, position, and number of the teeth of different animals; all of which bear a direct and intimate relation to the kind of food on which they subsist. Thus the teeth of the Lion, the Wolf, and the Cat, are constructed for tearing the flesh of animals; while those of the Cow, Sheep, and Deer, are made to crop the tender herbs.

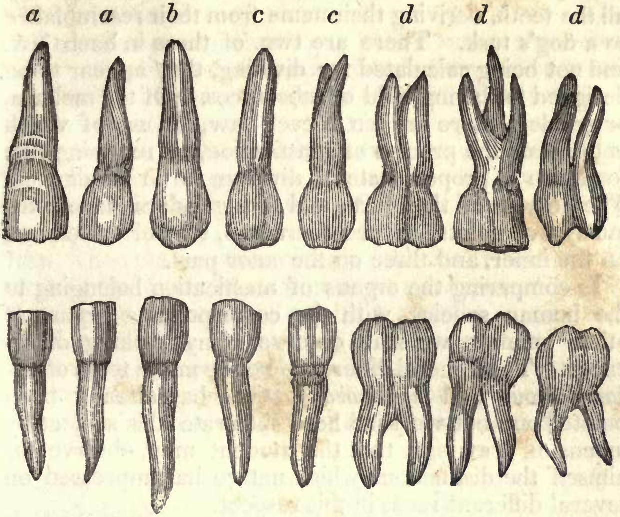
The teeth of the Lion could no better perform the office assigned to those of the Cow, than the Cow could rend the skin, and divide the muscles of a living victim, in the manner of the Lion.

Teeth of Man.—In the human subject the number of

What is meant by mastication? Is chewing a vital, or a natural function? What is the use of mastication? How is the food moistened during mastication? What is said of the form of the teeth, in relation to the kind of food on which the animal lives?

teeth is thirty-two, the shapes and names of which it is proper here to present the student.

Fig. 75.



The upper row, Fig. 75, represents the upper teeth on the left side; the lower one, the under teeth on the same side. Those situated in front of the jaw, the bodies of which are wedge shaped, are called the *incisores*, or cutting teeth, *a a*. At the sides of the cutting teeth, and posterior to them, stand the *cuspidati*, or canine teeth, *b*. The bodies of these are also somewhat wedge-shaped, and are usually called the *eye teeth*. Next behind the canine, come the *bicuspidati*, or the two first grinders, *c c*. The bodies of these are oval, with the surfaces often slightly indented. Behind these stand the *molares*, *d d d*, forming the third, fourth, and fifth grinders. In the upper jaw, the three last grinders generally have each three fangs, while the corresponding ones of the under jaw have only two.

The use of the incisors is for cutting and dividing the

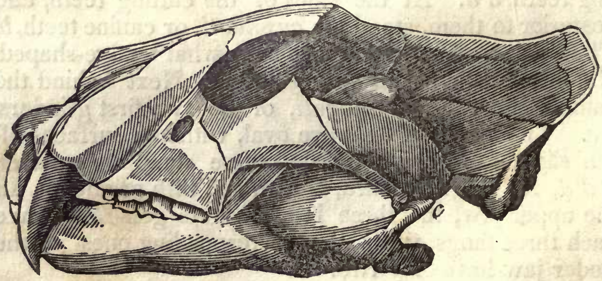
What number of teeth has the human species? What are their names, and how are they situated with respect to each other?

food in the manner of a wedge, and thus reducing it into pieces of a convenient size to be easily managed by the muscles of the mouth. The canini are the longest of all the teeth, deriving their name from their resemblance to a dog's tusk. There are two of these in each jaw, and not being calculated for dividing, they appear to be designed for laying hold of substances. Of the molares, or grinders, there are ten in each jaw, the use of which is to finish the process of mastication, by reducing the food into a proper state of division to be swallowed. The crowns of the fourth and fifth grinders have commonly five points, or protuberances, two of which are on the inner, and three on the outer part.

In comparing the organs of mastication belonging to the human species, with the corresponding organs of other animals, we shall observe many striking differences. The general difference between the teeth of the *carnivorous* and *herbivorous* tribes has already been pointed out, but we shall here illustrate this subject by means of drawings, that the student may observe for himself the distinctions which nature has impressed on several different races in this respect.

Teeth of the Tiger.—As an example of the masticating apparatus with which the feline race is furnished, the head of the Tiger, Fig. 76 is represented. All parts of

Fig. 76.



this apparatus are evidently formed for the destruction of life, and for tearing and dividing the fleshy fibres.

What are the uses of the canine teeth? What office do the molar teeth perform?

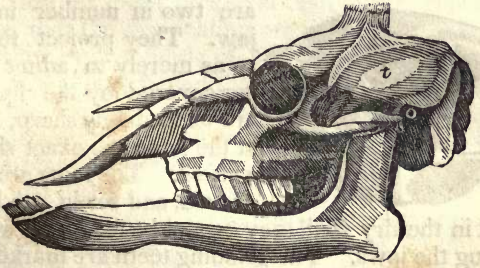
The canine teeth are of enormous size and strength, tapering gradually to a sharp point, and turned inwards for the purpose of holding whatever they grasp, like a pair of hooks.

They also pass each other in such a manner, as when once fixed, to render it impossible for the victim to escape without leaving the included part within the jaws of the animal.

The molar teeth instead of being rounded and blunt on the crown for grinding, are armed with pointed projections which correspond in the opposite jaws, so as exactly to lock into each other like the teeth of a steel trap, when the mouth is closed. All the muscles which close the jaws are of enormous size and power, so that their action imprints the bones of the skull and jaws with deep impressions. The *condyle* or articulating surface of the jaw *c*, is received into a deep cavity, constituting strictly a hinge joint, which has no grinding motion, but is confined to that of opening and shutting, like a pair of huge forceps.

Teeth of the Antelope.—As an example of the herbivorous animals, the skull of an Antelope is represented by Fig. 77. In this animal the lower jaw is furnished with

Fig. 77.



eight cutting teeth, the upper having none. There is no canine teeth in either jaw. The grinders have extended flat surfaces, fit only to reduce tender substances to a pulpy mass. The temporal muscle attached at *t*,

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Describe the most remarkable parts of the masticating apparatus in the tiger.

and spreading on the lower jaw, and by which the latter is chiefly moved, is small and feeble when compared with the corresponding part in the feline race. The articulation of the lower jaw, instead of being such as to allow only of a hinge-like action, is so connected as to play laterally with a grinding motion.

Such are the differences which the Creator has made between the masticating organs of the flesh-eating, and the grain-eating races of quadrupeds.

Teeth of the Gnawers.—There is still another family of Mammalia, which are remarkably well distinguished by their teeth, and which remove them very decidedly from either of the above classes. These are the *Rodentia* or gnawing quadrupeds, as the Squirrel, Rat, Beaver and Rabbit.

These animals appear to be formed for gnawing the hardest of vegetable bodies, as the shells of nuts, or for living on dry tough materials, as the bark of trees, and even on the woody fibres. They are generally of diminutive size, and reside mostly either in hollow trees, or in burrows which they dig for themselves.

As an example of the chewing mechanism of this family, the skull and teeth of the Rat are represented by

Fig. 78.

Fig. 78. The cutting teeth are two in number in each jaw. They project forward so as merely to admit of being covered by the lips, and are exceedingly sharp, having at the edge the exact shape of a chisel. The roots are large, curved, and set in solid bone, so that in the dry skull they cannot be extracted without breaking the jaws. The grinding teeth are marked with raised, angular lines, by which they are rendered very perfect instruments for the trituration of hard substances.

Masticating Organs in Man, compared with those of the Mammalia.—In comparing our own organs of mastica-

What is the difference between the teeth and jaws of canivorous and herbivorous animals? What peculiarities do the teeth of the gnawers present?

tion with those of other animals, we may remark in the first place, that man has neither the canine instruments of the carnivora, nor the cropping incisors of the herbivorous tribes. Neither are his grinders pointed like the first, or smooth and extended on the surface like the last. But notwithstanding the want of those prominent, and decisive features, by which the teeth point out in so remarkable a manner, the kind of subsistence to which each class of other animals is confined, still this very want of coincidence, is a decided characteristic of the habits, and propensities of man with respect to his food.

Having neither the instruments which are best fitted for tearing raw flesh, nor those which are proper for cropping grass, his organs of mastication are intermediate between these, and are better constructed than either, for the breaking down of semi-hard bodies, or those of moderate cohesion. In the mild, or savage state, the teeth of man would hardly be sufficient for the services which we might suppose would be required of them; though in this, as in other cases, the organs concerned would undoubtedly be strengthened in some proportion to the power required; hence the masticating muscles of savages, who take their food without cooking, are far more powerful than ours. It is clear, however, that the masticating organs of man were not intended for such a mode of life, but on the contrary, that the Creator designed that he should employ a portion of his faculties in modifying and preparing the natural productions of the earth for his food. This is proved most clearly from the structure both of his masticating, and digestive organs.

It is true that man in his natural or savage state, has the power of digesting many substances, in the condition of natural productions; and this habit, though necessity may be acquired by the most civilized. There are also certain vegetables, as ripe fruits, which, in their natural condition, are of easy digestion, and are coveted

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How do our teeth compare with those of other animals? Are the teeth of man constructed to take food in its natural state? What is the conclusion?

as delicacies among all classes, whether savage orcivilized. But that these can only be employed as adjuvants to a more nutritive diet, is shown by the fact, that whoever undertakes to live exclusively on such food, will soon find his muscular powers in a condition to require other support; and yet of the natural productions, it would seem that the pithy and succulent fruits would afford the most wholesome nourishment.

It is not denied, that many races of men, have lived, and do still contrive to subsist on food taken in its uncooked state; but it is also true that such races are generally indolent in their habits, stinted in their growth, feeble in muscular powers, and often nearly, or quite idiots in their intellects.

The organization of man, therefore, appears absolutely to require, both for the developement of his animal system, and the perfection of his intellectual powers, that his food should, at least in part, consist of the flesh of animals prepared by cooking for the processes of mastication and digestion, and without which, it appears that he cannot perform the muscular, or intellectual duties which his station in the scale of existence demands.

ORGANS OF DIGESTION.

Having described the organs by which the food is prepared to pass into the stomach, it is now time to describe that organ as it is found in different animals, and to point out more particularly than we have done, the processes by which aliment is converted into nutrition.

Human Stomach.—The principal organ concerned in digestion, is the *Stomach*. This is a large membranous bag, situated obliquely across the lower part of the chest, Fig. 79. Its shape is not unaptly compared to that of the bellows of a bag-pipe. In the adult man it is capa-

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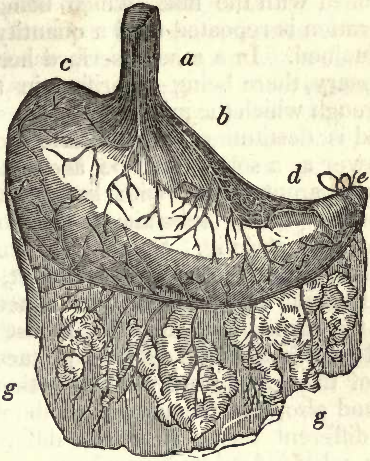
Can man live on the unprepared productions of the earth or not? Is this the state in which he was designed to live? What effect does this mode of living have on the human race? What is the conclusion with respect to the food of man? What is the principal organ concerned in digestion?

ble of holding about three pints, when moderately distended. As already stated, under Fig. 74, *a*, is the

Fig. 79.



esophagus, or passage from the mouth; *b*, the cardiac portion; *c*, the left extremity; *d*, the small extremity; and *e*, the pylorus, tied; *g g*, the omentum, or caul, which is attached to the outside of the stomach, and falls down from it like a curtain.

Gastric Juice.—The chief agent concerned in digestion is the *Gastric Juice*, as already noticed. This fluid is secreted by the inner coat of the stomach, and is supposed to act chemically on the alimentary substances, since in many instances, the appearance produced is precisely like that which remains after the action of a chemical agent.

The effect of the gastric liquor on different substances bears no proportion to their mechanical texture, or other physical properties; for while in some animals it speedily dissolves bone, and the hardest membranes, it produces not the slightest effect on other substances of the most delicate texture, as the fibres of cotton, or the skins of fruits.

What is the chief agent of digestion? In what manner is it supposed that the gastric fluid operates on the aliment?

Physiologists have contrived to extract the gastric juice from the stomachs of various animals by means of a sponge, which being introduced in the dry state is withdrawn filled with the fluid, which being squeezed out, the operation is repeated until a quantity for experiment, is obtained. In a case described hereafter, this was unnecessary, there being an orifice in the human stomach, through which the juice was taken. The fluid thus obtained is destitute of any sensible properties by which its power as a solvent can be accounted for. It is a clear transparent liquor, with little taste or smell. But its action on various substances was found to be very peculiar and striking. Spallanzani formerly the most celebrated experimenter on this subject, found, that when boiled meat was exposed to the action of this agent, from the human stomach, that it lost its fibrous texture, and was finally reduced to a pultaceous mass, in imitation of the actual process of digestion.

It was found also, that this juice from the stomachs of animals of different races, produced different effects, thus proving, what indeed had ever been proved by the animals themselves, that the stomachs of eagles and other carnivorous animals cannot digest vegetables, nor can the sheep and ox digest meat. That from the stomach of omnivorous man however, was found to dissolve both vegetable and animal matter, with equal facility.

Chemical effects of the Gastric Juice.—Nearly all physiologists of the present day, are agreed that the change produced by the action of the gastric fluid, on the aliment of the stomach, must be referred to chemical principles, and yet nothing can be detected in the juice itself by chemical analysis, which in any degree accounts for the phenomena produced.

The *coagulating* effect of the gastric juice, is its most obvious property. By this property, fluid substances, whether animal or vegetable, which are capable of coagulation, are rendered nearly solid. Thus, the white of

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When the gastric juice is extracted from the stomach and mixed with food, what effect is produced? What was proved with respect to the capacity of different animals to digest the same kind of food? On what principle do physiologists account for the effects of the gastric juice?

eggs, milk, and many other substances susceptible of being converted into nutriment, are speedily reduced to coagula, after which they are entirely dissolved by the gastric juice. The effects and design of this provision is, to retain the aliment in the stomach, a sufficient length of time to be thoroughly acted upon by its digestive power. For it has been ascertained by experiment, that if the aliment consists of too large a proportion of fluid matter, though ever so nutritive in its qualities, the nourishment it affords will be but small in quantity, especially if the fluid be incapable of coagulation, because it passes beyond the stomach, before it is fully digested or dissolved.

Dr. Hunter ascertained that this coagulating property belongs to the gastric fluid of every animal he examined for this purpose, from man down to the reptiles.

Experiments on the digestibility of different kinds of aliment will be found in another place.

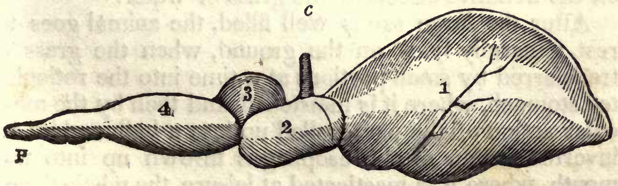
COMPARATIVE DIGESTION.

The human stomach, as we have seen, is exceedingly simple in its construction, consisting merely of a single sac with two apertures.

The corresponding part of herbivorous animals consists of a far more complex apparatus, being composed of four distinct sacs or stomachs, communicating with each other, and exhibiting as a whole one of the most impressive examples of Creative design, any where to be found in animal structures.

Stomach of a Sheep.—The delineation, Fig. 80, repre-

Fig. 80.

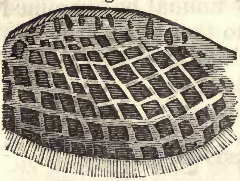


What is said to be the most obvious property of the gastric juice? What is said concerning fluid nutriment?

sents the stomach of a sheep, of which 1, 2, 3, 4, mark the four divisions, *c*, being the esophagus, and *p*, the pylorus.

The grass which is taken in large quantities by these animals and swallowed in nearly a dry state, and with little chewing, is first received into the large sac, or store room, No. 1, which we may call the first stomach. Here it is softened by the warmth of the animal, and a slight degree of moisture. Connected with this is the second stomach, No. 2, which is much smaller; and from its internal membrane being formed into irregular folds, resembling a net-work, it is called the *honey-comb stomach* or *reticule*.

Fig. 81.



This reticulated appearance is shown by Fig. 81, which represents a portion of the inner membrane of this part.

A singular and curious connection exists between this stomach and the first; for while the esophagus appears naturally to open into No. 1, there is on each side of its termination a muscular ridge, which projects from the orifice of the latter, so that the two together form a channel leading into the second stomach; and thus, the food can pass, probably, at the will of the animal, into either of these cavities. The design of this arrangement we shall see directly.

From the observations of Sir Everard Home, it appears that the water drank by the animal passes directly into the second cavity, while the grass always enters the first; these apertures must therefore be opened and closed at will, or by a natural motion, depending on the irritative effects of the grass or water.

After the large sac is well filled, the animal goes to rest, generally lying on the ground, when the grass is transferred by small portions at a time into the reticulated stomach, where it is moistened, and then by the muscular action of the part, rolled up into a ball, and by an inverted action of the esophagus thrown up into the mouth, where it is masticated at leisure, the whole forming the process well known under the name of *rumination* or *chewing the cud.*

After the mass thus elevated, has been well ground by the molares, it is again swallowed and passed into No. 3, or the third stomach, the orifice of which is brought forward to receive it by the action of peculiar muscles, at the same time the mouths of the two other stomachs being closed to prevent its admission.

The food is now prepared for digestion, and accordingly passes into the fourth stomach, when, being mixed with the gastric juice it is converted into chyle, which passing into the circulation, becomes the nutriment of the animal. Who can examine such mechanism without *feeling* astonishment and awe; and without *seeing* wisdom and design?

In the calf, the milk is conveyed directly from the esophagus to the fourth stomach, where it is coagulated by the gastric liquor, and then assimilated into nutriment. It is this stomach of the young animal which forms the substance called *rennet*, and which, in consequence of the gastric juice it contains is universally employed to coagulate the milk for the formation of *cheese.*

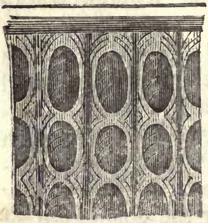
Relation between the Horns and Stomach.—That there should exist any connection between the horns of an animal, and its stomach; or that the absence, or presence of the former should indicate any thing in reference of the latter, is what no one could have suspected; and yet, Sir E. Home has shown that ruminants with horns, as the Cow, and Sheep, and Goat are universally furnished with four stomachs; two for preparing the food, one for rumination, and one for digestion, as already explained; while those without horns, as the Camel, Lama, and Rabbit, have only one preparatory stomach before rumination, which answers the purpose of the two, in the horned animals. Why such a difference should exist in animals so nearly allied in general structure and habits, is one of the mysteries of nature.

Water cells in the Stomach of the Camel.—There is a remarkable provision in the stomach of the Camel, by the use of which, that animal, and no other, is enabled to traverse the wide and arid deserts of the East.

The second stomach of this animal has a separate compartment in which is situated a series of cellular, or sac-like appendages, the mouths of which are capable of being closed by strong muscular bands. These cavities are the reservoirs of water, so often spoken of by those who have described the habits of this animal.

When the Camel drinks, the muscular bands are relaxed, and the cells are filled with the fluid, after which, their mouths are closed, and the functions of the stomach are performed as usual. When the contents of the stomach require to be moistened, which is indicated by a sense of thirst, the bands are relaxed, and a sufficient quantity is allowed to escape. Fig. 82 represents a portion of the stomach, showing these appendages on a small scale, with the muscular bands relaxed.

Fig. 82.



It is said that the sagacious animal when about to start on a journey across the desert, which he probably discovers by the preparations, distends these water vessels to the utmost with the precious fluid, which remains pure and sweet to the end of the journey.

Water cells in the Elephant.—It is well known that the Elephant has a method of dislodging insects from such parts of his body as he cannot reach with his trunk, by forcibly ejecting a quantity of water on them; and this he does, though he has drank no water for several hours.

The fountain whence the Elephant obtains water for this purpose, appears to have remained a mystery until Sir E. Home discovered in the stomach of this animal a cavity similar to that of the camel, and capable of

What is said of the difference in the stomachs of ruminants, with, and without horns? What is said of the water sacs of camels?

holding about six quarts of fluid. This when filled is closed up by a muscular band, and employed not only for shooting at flies, but also to moisten the contents of the stomach if occasion requires.

THE FOOD OF MAN AND OTHER ANIMALS.

It is the object of this work, not only to convey to the minds of youth such a knowledge of Comparative and Human Physiology, as may be useful to them for the common purposes of life; but also to instruct them in the application of these principles to their own persons, so far at least as the functions of the stomach, muscles, and brain are concerned. With this view it is proposed here to inquire into the subjects of food and digestion, more particularly than we have done; what we have said of the digestive process in man being only an introduction to what follows.

Elements of Nutrition.—Chemistry has taught us that the most important principles of diet, derived from animal substances are *fibrin*, *albumen*, *jelly*, *osmazome*, and *oil*. Fibrin is the muscular fibre, composing the lean parts of all meats; albumen, or coagulable lymph composes a part of the blood, and is abundant in the animal system. The white of an egg is nearly pure albumen; jelly and oil need no description; osmazome is a peculiar juice, or extractive matter, which is not coagulable by heat, and on which the flavor of different meats depends. It probably consists of a portion of the fibrin slightly altered by the heat.

Food, Nutritive and Digestible.—Articles of food may be considered in two respects, viz. as *nutritive* and *digestible.* Substances are nutritive in proportion to their capacity to yield the elements of chyle; they are digestible in proportion to the facility with which they are acted upon by the gastric juice. Between these two

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What are the nutritive parts of animals? What is albumen? What is osmazome? In what proportion are substances nutritive? In what proportion are they digestible?

properties there is an essential difference in the articles usually employed in diet. Some substances which contain the elements of chyle in abundance afford little nutriment because they do not readily go through the digestive process; while others which contain comparatively but a small quantity of these elements, afford more nourishment, because they are more completely dissolved by the gastric juice. Animals in the natural state adhere with remarkable uniformity to the same kinds of food. There are many carnivorous animals which feed only on a certain kind of flesh; some upon the flesh of quadrupeds; others upon that of birds; and others again upon that of insects. Among herbivorous animals, some subsist only on certain kinds of plants; others on certain parts of particular plants, as the seed, the fruit, the leaves, and so on, while entire tribes of insects appear to be exclusively attached to some one species of vegetable matter.

We have seen that there is a manifest connection between the substances on which animals feed and the structure of their masticating organs, indicating that the selection is not the effect of accident, but depends on the original conformation of the parts. Thus, as we have already shown, the teeth of some are constructed for seizing and tearing; others for gnawing, and others only for cropping the delicate parts of plants. The beaks and claws of carnivorous birds, are most formidable weapons; while those of the goose and duck are formed only for scooping and swimming. All these diversities of structure are obviously adapted to receive as great a variety of food. We have seen also, that the stomachs of animals are of different forms and capacities, and that there is an intimate relation between their masticating organs and the powers of digestion.

Man requires a variety of Food.—The structure of our own species as already shown, places man between the carnivorous and herbivorous animals with respect

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Why do not substances containing equal portions of the elements of chyle afford equal nourishment? What is said of the adherence of animals to the same kind of food? Where is man placed in the scale of creation with respect to his food?

to his food, and therefore he has the power of accommodating himself to a wider range, and a greater variety of nourishment than any other animal, and which he seems also to require.

For, while animals in the natural state, of choice, confine themselves to a particular kind of food, the organization of man, it would appear, makes it necessary for him to partake of a variety of nourishment. We do not contend that the stomach of man, or his health and vigor, require that he should be an adept in the science of gastronomy, and indulge in the stimulating mixtures of the luxurious. On the contrary the physiology of the Stomach, as well as the known consequences, clearly prove, that the long continued use of highly stimulating food, destroys the digestive functions, and consequently tends to direct debility, and visceral derangement. Independently of the use of vinous or alcoholic admixture, it is clearly proved, that a protracted use of highly irritating condiments, not only induce general prostration of muscular power, but finally exhaust the irritability of the digestive organs, and cause obstructions in other viscera, so as to superinduce a condition of the whole system, which neither future abstemiousness, nor sanative remedies can change, and which therefore, must terminate in a general dissolution of the whole.

But a variety and admixture of nourishment is far from involving an abuse of the digestive powers, and that the organization of our species requires such a variety, has been proved by various and repeated experiments.

Dr. Stark's experiments.—The fact last mentioned has been strikingly illustrated and abundantly proved by the recent experiments of Dr. Stark, of Vienna, upon himself. This zealous and self-denying experimentalist, in order to establish the physiological effects of various kinds of diet on the human system, confined himself

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Does the organization of man require a variety of food or not? What is said of the continued use of stimulating condiments? What were the experiments of Dr. Stark? What were the results of these experiments?

exclusively to a single article of food, for a certain length of time; as bread, or milk, or meat, each of which in its turn was his sole nutriment. But the result showed that the system is invariably brought into a state of extreme debility by such a course of diet, and that there is not a single article of food, not even the most nutritious, that is capable of sustaining the vigor of the body, or of even maintaining life itself, for any considerable period of time, at least under ordinary exercise. A lamentable proof of this, was exhibited in the experimenter above named, who by confining himself to a single article of diet, for a considerable length of time, as already stated, finally so ruined his constitution as to bring on premature death.

Dr. Magendie's experiments.—Dr. Magendie of Paris, resumed the experiments of Dr. Stark, so far as to confine various animals to a single article of diet, which although it contained an abundance of nutriment, was not always that on which animals naturally subsist. Thus dogs, which are in the domestic state, are omnivorous animals, when fed on white sugar and water alone, soon become emaciated, lose their appetites and sight, and perish for want of nutriment. If fed on white bread and water, the same result follows. Rabbits, which eat hay, cabbage, corn, barley, and carrots indiscriminately, cannot live for any length of time when confined exclusively to one of these articles.

It is a curious and instructive fact, that when an animal has become emaciated by living on a single article of food, although it will then receive other kinds of food with avidity, yet it does not gain its strength, but continues to waste away, and finally, dies at about the same time it would have done, had the exclusive diet been continued.

Experiments of Sir A. Cooper.—Sir Astley Cooper has lately made a variety of experiments on the facility with which many substances usually employed in diet

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What were the results of Dr. Magendie's experiments on animals? What fact is stated about the inability of animals to thrive on other food after being long confined to a single article?

are digested. The result of these inquiries show that of the meats, *pork* is that which passes most rapidly through the digestive process; next to this, *mutton*, then *veal*, and lastly, *beef*, which by these experiments, appears to be the least digestible food of these four kinds of meat.

By other experiments, he found that *fish* and *cheese* are substances of very easy digestion, and that the *potato* passes through the process with facility, though with less rapidity than the others. Its skin is entirely indigestible. These experiments were chiefly made on dogs.

Some of these results accord with the general experience and prejudices of dyspeptics and gastronomics, while others do not. There is, however, a great difference in the action of different stomachs, which often appears to depend entirely on preconceived opinions and prejudices.

There is an intimate connection between the gastric organs and the brain, and in consequence of which, an opinion formed with respect to the capability of the stomach to digest a given substance, is often found an experiment to be realized. Let a sedentary dyspeptic, for instance, get the opinion firmly rooted in his mind, that he cannot digest pork, or beef, or white bread, or any other article, and let him try by way of experiment any of these, and the opinion previously formed will undoubtedly be confirmed.

On receiving such diet, the man begins to examine his feelings; he places his whole mind on his stomach; and whether it be so or not, imagines the thing *lies heavy*, and finally actually becomes distressed, for fear he should be so. The consequence is, that the process of digestion really becomes suspended, and this, on the long established and well known principle, that fear and anxiety by operating through the nervous system produce universal debility.

Dr. Beaumont's experiments.—But the most complete and satisfactory series of experiments ever made

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What were the results of Sir A. Cooper's experiments with respect to the digestion of different kinds of meat? What is said of the influence of prejudice on digestion?

on the subject of digestion, are those of Dr. Beaumont of the U. S. Army. The subject of these experiments was a man named St. Martin, who in consequence of a gun-shot wound which perforated his stomach, and which on healing, left an aperture into the cavity of that organ, presented opportunities before unknown, for the prosecution of such inquiries. The aperture was situated between the left breast and the pit of the stomach, and of such size as to enable the experimenter to introduce various substances, and to examine the food, taken in the usual manner, at any time during the process of digestion. This was done without pain to the subject, who remained, with the exception of his wound, a sound and healthy man, performing all the duties of a common laborer, with the usual strength and facility.

Nature had formed a sort of valve which closed the aperture from the interior and which prevented the contents of the stomach from escaping, but on pushing this aside and placing the body of the subject in a certain position, either the food or gastric juice was obtained in any desirable quantity for experiment. A pint of the latter was sent to Europe for analysis and experiment.

The results of Dr. Beaumont's inquiries in many instances do not materially differ from those which had been made by other philosophers, but in other instances they vary considerably from any which have heretofore been made public. Our limits must confine us to the statement of only a few of the most important results among the great number which the volume contains.

The experiments were made both by means of St. Martin's digestive organ, and by the gastric juice extracted and placed in vials, which were kept at the temperature of 100 degrees.

Boiled rice was digested in the stomach in 1 hour, while sago, tapioca, barley and boiled milk, require 2 hours and 15 minutes. Tripe and pigs feet 1 hour. Turkey, roasted and boiled, goose, pig, beef's liver broiled, lamb, and chicken were digested in from 2 hours 18 min. to 2 hours 45 min., so that with respect to these substances, it appears that there is very little choice as to time. Eggs, hard boiled, 3 h. 30 m., do. soft boiled, 3 h. Custard baked, 2 h. 45 m. Codfish, salted, and boiled, 2 h. Trout, salmon, boiled, 1 h. 30 m. do. fried, same time. Bass, striped, 3 h., flounder and catfish, each 3 h. 30 m. Beef fresh and lean, rare roasted, 3 h. do dry roasted, 3 h. 30 m. Salt beef boiled, 2 h. 45 m. do. with mustard, 2 h. 30 m. Beef steak broiled, 3 h. Pork, fat and lean roasted, 5 h. 15 m. Pork, recently salted and boiled, 4 h. 30 m. Do. fried, 4 h. 15 m. do, raw, 3 h. Mutton fresh, roasted, 3 h. 15 m. Veal, broiled, 4 h. Fowls, domestic, boiled and roasted, 4 h. Chicken soup, 3 h.

Of vegetables, wheat bread fresh baked, required 3 h. 30 m. Corn bread, 3 h. 15 m. Sponge cake, 2 h. 30 m. Green corn and beans, 3h. 45 m. Apple dumpling, boiled, 3 h. Apples, sour and mellow, 2 h. Do. sweet and mellow, 1 h. 30 m. Parsnips, boiled, 2 h. 30 m. Potatos boiled, 3 h. 30 m. Do. roasted, 2 h. 30 m. Cabbage head raw, 2 h. 30 m. Do. with vinegar raw. 2 h. Do. boiled, 4 h. 30 m.

With respect to the experiments with the gastric fluid in vials, they present little interest when compared with those made on the living animal. We may however state that it requires from three to six times as long for the digestive solution to be completed in this way as in the stomach.

Among the inferences which Dr. Beaumont draws from all his experiments on this subject, are the following.

1. That *animal* and *farinaceous* aliments are more easy of digestion than *vegetables*.

2. That digestion is facilitated by minuteness of division and tenderness of fibre. Hence the importance of thorough mastication in case of weak stomachs.

3. That the ultimate principles of aliment are always the same, from whatever kind of food they may be obtained. The chyle therefore from vegetable and animal food, consists of exactly the same elements, being elaborated therefrom by the gastric action.

4. That the *quantity* of food generally taken into the stomach is greater than the system requires.

5. That *solid* food of a certain texture, is easier of digestion, than fluid.

6. That stimulating condiments are injurious to the healthy stomach.

7. That the *continued use of ardent spirits always produces disease of the stomach.*

8. That *hunger* is the effect of *distention* of the vessels that secrete the gastric juice.

9. That the temperature of the stomach is 100° of Fahrenheit.

10. That the action of the gastric juice dissolves the food and alters its properties.

11. That the gastric liquor *coagulates* albumen, and afterwards *dissolves* the coagula.

12. That the gastric juice is a clear and transparent fluid, a little salt and perceptibly acid to the taste. When pure, it suffers no change by keeping. Dr. Beaumont having kept a quantity in a vial for eleven months without any perceptible change.

13. That gentle exercise facilitates the digestion of the food.

14. That *water*, *ardent spirits*, and most other *fluids* are not affected by the gastric juice, but disappear from the stomach soon after they are received.

It may be noticed that there is some discrepancy between Dr. Beaumont's results and those of Sir A. Cooper, especially with respect to the digestion of Pork and Beef. But since the former experimenter had the best opportunity ever afforded to arrive at true results, while those of the latter were made chiefly on dogs, there can be no doubt which is the most deserving of confidence.

The facts above stated are so plain as to allow any one to draw his own inferences, and we therefore leave this subject to the reader, which has already been carried to an extent much beyond what was originally intended.

PART IV.

VITAL FUNCTIONS.

CIRCULATION OF THE BLOOD.

It is but recently, that movements in the fluids of insects analagous to the circulation in the larger animals has been discovered. At the present time however, all naturalists agree that such a circulation does exist.

It will be remembered that insects are entirely without lungs, and that the respiratory function is carried on in them by means of minute tubes on each side of their bodies called *spiracles* or *stigmata.*

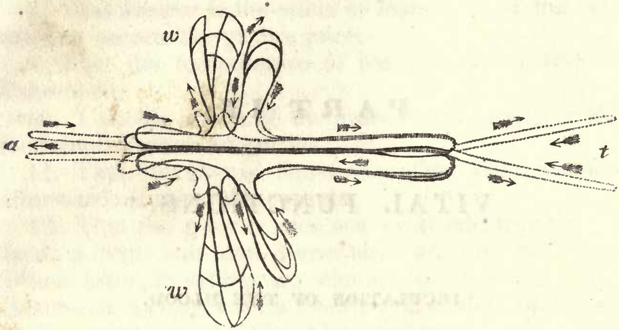
Along the backs of insects there is a tubular organ, called the *dorsal vessel.* This extends the whole length of the back, and is found in every stage of their developement, from the larva to the perfect state. It contains a fluid which appears to have a wave-like motion, backwards and forwards, by the alternate contractions and dilations of the muscles of the vessel, producing a kind of pulsation.

This organ performs the office of the hearts of other animals, its contractions throwing out a portion of the fluid it contains, into all parts of the insect, even into its wings, from which it again returns to the dorsal vessel, as the blood does to the heart.

In some insects, whose bodies are transparent, the whole circulation may be distinctly seen by means of a microscope.

In the *Ephemera marginata*, a little four-winged fly, the motions of the fluid are quite distinct, and the course it takes is represented by Fig. 83, the direction of its

Fig. 83.



movements being indicated by the arrows. The black line along the back is the dorsal vessel; *a*, representing the currents in the antennæ, *w*, in the wings, and *t*, in the tail. In all these parts the vessels form loops derived from the main vessels of the trunk. The currents of blood are unequal in their motions, being accelerated by the impulsions they receive from the contractions of the dorsal vessel, which as we have already noticed is the substitute for a heart in these animals.

CIRCULATION IN THE AMPHIBIA AND FISHES.

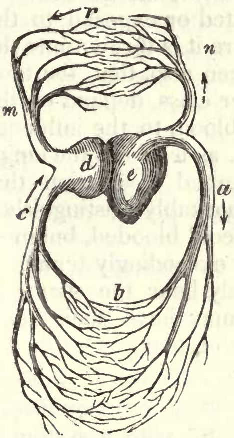
The most simple apparatus for the circulation of the blood in an air breathing animal, consists of a single *auricle*, a single *ventricle*, with two *arteries*, and two *veins*, or rather with a single artery and vein divided into two trunks each.

Circulation in the Frog.—These parts are represented as they exist in the Frog, by Fig. 84, where *d*, is the auricle, *e*, the ventricle, *a*, the large *artery*, which divides and sends a branch to *r*; *c*, the great vein called the *vena cava*, which like the great artery, divides and also

Explain the course of the circulation as it takes place in insects?

sends a branch to *r*. The arrows show the course of the circulation. The blood flows into the auricle *d*, from the vein *c*, which comes from all parts of the body, except the lungs. It also flows through the vein *m*, which comes from the lungs, and is called the *pulmonary* vein. Both these vessels deliver the blood in a continued stream. When the auricle is full of blood, it contracts and throws its contents into the ventricle *e*. The ventricle then contracts and sends a part of the blood through the *pulmonary* artery *n*, to the lungs, while the other, and greater portion passes through the aorta, *a*, to all the other parts of the system. While the blood is thus flowing through the large vessels, near the heart, it is constantly passing from the small arteries into the small veins, which communicate with each other in every part of the body, as shown at *b* and *r*. These little veins form branches which grow larger, as they approach the heart, as those of the arteries grow smaller as they recede from it, in the same manner that the limbs of a tree are enlarged as they approach the root, and lessened towards the top. The circulating fluid being thus collected from all parts of the system, is constantly pouring into the auricle by the great veins, to be again sent to all its parts, by the ventricle, and so on, in a continued round during the life of the animal.

Fig. 84.



This simple, or single apparatus is not only such as is found in the Frog, but may be taken as an example of the circulating system in all the cold blooded quadrupeds.

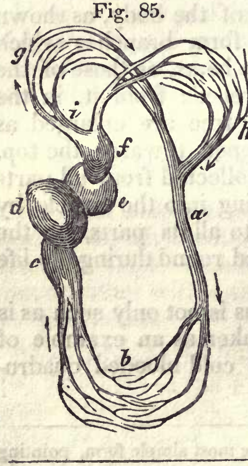
Explain the circulation as it occurs in the most simple form, pointing out the names of the different parts of the apparatus, and showing the course of the blood? To what class of animals does this simple circulation apply?

On inspecting the plan, Fig. 84, it may be remarked that in these animals only one half of the blood is sent to the lungs before it again circulates through the general system. The general circulation, therefore, consists of one-half arterial, and one half venous blood. We shall see directly that in the warm blooded animals the circulation is double, and that in these, all the blood is sent through the lungs, to be aërated or exposed to the influence of the atmosphere, before it is thrown into the general circulation. It will be seen also, that the temperature and vivacity of the latter class, depend on the exposure of the whole mass of blood, to the influence of the oxygen of the atmosphere, as it passes the lungs.

It is owing chiefly to this limited circulation that amphibious animals are so remarkably distinguished from others. They are not only cold blooded, but most of them are sluggish, languid, and exceedingly tenacious of life, so that they will not only bear the strongest stimulants without injury, but may have their limbs amputated with only slight marks of pain.

Circulation in Fishes.—In Fishes the organs of circulation consist of four cavities, *c*, *d*, *e*, *f*, Fig. 85, with a system of veins and arteries for conveying the blood to, and from the heart. Of these cavities, *d*, is the auricle, and *e*, the ventricle, c, and *f*, being dilations of the principal vein and artery, at their junction with the heart. The heart, in this system, belongs exclusively to the gills or *branchia*, which in Fish are the organs of respiration. There is no aorta proceeding from the heart, which carries the blood to all parts of the system, as in other animals. The branchial arteries *f*, convey

Fig. 85.



What kind of blood circulates through the systems of amphibious animals? To what cause is the coldness and languor of these animals owing? Which is the auricle and which the ventricle in the heart of a fish?

ths blood to the gills, *g*, *h*. There it is *aërated*, or exposed to the air, which the water contains. It is then collected by the branchial veins *i*, which, instead of carrying it directly to the heart, as in man, unite into a single large trunk *a*, which passes down the back, and performs the office of the aorta, by distributing it to the different parts of the body. The circulating fluid is then conveyed to the auricle *d*, by the large vein *c*, which answers to the vena cava. The blood then passes into the ventricle and begins its circulation as before.

In Fishes the heart is exceedingly small when compared to that of other animals of the same bulk, its weight being only to that of the body, as 1 to 351, or even 1 to 768 in the different species; while in man the weight of the heart is to that of the body, as 1 to about 160.

The proportion of blood in this class is also very small, and the vessels few in number. The quantity of oxygen likewise, which Fishes obtain, being only that contained in the air of the water, must be exceedingly minute. Hence it is, that their flesh is white, presenting a remarkable contrast to the red color of that of animals belonging to the higher orders, as quadrupeds and man.

CIRCULATION IN WARM BLOODED ANIMALS.

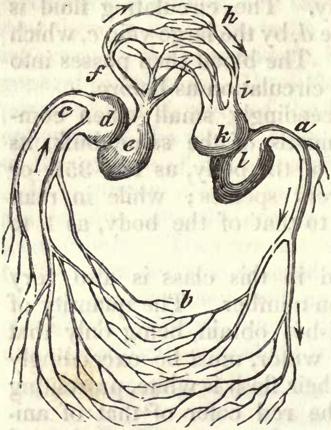
In proportion as animals rise in the scale of organization and capacity, so does the complexity of the apparatus for carrying on the circulation increase.

Amphibious animals and fish, as just shown, are provided with a single auricle, and a single ventricle only. But in all warm blooded animals there are two auricles and two ventricles, and two systems of circulation. In the first, the heart is single; in the last, it is double; one being for the circulation through the lungs, called the *pulmonic;* the other for the general circulation, called the *systematic*. The pulmonic is on the right side; the systematic on the left.

What office does the heart perform in the fish? What is said of the size of the heart in fish? What is the difference between the heart of a fish and that of a quadruped?

The two hearts separated.—The two hearts in the natural state are joined together, but that the student may the more clearly comprehend the two systems, they are here represented separate, Fig. 86.

Fig. 86.



In this plan, *d* represents the right auricle; *e*, the right ventricle; *k*, the left auricle; *l*, the left ventricle; *a*, the aorta; *i*, the pulmonary veins; *f*, the pulmonary arteries; *c*, the vena cava; *b*, the meeting of the small branches of the aorta, and vena cava, and *h*, the meeting of the pulmonary veins and arteries.

The circulation is as follows. The blood is conveyed by the vena cava, *c*, to the right auricle, *d*, and poured into the ventricle, *e*, which contracting, throws it through the pulmonary artery, *f*, to the lungs, where it is oxygenated, or purified and made fit for general circulation. The pulmonary veins then receive, and convey it to the left auricle, *k*, by which it is transmitted to the ventricle, *l*, which contracting with great power, propels it to all parts of the system through the aorta *a*. From the small branches of the aorta, it is received into those of the vena cava, by which it is transmitted to the right auricle, the point where we commenced. In all the Mammalia and Birds, this is the routine of the circulation.

The two Hearts united.—It only now remains to show the two hearts of man united, that the pupil may observe how they naturally exist as a single organ in external appearance. Fig. 87 represents the double heart, show-

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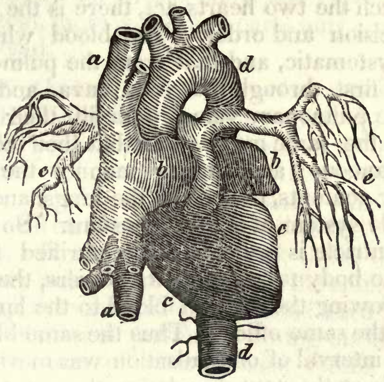
What are the two systems of circulation in quadrupeds and man called? Describe the circulation in man.

ing the several parts as they actually exist. The upper *a*, shows the pulmonary vein, the lower *a*, the vena cava;

Fig. 87.



b, b, the right and left auricles; *c, c*, the right and left ventricles; *e, e*, the right and left branches of the pulmonary artery; *d, d*, the aorta.

But notwithstanding the two hearts are thus united within a single envelope, the right and left cavities are perfectly distinct from each other as represented by Fig. 86; the two ventricles having between them a strong muscular partition, which allows of no communication from one side to the other.

In the lower orders of animals, as already shown, the circulating fluid is composed of one half venous blood, or blood which has not passed through the purifying and renovating influence of the lungs. In the heart just described, the two systems of circulation are so separated as to entirely prevent the two kinds of blood from mixing with each other.

The color of the arterial blood is light red, while that of the veins is dark purple. This change is produced by the exposure of the venous blood to the air in its passage through the lungs, by which it either loses

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Are the pulmonic and systematic circulation perfectly distinct in the warm blooded animals? What is the color of arterial blood? What is the color of venous blood? How is this change of color produced?

a portion of carbon, or absorbs a quantity of oxygen, as will be seen when we come to treat of respiration.

The two Hearts act together.—With respect to the time at which the two hearts act, there is the most wonderful precision and order. The blood which returns from the systematic, and that from the pulmonic circulation, the first through the vena cava, and the other through the pulmonary veins, both fill their respective auricles at the same moment, so that their contractions are simultaneous; and in like manner the ventricles throw their contents, the one to the lungs, and the other to the whole system at the same instant. So that while the left ventricle is propelling the purified fluid to all parts of the body to renovate its powers, the right ventricle is throwing the vitiated blood to the lungs to prepare it for the same office. Thus the same blood, which during the interval of one pulsation was moving through the lungs, is at the next circulating through the body.

Number of Pulsations, and Muscular power of the Heart.—The ventricle of the human heart contains only about an ounce of blood, but this is changed more than sixty times every minute. Estimating the number of contractions at 70 per minute, which is about the medium number in health, then the quantity of blood which passes through the heart is about 300 pounds every hour of our lives, making upwards of three tons in each 24 hours.

"An anatomist," says Paley, "who understood the structure of the heart, might say beforehand that it would play; but he would expect from the delicacy of some of its parts, and the complexity of its mechanism, that it would always be liable to derangement, or that it would soon work itself out, yet does this wonderful machine go on, night and day, for eighty, nay, an hundred years together, at the rate of an hundred thousand strokes every 24 hours, having at every stroke a great resistance to overcome, and will continue this action, for

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In what order do the two ventricles of the heart act? What different offices do the two ventricles possess? How much blood passes through the heart every 24 hours?

this length of time, without disorder and without weariness. To those who venture their lives in ships, it has often been said, that there is only a plank between them and destruction; but in the body, and especially in the arterial system, there is in many parts only a membrane, a skin, a thread."

Effects of Alcohol on the circulation.—We may suppose, says Dr. Barry that the more quick the motion of the blood, the sooner old age will advance, or the sooner the machine will wear out, and other circumstances being equal, that the number of years which all men may attain, will be in reciprocal ratio to the velocity of their pulses. If we allow 70 years to be the age of man, and sixty pulses in a minute, for the common measure of a temperate man, then we should have 2,209,032, 000, as the number of pulsations during his life. But if another, by reason of intemperance forces his blood into motion at the rate of 75 pulses in a minute, then instead of living three score and ten years, he will run through his whole number of pulsations in 56 years, thus cutting short his days by the term of 14 years.

Barry on Digestion, London, 1759.

This is certainly a sober consideration, and ought to be carefully weighed by those who urge along the current of their blood by mixing it with alcohol, for as we have already seen, this liquid is taken into the blood in the same state in which it goes into the stomach, the gastric liquid having no power to change it into nourishment. The circulating fluid of him who drinks distilled spirits though it be mixed with water, is therefore a compound of blood and alcohol, which stimulating the left ventricle and making it contract with unwonted rapidity, increases the number of pulsations and exhausting the irritability, produces a weak and flabby condition of the machinery, which finally refuses to perform its functions, the miserable possessor sinks down and dies before his time.

What is said concerning the quickness of the pulse and the age to which a man may live? How much is it supposed that a person may shorten his days by quickening his pulse five times a minute by stimulants? Is alcohol digestible or not? What is the composition of one's blood who drinks spirits?

Alcohol not the product of distillation.—It was once supposed that the chemical changes which any fermented liquor undergoes to produce alcohol, took place only when it was heated, and that thus alcohol was the product of distillation. This supposition, though long since exploded by the light which analytical chemistry has thrown on the subject of the composition of bodies, is still maintained by the ignorant. Thus it was said that the juice of the grape, by the vinous fermentation merely, never produced alcohol, and therefore if a wine could be obtained and kept, without any admixture of brandy, we should have a liquor free from the former pernicious element. Acting, perhaps entirely, on this belief, several importers sent to their foreign correspondents to have wine manufactured without the addition of brandy, and thus the country was furnished with a wine which many people believe contains no alcohol; and not a few, who on no account would touch a drop of common wine, do not hesitate to take freely of this. It is not a little surprising, by the way, that such do not find by the cheering effects, that this wine contains alcohol as well as that made in the usual manner, with which it is well known a certain portion of brandy is mixed. This is done under the impression that the juice of the grape does not naturally produce a sufficient quantity of alcohol to preserve the wine, and therefore without the addition of a little brandy, or alchohol in some other form, the *vinous*, would run into the *acetous* fermentation, and thus, that the wine would become vinegar. With respect to certain light wines this is true, but experience appears to have proved that there is a difference in grapes in this respect, and that some kinds of wine do not require any addition of alcohol for their preservation, that which the juice produces being amply sufficient for this purpose.

Now this is not the place to go into a history of this subject, and we have made this digression, merely for the purpose of showing those who still maintain that alcohol is the product of distillation, and that therefore he who drinks the *pure juice of the grape*, drinks no alcohol, labors, or rather *drinks* under a mistake, and that he who receives into his stomach this kind of wine, urges forward his circulation, and increases the number of his pulsations, equally with him who takes any other kind of wine containing the same proportion of alcohol. For, in respect to the intoxicating effects, it makes no difference whether the alcohol be the natural product of the grape, or whether it is added in the form of brandy.

That alcohol is the product of the vinous fermentation only, and that it exists in all fermented liquors, before they are heated, or distilled, and therefore that it is not produced, but only obtained in a separate state by distillation, is shown by the fact, that it can be separated from wine, cider, beer, or any other fermented liquor by several processes in which no heat, above the ordinary temperature of the atmosphere is employed.

The author of this work about six years since, made a series of experiments on many kinds of fermented liquors, for the purpose of ascertaining the percentage of alcohol which might be obtained from them without heat; and for the benefit of those who desire to satisfy themselves on this point, he will state in few words, how they can do so. Take a glass tube, say two feet long, and half fill it with cider, or wine, to which it is known no alcohol has been added. Then drop into the tube some carbonate of potash, previously well dried by heat, and continue to do so until all the water of the cider or wine is absorbed by the potash, and the alcohol rises to the surface. This will be known by the appearance of the alcohol and its separation from the water at the upper part of the tube. The liquor thus obtained, may be tested by burning, or in any other way most satisfactory to the experimenter. This simple method is merely intended for those who desire to satisfy themselves whether alcohol is the product of distillation, or not, the percentage requiring a more careful analysis, though precisely on the same principles.

Alcohol may also be obtained from a fermented liquor, by exhausting the air from its surface by means of an air pump, in consequence of which the alcohol being lighter than the other ingredients of the liquor will rise to the surface.

By means of the potash, the author found that a sample of the pure juice of the grape contained about 14 per cent. of alcohol.

Muscular force of the Heart.—Some of the old physiologists attempted to compute in numbers, the force of the muscular contractions of the heart, but this appears to be impracticable, and if it could be done, would present a mere physiological curiosity. That the heart contracts with an enormous power, when compared with its size as a muscle, there is no doubt. The obstacles it has to overcome in dilating the contractile tendency of the arteries through all their ramifications, must alone require a very considerable force. It must be remembered, that it requires a much greater mechanical force to propel a fluid through an angular or tortuous tube than through a straight one; and that few of the arteries run in a direct course, many of them making a full semi-circle in passing from the heart to the other parts of the system. This may be observed on viewing the plans of the heart, where it will be seen that the great circle of the aorta must materially impede the velocity of the blood through it. But notwithstanding these obstacles, we find that the force of the blood through the arteries, even in the extremities, is so great, that when we sit cross-legged, the pulsation of the artery in the ham, which is pressed by the under knee, is so strong as to raise the whole extremity, and give it a vibratory motion at each beat of the heart. When we consider the length of the lever, the shortness of the purchase, and the elastic nature of the fulcrum, we cannot but be astonished at the prodigious force with which the heart must contract, in order to give such power, at such a distance, to a little artery not larger than a pipe stem.

Operative surgeons are well aware of this contractile force, when they have to do with wounded arteries, for in most cases it is found that compression is entirely inadequate to bring the sides of an artery into such contact as to stop the bleeding, and even ligatures, if not

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What is said of the power with which the heart contracts? What proofs are given of this contractile power?

very carefully tied, are no security against the impetus of the blood.

RESPIRATION.

Respiration or breathing, is the act of receiving a portion of air into, and throwing it out of the lungs. Receiving the air, is called *inspiration*, and rejecting it, *expiration*.

Atmospheric air is so absolutely necessary to the organized creation, that neither plant nor animal can live without it. No vegetable seed will germinate without a portion of air, nor will the eggs of insects change into larvæ if confined in a vacuum.

Even the most minute animals, and those which are most tenacious of life, as the infusoria, which may be dried and kept any length of time, and revived again by moistening, are still unable long to survive when deprived entirely of air.

It is true that a great proportion of animals are so constructed as to require but a very minute portion of air. Thus the Mollusca, and Fish, which live constantly under water, can only receive that with which the fluid is mixed. But the Creator has amply provided for the wants of these creatures in this respect, by giving the fluid in which they live, the power and propensity to absorb air, so that water in its natural state, at whatever depth from the surface it may be taken, is always found to contain a portion. But if the water in which a fish is confined be covered with oil, by which, the air is entirely excluded, the fish soon dies.

As we ascend in the scale of organization, we find that animals require more and more air, and that they increase in vivacity and power in some proportion to the quantity which they consume. In the very lowest orders there is no provision of any special organs for respiration. Thus in some of the Zoophytes the organs of nutriment and those of respiration are the same. In

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What is meant by respiration? What is said of the necessity of air to plants and animals? Where do fish obtain air? What is the difference between the lower and higher orders with respect to air?

others, this function is performed by the skin. But in those which are a step above these, we find some special preparations for this function. In the Mollusca, the organs of respiration are situated near the outer margin of the shell, and consist of parallel filaments arranged like the teeth of a fine comb. These are called *branchia* or gills.

Respiration of the Oyster.—These organs are repre-

Fig. 88.

sented by Fig. 88. Their mechanism when closely examined is exceedingly curious, and somewhat intricate. There is a triangular canal *d*, which leads through the whole length of the organ where it is attached to the body. By means of this, the water is admitted to the interior of the gills generally. Besides this provision for the admission of water, by a sort of canal, there are numerous small apertures, *e*, by which the fluid is sent to every feather of the gills. The parts *f f*, are the feathery extremities of this organ, which appear like a treble fold of some fine fabric, suspended like a festoon.

After the water, thus admitted into the branchia has performed its office of aëration, it is again expelled by a different opening.

Another step in the scale of animal existence brings us to the Fishes, the branchial apparatus of which is much more complicated and important than that of the mollusca. In these, the respiratory action is more essen-

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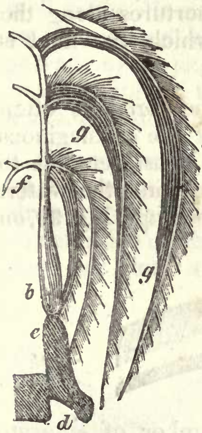
What are the respiratory organs called in the mollusca and fishes? How is respiration performed in the oyster?

tial to life, than in the lower orders. A Fish soon expires if taken out of the water, but an oyster will live for weeks, with only that which it retains in the shell.

Respiration in Fishes.—One side of the gills of a Fish is distinctly represented by Fig. 89, which also shows the heart and artery by which the blood is sent to these parts. Of the heart, *d*, is the auricle, *e*, the ventricle, *b*, the enlargement of the artery, called the *bulbous arteriosus*, which is shown distinctly in Fig. 85, *f*, the brancial artery, *g*, *g*, the gills. We here have an opportunity of observing how near the heart of the Fish is to the lungs, and consequently of inferring the importance of well supplying these parts with blood. This arises from the circumstance that the heart throws the blood only to the gills, and not to the other parts of the body as in the other animals, hence a large proportion of the blood of the whole system, is constantly in the gills, to be well purified by the air before it circulates through the other parts, and this is the reason why these parts are highly colored with blood, while the other parts of the Fish are white.

Fig. 89.



The gills consist of filaments arranged somewhat like the feathers of a quill. When these filaments are closely examined, they are found to be covered with minute processes crowded close together, and on which may be observed millions of capillary blood vessels, spread like a net-work over the whole surface. It is through the thin coats of these vessels that the air acts upon the blood they contain.

In the osseous or bony fishes, there is a large flap called the *operculum*, which covers the gills from injury, and below which there is an opening for the escape of the water, after it has performed its office. The pro-

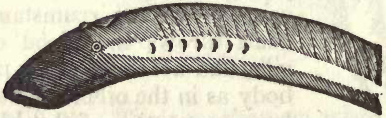
How is this function carried on in the fish?

cess of respiration is performed by taking the water into the mouth, and forcing it through the gills, which separating their filaments exposes every part to its action.

In the cartilaginous fishes, or those which have no bony frame, as the lamprey, there is no operculum provided for the escape of the water during respiration, but instead of this, there are several apertures along the sides of the neck, or throat through which, the fluid is thrown.

Respiration in the Lamprey.—In the *Lamprey* often called the *Lamper-eel*, which is one of the cartilaginous tribe, the organs of respiration are so constructed as to be independent of the mouth in receiving the water. In this fish there are seven external openings, Fig. 90, on

Fig. 90.



each side leading into the same number of separate oval bag-like appendages, situated horizontally, the inner membrane of which, has the structure of gills. Into these openings the water is drawn by the action of certain mucles, and having performed its office, is again ejected by the same orifices.

Were it not for this curious and singular provision, the Lamprey would be unable to enjoy its usual habit of adhering by the suction of the mouth to a smooth stone or other solid, or grasping and sucking its food by which it lives.

ATMOSPHERIC RESPIRATION.

Having thus described the respiratory organs in several orders of inferior animals, we now come to those,

What difference is there in the respiration of the cartilaginous and bony fishes?

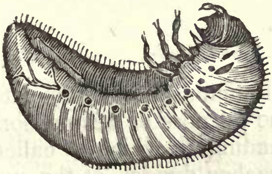
which, standing higher in the scale of creation, respire the atmosphere in its gaseous form.

The physiology of this class is no less diversified than that of aquatic animals. Its members have a greater complexity of structure, and in general, much more vivacity of action than the class already described.

To this division belong the Insects and Amphibia as well as the Mammalia, including Man. In Insects the air is respired by means of *trachea*, which generally pervade every part of the system, even to the wings. In the Amphibia the air is swallowed, while in the Mammalia, it is admitted into *pulmonary cavities* or lungs.

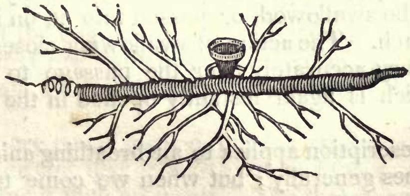
Respiration in Insects.—The external orifices of the trachea in Insects are called *spiracles* or *stigmata*, as already explained. These are usually situated in rows on each side of the body. In the larvæ of many Insects they are quite apparent to the eye. Fig. 81 shows these organs in the form of dots along the side of the larva, of the honey bee. These orifices lead to trachea or air tubes situated within the body of the Insect, and which ramify so as to distribute air to all its parts. On this account, these air tubes have often been mistaken for blood vessels.

Fig. 91.



The drawing, Fig. 92, represents the magnified form of a trachea and its branches, as they exist in certain

Fig. 92.



What is said of the physiology of air breathing animals? What is the difference in the respiration of insects and man? What are the stigmata of insects?

Insects. The cup-like appendage situated on the upper and central part of the trunk, is the stigmata, opening from the atmosphere to the trachea. There are, as above shown, about ten of these orifices, on each side of the larva or caterpillar of most Insects.

These stigmata are always open and full of air, and if an insect be immersed in water, minute bubbles of air may be seen escaping from each, being excluded by the fluid. While under the water, the trachea often present a silvery appearance, from the air they contain. If all the air is expelled, and the vessels are filled with water, the Insect is drowned; and if the stigmata be closed by oil or any other substance, so as to prevent the ingress of air, the insect will be suffocated.

In the winged Insects, every part is furnished with air tubes, which ramify in all directions, and which circulate air as the arteries do blood. The *nervures*, which have the appearance of veins on the wings of butterflies and other Insects, are a part of the organs of respiration.

RESPIRATION IN REPTILES.

In the vertebrated terrestrial animals, the organs into which the air is admitted for the purpose of respiration, are called *lungs;* the tube leading to which is called *trachea,* or wind pipe. The trachea divides at the upper part of the chest into two tubes, leading to each lung, and these are called *bronchia.* The upper end of the trachea, which lies before the passage to the stomach, called the *esophagus,* is carefully guarded by a valve called the *epiglottis,* from the intrusion of any substance about to be swallowed, or passed into it, on its way to the stomach. The action of swallowing closes the epiglottis very accurately over the passage to the wind pipe, which is again instantly opened in the act of respiration.

This description applies to air breathing animals, with back bones generally; but when we come to examine

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What are the lungs? What is the tube called which leads to the lungs? What are the bronchia? What is the epiglottis, and what its use?

the different orders, or tribes, we shall find a great diversity in the situation, forms, and structures of these different parts. In the reptiles, as the Frog and Snake, the epiglottis is wanting, the food being carried over the aperture of the trachea by the tongue.

The lungs of reptiles are large sacks situated on each side of the chest, into which the bronchia lead.

The mechanism by which the air is taken into the lungs in these animals, is exceedingly curious, and quite peculiar to this tribe, it having been for a long time a subject of controversy among naturalists, how these creatures breathed.

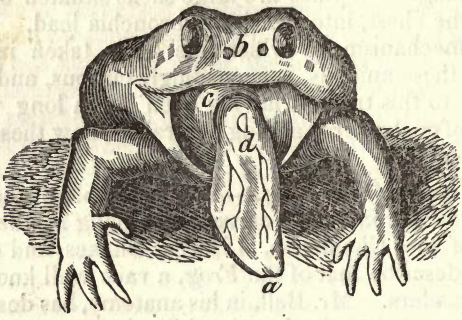
Respiration of the Frog.—As an example of the manner in which breathing is carried on among reptiles, consisting of the Chamelion, Lizards, Snakes, and others, we will describe that of the *Frog*, a race well known to all our readers. Mr. Bell, in his anatomy, has described this process at length; but the following extract is sufficient for this work.

On watching a Frog ever so carefully, when it is still and quiet, we can scarcely discover any signs of respiration, since it never opens its mouth to receive the air, and there is no motion of the sides to indicate that it breathes. Yet on any sudden alarm, we see the animal blowing itself up, as if by some internal power, while at the same time its mouth remains entirely closed. We may perceive, however, that its throat is in motion, as if the reptile was so careful of its mouthful of air, as to transfer it backwards and forwards between its mouth and lungs. But if we direct our attention to the nostrils, we may observe in them at twirling motion at each movement of the bag under the throat; for it is through the nostrils that respiration is carried on in this animal, there being no other communication between the lungs and the air.

The jaws are never opened but for eating, which is only for the instant that it darts out its tongue, and as quickly returns it with an insect. The throat, and sides of the mouth, form a kind of bellows, to which the nostrils are the inlet; and it is by the contraction of this part, that the air is swallowed, and forced down the trachea into the lungs.

The aperture leading from the mouth to the lungs, is through the middle of the back part of the tongue. Fig.

Fig. 93.



93 represents this odd apparatus; *a* the tongue, *d* the orifice to the trachea, *c* the throat, and *b* the nostrils.—The tongue is not attached far back in the throat, like that of other animals, but lies fixed to the lower jaw, or chin, so as to increase its length out of the mouth. If the mouth of a Frog be forcibly kept open, the creature is soon strangled, because the aperture through the tongue is not only thus closed, but were it open, there would be no respiration without the action of the bellows, which by opening the mouth is destroyed.

This is the mode in which most of the reptiles perform their respiration, the process being that of *swallowing* the air, rather than breathing it, as other animals do.

RESPIRATION IN BIRDS.

In Birds the respiratory apparatus is quite different in most respects, from that of reptiles. There is also a remarkable difference in the mode in which the process is performed.

In these races, the air does not merely pass into the lungs, but is drawn through them, into the large air cells which are contiguous. This is done by elevating the

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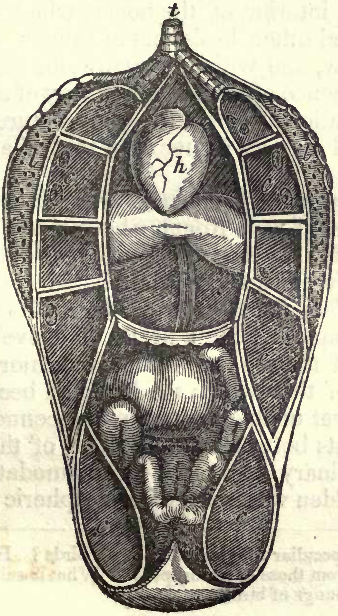
How does the respiration of the frog differ from that of other animals?

chest, by a set of muscles for this purpose. When the chest is depressed, this air is again expelled through the same vessels by which it was admitted ; so that in these animals, *the same portion of air passes twice through the lungs.* This is a wonderful provision, and one in which we cannot but behold Creative wisdom and design.

The habits of Birds require that levity should be combined with strength, in their conformation. Had the lungs been constructed like those of quadrupeds and man, where the air is merely taken in and thrown out, a considerable addition of weight must have been the consequence. But by the very peculiar structure of the whole apparatus, which allows the air to be twice breathed, the lungs could be reduced to a very diminutive size, and still the aëration of the blood be as perfect as in quadrupeds; and this is the admirable plan adopted in these animals.

Lungs of the Ostrich.—This mechanism will be un-

Fig. 94.



derstood by the plan, Fig. 94, which represents the lungs and air cells of an *Ostrich*. The trachea *t*, is seen to divide into bronchia, which pass to the lungs on each side. These, after entering the lungs, divide into numerous branches, and pass quite through their substance, opening on the outside by many apertures, which may be seen at *l l*, these parts being the true lungs of the bird. They are small, and thin, forming the dark substance always seen in carving a fowl, along the back, and between the ribs.

These apertures admit the air into several large air cells, *c c c c*, which occupy a considerable proportion of the interior bulk. These cells enclose some of the principal viscera, as the liver, stomach, and heart, and extend down the sides the whole length of the body. Numerous air cells also exist in other parts, with which these are connected by little punctures seen at *c c*.

The air vessels thus described, not only communicate with numerous others in different parts of the body, but also with the interior of the bones, which especially in the Eagle, and other birds that are much on the wing, are left hollow, and without marrow, for this purpose.

In consequence of the large quantity of air consumed by the respiration of Birds, the temperature of their bodies is several degrees higher than that of any other animal.

"The peculiarities of structure in the respiratory system of birds," says Roget, "have probably a relation to the capability we see them possess, of bearing with impunity, very quick and violent changes of atmospheric pressure. Thus the Condor of the Andes is often seen to descend rapidly from a height of above 20,000 feet, to the edge of the sea, where the air is more than twice the density of that which the bird had been breathing. We are as yet unable to trace the connection which probably exists between the structure of the lungs, and this extraordinary power of accommodation to such great and sudden variations of atmospheric pressure."

What is there peculiar in the respiration of birds? How do the lungs of birds differ from those of quadrupeds? What is said of the air cells surrounding the lungs of birds?

The Birds rank above all the animal creation in vital energy, as well as in muscular action. This appears to be in consequence of the double effects of the respiration on the circulating fluid, as it passes through the lungs.

RESPIRATION IN THE MAMMALIA.

But notwithstanding, we see in the birds, a wonderful adaptation of the respiratory apparatus to the wants and conveniences of that order, still we shall find, that the construction of the pulmonary system of Man and the other Mammalia, involve physiological advantages not to be found in any other class of animals.

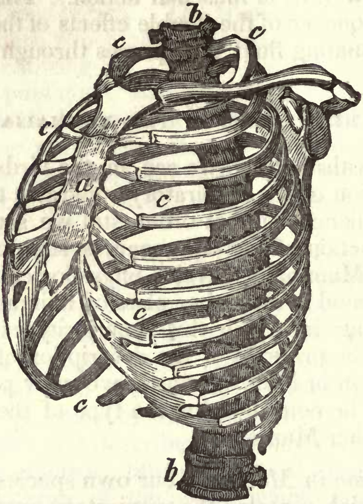
The points in which this superiority exists will be noticed in the progress of the description of the organs of respiration in Man, to which we now proceed, and which may be considered as the type of the same parts in all the other Mammalia.

Respiration in Man.—In our own species, the thorax or chest which contains the respiratory organs, as well as all the other vital parts, is entirely surrounded by a frame work of bone, so that these parts are defended with great care from external injury. These bones consist of the *spine*, the *ribs*, and the *sternum*, or breast bone.

Trunk of the Human Skeleton.—The trunk of the Human Skeleton is represented by Fig. 95, of which *a*, is the sternum, *b b*, the spine, and *c c c c*, the ribs. These bones, it is well known, are connected together in the living system, by muscles and ligaments, and by which they are moved in a slight degree in the act of respiration.

In what respect do the birds rank above all other animals? What is said of the perfection of the pnlmonary system in man? What are the parts of the human skeleton which enclose the organs of respiration?

Fig. 95.



Parts concerned in Respiration.—The parts concerned in the respiration of Man may therefore be arranged into three divisions: First, the bones which form the respiratory cavity; second, the muscles by which these bones are moved; and third, the respiratory organs themselves.

Belonging to the first division, there are one *sternum*, twelve pieces of the spine, called the *dorsal vertebræ*, and *twenty-four ribs*.

The second division consists of the *diaphragm*, and *several pairs of muscles.*

The third division contains the *trachea*, *bronchia*, and *lungs*.

There is no necessity of describing the skeleton of the trunk, having already done so for another purpose, under figures 63, 64, and 65.

The muscles concerned in respiration are the diaphragm, and the *intercostal* muscles, together with several

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What is the principal organ concerned in respiration?

others of less importance. The intercostal, or the muscles between the ribs, as the word signifies, assist in elevating the sternum and ribs, and thus of enlarging the capacity of the chest in the act of inspiration, or drawing in the breath. But the diaphragm is by far the most important muscular agent in the process of respiration.

Situation of the Diaphragm.—This part is situated transversely and obliquely scross the body, dividing the interior into two parts. Its anterior attachment is to the inner surface of the breast bone, thence running down in the direction of the ribs, it is attached to the vertebra of the loins. The heart, large blood vessels, and lungs are thus situated above and behind tbe diaphragm, while the stomach and liver are situated below and before it. It is firmly attached to the pericardium, a membrane surrounding the heart, and through it pass the esophagus and large blood vessels.

The centre of the diaphragm is tendinous, but around its whole circumference, it is composed of muscle. The muscular part only, is that which contracts and dilates during respiration.

It is chiefly by the alternate contraction and relaxation of this muscle, that the air is drawn into, and expelled from the lungs.

The *trachea*, or wind pipe, as we have before shown, leads from the back part of the throat to the *bronchia*, while the latter, is merely a division of the former into two parts leading to each lung.

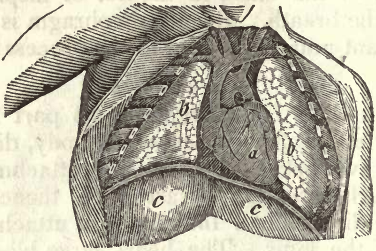
The bronchi, when they reach the lungs divide into numerous ramifications forming air tubes throughout their whole substance, so that the structure of these parts appear to consist of little more than fine air tubes, made of a thin and delicate membrane.

The *lungs* thus constructed, are two spongy, flatish, conical bodies situated within the lateral cavities of the chest, which they completely fill.

What is the situation of the diaphragm? What part of the diaphragm is muscular, and what part tendinous? What portion contracts and relaxes during respiration? What become of the bronchia after they reach the lungs?

Human Lungs and Heart.—Fig. 96, represents the lungs, together with the heart and large arteries, and

Fig. 96.



diaphragm as they are situated in Man; *a,* the heart; *b b,* the lungs; *c c,* the diaphragm. The bases of the lungs, it will be observed, rest upon the diaphragm, with which they are always in close contact. The lungs are distinguished into parts, called *lobes,* which are partial divisions of their lower parts. The right side of the chest being larger than the left, because the heart is principally on the left side, the right lung has three lobes, while the left has only two. The lungs are entirely made up of air cells and blood vessels, intermingling with each other in the closest manner, the two fluids being divided from each other by the thinest membranes. Thus as the blood passes through the lungs, it is largely exposed to the influence of the air through this membrane.

Such is the extreme tenuity of these vessels that Dr. Keil estimated the number of cells in the lungs to be nearly 180 millions, and Dr. Hales, supposing each air-cell at 1-100th part of an inch in diameter, computed that the whole surface in both lungs would be equal to 20,000 square inches. It is upon this surface that the venous blood is distributed by an equal infinity of vessels, and by which means it is aërated, or changed into arterial blood, which is then immediately sent to renovate and vivify the whole system, as shown in the

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What are the relative situation of the lungs, heart, and diaphragm? What is the substance of the lungs composed of? What amount of surface is it computed the air vessels of lungs contain?

description of the circulation. What a masterly! what a wonderful piece of mechanism this! A surface of air several hundred feet in extent, and a surface of blood of similar dimensions, all within the bulk of eight or ten inches long, and five or six in diameter. Where shall we look for a parallel, even among the effects of Infinite wisdom?

CHEMICAL EFFECTS OF RESPIRATION.

The atmosphere, as already stated, acts upon the blood through the tissue of vessels in which both fluids are confined. The most obvious effects resulting from this action, is the change of color from the dark purple hue which the venous blood has, when it comes to the lungs, to the bright vermillion which it assumes when it returns to the left ventricle of the heart.

The atmospheric air which produces this change, is composed of 20 parts of *oxygen gas*, and 80 parts of *nitrogen gas*, with a variable portion of *carbonic acid gas*. After the action of the air upon the blood, and when it is again thrown out of the lungs, it is found that a portion of the oxygen which it contained has disappeared, and that it is replaced, or nearly so by carbonic acid gas. There is also a quantity of watery vapor, always emitted from the lungs at every expiration.

The quantity of oxygen consumed in respiration, not only depends on the kind of animal, but also on the different conditions of the same animal. Thus animals of the lower order, as the Mollusca, require very little oxygen, and will live for a long time in an atmosphere in which Birds, and Mammalia have perished for want of it. The same animal also, when exercising vigorously, consumes, and requires more oxygen than when at rest.

Now carbonic acid is composed of carbon and oxygen, and since the oxygen disappears in the act of respiration, and there is a like quantity of the former gas found in its place, it is inferred that the oxygen has com-

What is the most obvious effect of the action of the air on the blood of the lungs? What is the composition of air? What is the effect of respiration of the composition of the air respired?

bined with a portion of carbon from the dark blood in the lungs, and that while carbonic acid is thus formed, the blood becomes of a lighter color in consequence of parting with a portion of carbon, and this undoubtedly is the true theory of respiration.

The blood having thus parted with its super-abundant carbon which escapes in the form of carbonic acid gas, acquires its natural vermillion color, and is again qualified to be transmitted to the different parts of the system, for their nourishment and growth.

It is found by analysis, that the venous blood contains a greater proportion of carbon than the arterial blood, and also a greater proportion than the animal solids or fluids. Now the elements of blood are *oxygen*, *hydrogen*, and *nitrogen*, and it is from the blood that all the other parts are formed. Hence in the formation or growth of other parts, if there is employed a greater proportion of the other elements, and a less proportion of the carbon than the blood contains, the effect is, an accumulation of the latter in the blood. And as an excess of carbon appears to be noxious to the animal economy, this excess is removed by combining with the oxygen of the atmosphere as the blood circulates through the lungs.

Respiration analagous to combustion.—The process of respiration has long since been considered analagous to that of combustion, which is certainly the case. In ordinary combustion the carbon of the combustible body unites with the oxygen of the atmosphere, and while heat is evolved, carbonic acid escapes, being the joint product of the carbon and oxygen. Mr. Roget has carried this idea so far as to turn the respiratory apparatus into a regular furnace, with bellows &c. "The food," says he, "supplies the fuel, which is prepared for use by the digestive organs, and conveyed by the pulmonary arteries, to the place where it is to undergo combustion: the diaphragm is the bellows, which feeds the

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What is said of the quantity of oxygen consumed by animals? What is the composition of carbonic acid? What are the elements of blood? How do you account for the accumulation of carbon in the blood?

furnace with air; and the trachea is the chimney, through which the carbonic acid which is the product of the combustion, escapes."

Animal Heat.—That animal heat depends on the process of respiration, and that the temperature, whether higher or lower, depends, at least in some degree, on the quantity of oxygen consumed, there is good reason to suppose. The uniform relation which may be observed between the temperature of animals and the energy of the respiratory function, affords a very strong presumption that this is the case.

It is true that many objections have been brought against this theory, and yet no other hypothesis has been offered which can be supported by so many concurrent facts as this. We find as a universal truth, that all hot blooded animals consume, or vitiate, large quantities of air by respiration, and that the whole mass of blood in these, is exposed to the action of the atmosphere, in a gaseous form. Whereas the cold blooded tribe depend for respiration on the minute portions of air the water contains, or are so constructed that only half of their blood is exposed to atmospheric influence. These circumstances have already been noticed and explained in the account we have given of comparative circulation and respiration.

Warm blood in Whales.—We find that when animals have all the habits of fish, and spend their lives among the ice of the northern oceans, they still have warm blood if their organs of respiration are so constructed as to expose the whole mass of circulating fluid to the influence of pure atmospheric air. Thus the Whales, and Dolphins have the breathing apparatus of the Mammalia, to which class of animals they belong, and like all the other members of this class have hearts with two ventricles, and a double system of circulation; and although they are constantly exposed to the temperature of the sea, that of their systems is similar to the other

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In what respects are the effects of respiration similar to those of ordinary combustion? What reason is there to believe that animal temperature depends on the quantity of air used in respiration?

members of the Mammalia tribes. The Porpoise is also another of this class. These animals are obliged of course, to come up to the surface to breathe, the action called *spouting* being merely the expiration of the air from the lungs, preparatory to the inspiration of another portion, and by which a quantity of water is thrown above the surface.

PART V.

SENSORIAL FUNCTIONS.

The *Sensorial Functions* are those which belong to the brain, as the general source of sensation and perception. The systems we have heretofore been occupied in describing, consisting of the Mechanical and Animal Functions, are only the foundations of the higher order of faculties which animals, and especially man are destined to exercise.

Brain and Nerves.—The functions of sensation, perception and voluntary motion, require the presence of an organized animal substance, which is endowed with very remarkable properties, and which is known to

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What are sensorial functions? What is the foundation of the sensorial functions?

physiologists under the name of the *medulary substance.* This substance composes the greatest proportion of the *brain, spinal marrow,* and *nerves.* These together, compose that set of organs generally known under the name of the *nervous system.*

The brain is the primary and essential organ of sensation, the nerves and spinal marrow being the instruments, or media by which external impressions are conveyed to this source of perception.

The nerves are bundles of white filaments or threads, which, like the blood vessels, are divided into branches, and finally into very minute fibres, which, in some instances are distributed to every part of the system; there being for instance not a portion of the skin which can be touched by the finest point, where there is not a nerve.

The nerves thus pervading the whole system, are those of *touch;* and they are universally present in all orders of animals, however low in the scale of existence. In the Mollusca and Polypi, these appear to be the only organs of sensation, since no external cause applicable to the other senses have the least effect upon them. They close their shells, or recede when touched, but often exhibit no other signs of life.

As we rise higher in the scale of animal existence, we find that the different orders are furnished with a greater number of these instruments of sensation. Thus some races have not only the nerves of touch but those of sight, those of hearing and smell being denied them. In the next step of organization, we may find all these, with perhaps the absence of taste; and it is only when we examine the highest orders of animals, that we find the senses of *touch, taste, smell, seeing* and *hearing,* all combined in the same animal.

The appearance of the nerves are every where similar, those of the touch, or taste, or smell, not being distinguishable from each other, except by tracing them to the organs of perception to which they refer.

What composes the nervous system? What part is the origin or source of sensation? How are sensations conveyed to the brain? How do the nerves appear? What is said of the nerves of touch?

Nervous Ganglia.—The nerves, as they pass along the different members often form *ganglia*, or knots, which are small oval masses of nervous substance, consisting of the ordinary filaments interlacing each other. A ganglion is represented at *g*, Fig. 97, through which

Fig. 97.

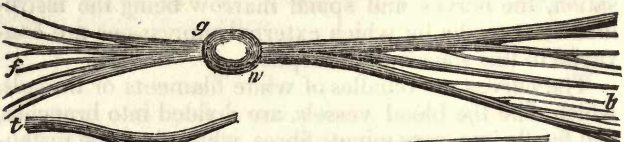

Fig. 98.

the nerve *n* passes, consisting at its origin of a number of separate filaments *f*, and again, sub-dividing into many branches *b*.

A *plexus*, or net work of nerves, is shown by Fig. 98. This is formed of four trunks, seen distinct at *t*, *t*, but which variously interlace each other, at the same time dividing into branches, before they proceed to their respective destinations.

The ganglia appear to be a kind of secondary sensoria, or rather perhaps reservoirs of the nervous power, and in which nervous filaments from the neighboring parts concentrate, or from which these filaments proceed. They are perhaps points where nerves conveying different kinds of intelligence to the brain meet, and by mingling their influence convey compound sensations to the mind.

But the subject of sensation and perception, as connected with the powers of reasoning and reflection, do not come within the scope of this volume, and we shall

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What are ganglia? What is a plexus of nerves? What are the uses of ganglia?

therefore proceed to describe the organs of sensation as they exist in the human species.

VISION.

"To those," says Mr. Roget, "who study nature with a view to the discovery of final causes, no subject can be more interesting or instructive, than the physiology of Vision, the most refined and admirable of all our senses."

In a great proportion of the complicated works of creation, although we may be able to see the most admirable mechanism, we are unable to trace its operations, step by step, and point out the ultimate end and object. "But in the subject which now claims our attention," continues Mr. Roget, "we have been permitted to trace, for a considerable extent, the continuity of design, and the lengthened series of means employed for carrying that design into execution; and the view which is thus unfolded of the magnificent scheme of the creation, is calculated to give us the most sublime ideas of THE WISDOM, THE POWER, AND THE BENEVOLENCE OF GOD."

The sense of Vision is intended to convey to us a knowledge of the presence, situation, and color of external, and distant objects, by means of the light which those objects are continually sending off, either spontaneously, or by reflection from other bodies. It would appear that there is only one part of the nervous system, so peculiarly organized as to be capable of being affected by luminous rays, and conveying to the mind the sensation of light; and this part is the *retina*, so named from the thin and delicate membranous net-work, on which the pulpy extremities of the *optic nerve* are expanded, establishing an immediate communication between that part and the brain.

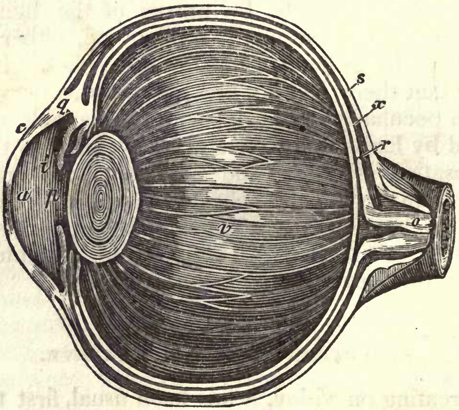
STRUCTURE OF THE HUMAN EYE.

In treating on vision, it has been usual, first to trace the optical principles so far as the eye is concerned, and then to apply these principles to the organ itself. But it is difficult to make these principles understood without the use of many diagrams, and lengthy explanations; and after all, we are obliged to refer to the eye itself, the most perfect of optical instruments, in order to illustrate these preparatory steps. We shall therefore begin with the structure of the eye, as the basis of visual physiology, and after which, such explanations will follow as will, it is hoped, make the subject in question, both plain and interesting.

The spherical form of the eye is preserved by firm membranes of various thickness, called the *coats* of the eye. The transparent media which these coats enclose, and which refract the light so as to form a picture on the retina are called the *Humors of the Eye.* There are three principal coats or membranes, called the *Sclerotica*, the *Cornea*, and the *Choroid*, besides which, there is the *Retina*, which covers the back part of the eye. The three humors are called the *Aqueous*, the *Vitreous*, and *Crystalline*, the latter being a firm body, is usually called the *Lens.*

Horizontal section of the Human Eye.—Fig. 99 represents a horizontal section of the right Human Eye.

Fig. 99.



How many coats has the eye, and what are their nanes? How many humors has the eye and what are their names?

The sclerotic coat, *s*, is that which surrounds all the others, being the exterior coat of the eye. This is a firm, dense membrane, and gives the eye ball its chief mechanical support. The sclerotica does not cover the front of the eye ball, that portion being covered by the cornea *c*, which forms the most prominent part of the organ. The sclerotic coat forms what is usually called the *white of the eye*, while the cornea covers the transparent front, through which vision is performed. The sclerotica is lined on the inside by the choroid coat, *x*, which is chiefly made up of a tissue of fine blood vessels, giving nourishment to the different parts of the eye. The retina, *r*, is an exceedingly thin and delicate expansion of the *optic nerve* *o*, situated within the choroid coat. This is the immediate organ of vision.

Of the three humors, the vitreous *v*, occupies more than three parts of the whole globe of the eye. It consists of a transparent jelly, which has somewhat of a glassy appearance, and hence, its name *vitreous*, or glassy. The crystalline humor, has the shape of a double convex lens, and occupies the front part of the eye, being situated between the aqueous and vitreous humors. The aqueous humor *a*, is a transparent, watery fluid which occupies the most prominent portion of the organ, immediately within the cornea. In this humor is situated the *iris*, *i*, a thin, circular membrane, which is of various colors in different persons, being black, in the black, and blue, in the blue eyed. On this account, this part is called *iris*, *i*, which means rainbow. Through the iris there is a central perforation, called the pupil, *p*, through which the light, or the images of objects pass to the retina. The iris is fixed to the choroid coat by a white elastic ring, called the *ciliary ligament*, *g*. The interior surface of the iris is lined with a dark brown pigment called the *uvea*.

Structure of the Iris.—The structure of the Iris is very peculiar, being composed of two layers of con-

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What is the situation of the sclerotic coat? What is the choroid coat? What is the situation of the cornea? Where is the vitreous humor situated? What is the shape and situation of the crystalline lens? What is the iris? What forms the pupil of the eye?

Fig. 100.

tractile fibres, Fig. 100. One of these layers form concentric circles, the other being disposed in the form of radii reaching from the pupil to the circumference.

The delicate fibres of which these layers are composed, perform the part of muscles in varying the size of the pupil. When those forming concentric circles act, the pupil is diminished; when those forming radii contract, the margin of the pupil is brought nearer the circumference, and of course the aperture is enlarged.

No piece of mechanism can excel this in simplicity, beauty, and perfection. By its contractions and dilations the quantity of light admitted into the eye is regulated. When its intensity would be injurious to the sensibility of the retina, then the circular muscles act and close the aperture, sometimes almost to a point; while, if the quantity of light flowing from objects be too small as during the evening, or on going into a dark room, the radiating fibres contract, and opening the aperture, admit as large a quantity of light as possible. We shall see hereafter also, that the contraction of the pupil serves to exclude such rays as would otherwise fall upon parts of the crystalline lens which are unfitted to bring them to a focus, and in which case vision would be confused and imperfect.

PHYSIOLOGY OF VISION.

Having thus described the mechanism of the eye, we will next explain the optical principles involved in the visual function.

The passage of light, through the air, or through any other medium of equal density, throughout, is always in straight lines. But when a ray of light passes into, or out of, a medium of a different density, it is bent, or

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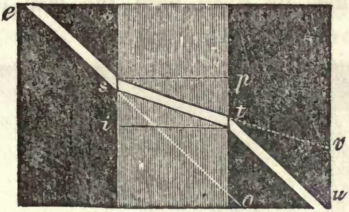
What is the structure of the iris? What are the different uses of the two coats? When a ray of light passes obliquely into, or out of a rarer, or a denser medium, how is the ray effected? In what direction is the refraction when it passes from a rarer into a denser medium?

refracted out of a straight line, unless it strikes the new medium in a perpendicular direction. Air, water, glass, or any other substance through which light passes is called a *medium*.

If the ray passes obliquely, from a rarer into a denser medium, as from air into water, or from water into glass, it is refracted *towards* a perpendicular line drawn from the surface of the medium. But when the ray passes out of a denser into a rarer medium, the refraction is *from* the same perpendicular.

Thus the ray *e*, Fig. 101, striking obliquely on the surface of a denser medium, at the point *s*, instead of

Fig. 101.



pursuing its original course along the line, *s*, *o*, is refracted into the direction *s*, *t*, which is a line situated between *s*, *o*, and *s*, *p*; this latter line being drawn perpendicular to the surface of the medium, at which the ray enters. When the ray arrives at *t*, it passes from a denser into a rarer medium, and is refracted in the contrary direction; that is, it inclines *towards* the perpendicular line *t*, *i*, drawn from *t*, within the denser medium, and describes the new course *t*, *u*, instead of *t*, *v*.

In all cases of refraction, the amount corresponds to the degree of obliquity of the ray to the surface which refracts it; while that ray which passes perpendicularly from one medium to another, no matter how different their densities, is not refracted at all, but pursues a straight course as though the media were of one and the same density.

In the application of these principles to the form of a dense medium, which shall bring the rays of light pass-

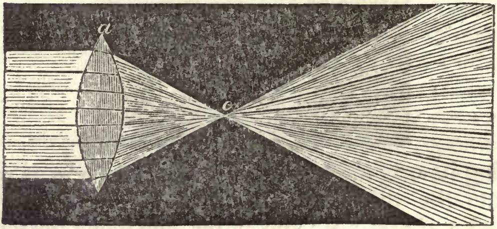
What is the direction when it passes into a rarer medium? What does the amount of refraction correspond with?

ing through it, from the air, to a point, or *focus*, it is plain that two sections of a solid transparent sphere with their plane faces applied to each other, is one of the forms which is indicated. This form, made of solid glass, is called a *double convex lens*, and which corresponds very nearly to the shape of the crystalline lens, in the human eye.

The amount of refraction being in proportion to the obliquity of the refracting surface, if the rays of light proceed in parallel lines, then the refractive power will be greatest, at the greatest distance from the central ray, and thus all will be concentrated at the same point.

It will be observed on inspecting the lens *a*, Fig. 102, and comparing its form with the law of refraction

Fig. 102.



above stated. that both sides of a sphere conspire to bring parallel rays of light to a focus; the first side by turning them *towards*, and the other *from* a perpendicular raised from their respective surfaces of refraction.

After the rays have been made to converge to a focus *e*, they cross each other, and again diverge from that point as shown by the figure.

It will be seen in the sequel, that the lens of the eye operates precisely on the rays of light, like the convex lens just described, only that the former is a more perfect instrument than any which can be constructed by the hand of man. But before we proceed to describe the manner in which vision is performed, we will show by a very simple experiment in what manner the images

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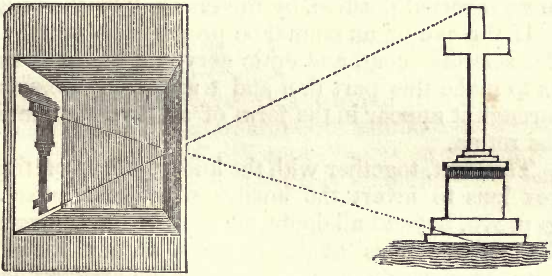
What is the form of a double convex lens? In parallel rays what part of a double convex lens has the greatest refractive power? Do both sides of the lens conspire to form the focus or not?

of external objects may be produced in a darkened room, as an illustration of the manner in which the same effect is produced in the eye.

Let a room be darkened so as to exclude all the light in every direction, except through a small aperture in a window shutter. The consequence will be, that the images of external objects, as trees, houses, and men, will be seen painted in the inverted position, on the opposite wall, or on a screen of white paper held before the aperture.

Cause of the Inverted Image.—The reason why these images are inverted, is, that the rays of light proceeding from the extremities of the objects must converge in order to pass through the small aperture, and consequently they cross each other, at that point, so that the lowest portion of the object is the highest part of the picture. All this will be readily understood by a bare inspection of Fig. 102, which represents a monument,

Fig. 103.



with the course of the rays from its extremities, crossing each other at the aperture, and a picture of the same inverted on the inside of the room.

This little experiment which almost any one can try, forms a faint *Camera Obscura.* The picture, however, becomes brighter by enlarging the aperture, but at the

How may a simple camera obscura be formed? Why is the picture brighter when the rays pass through a small aperture? Why is the image rendered indistinct when the aperture is enlarged?

same time is rendered more indistinct, because then the rays interfere, and mingle with each other.

The only method by which distinctness of the image and increased illumination can be obtained, is by collecting into one point a great number of rays, proceeding from the corresponding points of the object to be represented. This intention is answered by the use of a short tube containing a double convex lens, such as is represented by Fig. 101, inserted into the aperture. By this instrument, the rays are collected by refraction, and concentrated so as to present a perfectly defined and highly illuminated picture.

Now these illustrations, and principles, are exactly those which apply to the mechanism, and use of the human eye; which, in all respects, is a camera obscura, of the most perfect workmanship. The vitreous humor is the space occupied by the darkened chamber; the pupil is the aperture through which the light is admitted; the crystalline humor is the double convex lens, by which the rays of light are collected and concentrated; and the *retina* is the screen, on which the picture is painted, in an inverted position, by the crossing of the rays.

If the eye of an animal be prepared by cutting away the sclerotic coat, and optic nerve on the back side, so as to make this part thin and transparent, objects seen through it appear in the form of an inverted picture on the retina.

This fact, together with the known effect of the convex lens to invert the images of objects, is sufficient to prove, beyond all doubt, that the image is inverted on the retina. This might perhaps, at first thought, be considered as an imperfection in the eye, but we find that nature always attains her objects by the most direct and simple means. Another lens placed in the focus of the crystalline, would have corrected this inversion; and we find that finite mechanics resort to this method in the construction of terrestrial telescopes; that is, they add one more glass on purpose to correct the inversion of objects. But it is well known that this additional glass always proves an imperfection in the instrument on other accounts, since every glass, however perfect it may appear, still intercepts a portion of the light. In the eye the cause of this imperfection is avoided, and this too, without the least inconvenience to ourselves, since no one in health, has ever yet complained of the slightest difficulty in making the highest parts of objects appear at the greatest distance from the surface of the earth, whether he knew that he saw them in another position or not.

Now we have every reason to believe that our Creator, all things considered, has constructed us on the wisest and best plan, and therefore that he chose so to endow us, whether by a peculiar faculty or not, as to see things as they exist, though they are inverted in the eye, rather than to correct this inversion by an additional lens. This seems to be the only explanation which it is necessary to give this subject, for although physiologists have puzzled themselves to show how it is, that we see objects as we do, when all agree that the structure of the eye inverts them ; still we can discern no more difficulty in this phenomenon, that we do in the fact, that an engraver reverses all his lines, and that a printer reads his type with the same facility that he does a printed page ; both being matters of habit and experience.

Minuteness of the image on the Retina.—It would be a curious, and not uninstructive subject, as displaying in a very striking manner, the Wisdom and Power of God, in the mechanism of his creatures, to estimate the dimensions of the images of different objects, at various distances, on the retina, if indeed this could be done with any accuracy.

The expansion of the optic nerve which forms the seat of vision, is only about half an inch in diameter, and yet, on this space is painted with the most perfect accuracy the image of every object which the eye beholds. Now the eye in an elevated situation may look on the whole of a landscape to the distance of fifty miles; and without perceptibly moving the visual organs, include a lateral view of probably twenty-five miles; and yet the whole of this extent, must be pictured on

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How might the inversion of the picture on the retina have been corrected? Why do we see things perpendicularly ?

the diameter of half an inch at the same instant, otherwise it could not be seen at the same view.

The Rev. Dr. Dick, *in his* "Christian Philosopher," a work which should be read by all mankind, has calculated that a portion of the Castle of Edinburgh, equal to 500 feet long, and 90 in height, occupies on the retina only the *twelve hundred thousandth part of an inch*, when seen at a certain distance, and yet every part was distinctly visible. What then might be the dimensions of the picture of a fixed star on the same organ?

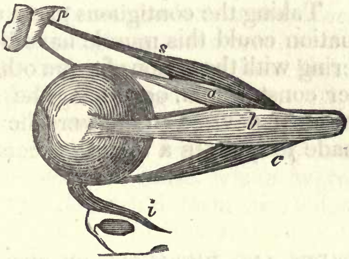
Mr. Roget in his "Animal and Vegetable Physiology," speaking of this organ, says, "few spectacles are more calculated to raise our admiration than this delicate picture, which nature has, with such exquisite art, and with the finest touches of her pencil, spread over the smooth canvass of this subtle nerve; a picture, which though scarcely occupying a space of half an inch in diameter, contains the delineation of a boundless scene of earth and sky, full of all kinds of objects, some at rest, and others in motion, yet all accurately represented, as to their forms, colors and positions, and followed in all their changes, without the least interference, irregularity, or confusion. Every one of those countless and stupendous orbs of fire, whose light, after travelling immeasurable regions of space, at length reaches our eye, is collected on its narrow curtain into a luminous focus of inconceivable minuteness; and yet this almost infinitesimal point shall be sufficient to convey to the mind, through the medium of the optic nerve, and brain, a knowledge of the existence and position of a far distant luminary, from which that light has emanated. How infinitely surpassing all the limits of our conception must be the intelligence, and power of that Being, who planned and executed an instrument comprising, within such limited dimensions, such vast powers as the eye, of which the perceptions comprehend alike the nearest, and most distant objects, and take cognizance at once of the most minute portions of matter, and of bodies of the largest magnitude! *Bridgewater Treatise*, vol. 2. p. 476.

MOTIONS OF THE EYE.

The socket of the Eye is considerably larger than the ball itself, the space between them being lined with a soft cellular substance, in which the eye easily turns in all directions. At the anterior part of the cavity are inserted the muscles which give motion to the ball.

A view of these muscles with their attachments to the different parts of the ball, but separated from the other parts, is given in Fig. 103. Four of these pro-

Fig. 104.



ceed in a straight course from the bottom of the orbit, arising from the margin of the aperture through which the optic nerve passes, and being inserted by a broad tendinous expansion into the fore part of the sclerotic coat. Three of these are marked *a*, *b*, *c*, in the figure ; the edge of the fourth being seen above and behind *b*. These *straight muscles*, as they are called, surround the optic nerve and the eye-ball, forming four longitudinal bands ; one, *a*, being situated above, for the purpose of turning the eye upwards ; a second *c*, situated below, for turning the ball downwards ; the two others, *b*, and its antagonist, perform the lateral motions from right to left.

Besides these straight muscles, the figure shows two others, *s*, and *i*, termed, from the manner in which they act, *oblique muscles*. When these act together, they

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What are the directions in which the straight muscles move the eye ball ? What motion do the oblique muscles give the eye ball ?

draw the eye forwards, serving as antagonists to the straight muscles. The upper oblique muscle *s*, is very remarkable for its anatomical structure. Its tendon passes through a little aperture in a piece of cartilage, which is fastened to the upper margin of the orbit. The tendon then turns back, forming a complete pulley, and is inserted into the upper side of the eye-ball as seen in the figure. It is obvious that the effect produced by the contraction of this muscle, is exactly contrary to that of the action of its fibres.

This muscle affords another instance of that simplicity, effect and design, which we so often meet with in the study of nature, and especially in the mechanism of the human frame. Taking the contiguous parts as they are, in no other situation could this muscle have been placed, without interfering with the action of some other part, nor could any other construction, occupying the same limited space, have been devised to answer the same purpose, being made to pull in a direction contrary to its own action.

MAGNITUDES AND DISTANCES OF OBJECTS.

An inquiry into the philosophy of vision for the purpose of ascertaining in what manner we are able to appreciate the distance of an object by its apparent magnitude, together with the subject of perspective, and the phenomena of vision generally, would lead us far beyond the limits of this work. We will however cite two or three curious cases, in order to show how far we are able to gain a knowledge of the forms, magnitudes, and distances of things without the aid of the eyes. So far as any of us can remember, we have always been able to form a judgment of the forms, distances, and magnitudes of objects, by the eye, and especially with respect to those which are not at very remote distances. But how far these distances are appreciated by walking from

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Describe the upper oblique muscle of the eye, and show its use? What is said of the mechanism of these muscles?

one object to another; and how much we are indebted to examination by the touch, for our knowledge of their forms, or how much our judgment of their magnitudes depend on comparisons, perhaps with our own persons, we are unable to determine. These cases show, that we are dependent for this kind of knowledge, in a great measure on former experience.

Chesselden's Case.—This was the case of a young gentleman who was born blind, or lost his sight so early and so entirely, that he had no remembrance of ever having seen any object, whatever, until he was fourteen years of age. His disease was a cataract in each eye, and at this age it was *couched*, as the operation is called, and by which his sight was restored.

"When he first saw," says Chesselden, "he was so far from making any judgment about distances, that he thought all objects whatever, touched his eyes, (as he expressed it,) as what he felt did his skin, and thought no objects so agreeable as those which were smooth and regular, though he could form no judgment of their shape, or guess what it was in any object that was pleasing to him. He knew not the shape of any thing, nor any one thing from another, however different in shape or magnitude; but upon being told what things were, whose forms he knew before, from feeling, he would carefully observe, that he might know them again: but having too many objects to learn at once, he forgot many of them; and (as he said,) at first, he learned to know, and again forgot thousands of things in a day. At first, he could bear but very little light; and the things he saw, he thought extremely large, but upon seeing things larger, those first seen, he considered less, never being able to imagine any lines beyond the bounds which he saw; the room he was in, he said, he knew to be but a part of the house, yet he could not conceive that the whole house could look larger." His cat, which of course he knew perfectly well by feeling, he did not know by sight, and being told what it was, closed his eyes, to ascertain the truth in his usual manner.

Mr. Wardrop's Case.—A case in many respects, much more interesting than Chesseldens, and described more in detail, was laid before the Royal Society of London, in 1826, by Mr. Wardrop, a celebrated oculist. This was the case of a lady born blind, but who received her sight at the age of 46, by the formation of an artificial pupil.

After a third operation, which Mr. Wardrop performed for the artificial pupil, she returned from his house in a carriage, with her eye covered only with a loose piece of silk. The first thing she noticed was a hackney coach passing by, when she exclaimed, "What is that large thing that has just passed by." In the course of the evening she requested her brother to show her his watch, which she looked at for some time, holding it close to her eye. She was asked what she saw, to which she answered, "that there was a dark and a bright side;" she pointed to the hour of twelve, and smiled. Her brother asked her if she saw any thing more; she replied, yes, and pointed to the hands of the watch. She then looked at the chain and seals, and observed that one of the seals was bright, which was the case, being a solid piece of rock crystal.

On the third day she observed the doors on the opposite side of the street, and asked if they were red: they were of an oak color. In the evening she looked at her brother's face, and said she saw his nose: he asked her to touch it, which she did; he then slipped a handkerchief over his face, and asked her to look again, when she playfully pulled it off.

On the thirteenth day of the operation, she walked out with her brother in the streets of London, when she distinctly distinguished the street from the foot pavement, and stepped from one to the other like a person accustomed to the use of the eyes.

"Eighteen days after the operation," says Mr. Wardrop," I attempted to ascertain, by a few experiments, her precise notions of color, size, and forms, positions, motions, and distances of external objects. As she could only see with one eye, nothing could be ascertained respecting the question of double vision. She evidently saw the difference of colors; that is, she received, and was sensible of different impressions from different colors. When pieces of paper, one and a half inches square, differently colored, were presented to her, she not only distinguished them from one another, but gave a decided preference to some colors, liking the yellow most, and then pale-pink.

When desirous of examining an object, she had considerable difficulty in directing her eye to it, and finding out its position, moving her hand, as well as her eye in various directions, as a person, when blindfolded, in the dark, gropes with his hand for what he wishes to touch.

She saw objects upright as we do, and not inverted. She seemed to have the greatest difficulty in finding out the distance of any object, for when the thing was held close to her eye, she would search for it, by stretching her hand far beyond its position, while on other occasions she grasped, close to her own face, for objects far remote.

From these cases, we may infer how faint the conceptions of the unfortunate blind must be to the charms and beauties of the external world, and yet having never enjoyed the pleasures which we derive from sight, and therefore being unable to compare their own conditions with ours in this respect, they are far from feeling that regret at their own situation, which we should, if deprived of sight. Indeed, we believe that most persons who never have enjoyed this sense, consider their condition by far less deplorable than that of the deaf and dumb.

Insensibility to certain colors.—Sir David Brewster has collected a number of instances in which the eyes of persons were either totally insensible to certain colors, or mistook one for another, although in every other respect, the visual organs were quite perfect. Some of these cases are the following.

Mr. Scott, who describes his own case in the Philosophical Transactions mistook *pink* for *pale blue*, and a full *red* for a full *green*. This was a family defect, since Mr. Scott's father, his maternal uncle, one of his sisters, and her two sons all mistook these colors exactly in the same manner.

A Shoemaker, named Harris, could only distinguish *black* and *white;* and when a child, never could distinguish the cherries on the tree from the leaves, except by their shape and size. The eyes of two of his brothers were equally defective.

A tailor at Plymouth, as described by Mr. Harvey of the same place, regarded the seven prismatic colors as consisting of only *yellow* and *light blue.* In other respects he could only distinguish with certainty *gray, white*, and *yellow.* This defect sometimes led him to ludicrous mistakes in his business. Thus, on one occasion he repaired a *black* silk garment with *crimson*, and on another he patched the elbow of a blue coat, with a piece of crimson cloth.

A still more ludicrous case is given by Dr. Nichol, of an officer in the British Navy, who purchased a blue uniform coat and waistcoat, with red breeches to match. Mr. Dugald Stewart was unable to distinguish any difference between the scarlet color of the Siberian crab apple, and the leaves of the tree.

Mr. Troughton, the celebrated optician, can distinguish with certainty only *blue* and *yellow.*

No satisfactory solution has been given of the cause of these defects.

COMPARATIVE PHYSIOLOGY OF VISION.

The lowest orders of animals, have no organs of vision which have ever been detected, and yet some of them have been supposed to be in a slight degree sensible to the impression of light. Thus it is said, the Medusæ, in a calm sea, are seen to rise towards the surface, until coming within the full influence of the sun's rays, they descend again before any part of their bodies come in contact with the atmosphere. The cause of the descent, and the reason why they never expose their bodies above the water, has been supposed to arise from the distinction they are able to make, between the light near the surface and that of the deep sea. It is most probable, however, that these animals are guided by the pressure of the water, rather than by the impression of light.

In the Snail, the eye is situated at the extremity of the tentacula or feeler.

Eyes of Insects.—Nearly all the Insects are furnished with organs of vision either in the larva, or perfect state, and many of them in both.

Many Insects are furnished with two kinds of eyes, one kind being situated on each side of the head, and so large as not to escape common observation. These are called *compound eyes.* The others are three in number and are situated on the top of the head, obliquely behind, and between these. These are called *stemmata.* They are either in a row, or in the form of a triangle.

The structure of the stemmata has been minutely examined by Professor Muller, who has ascertained that they contained a hard crystalline lens, a vitreous humor, and a choroid coat, the whole being covered externally by a hard convex coat. In Wasps, Bees, and Bugs, these parts are distinguished by the naked eye, and so far as external form and appearance are concerned, may be satisfactorily examined by a common magnifier.

In the spider the stemmata are of considerable size, their number being generally eight, and their situation on the top of the head, where they are disposed with much regard to symmetry.

The compound eyes of Insects are among the most complex and curious organs which the animal kingdom presents. In some tribes, as in the Wasps and Dragon fly they cover a large portion of each side of the head, and although when only slightly examined they present a smooth outside, and appear each as a single eye, yet they are formed of a vast number of separate cylinders or elongated cones closely packed together, each being a distinct eye, and capable of perfect vision. The exterior of each tube is a hexagon, a form which admits of the closest arrangement, like the cells of a honey-comb.

The number of these cylinders differ much in different Insects. In the Ant they are only 50; in some of

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What are the two kinds of eyes with which insects are furnished called? What are their situations? Give a description of the compound eye of an insect.

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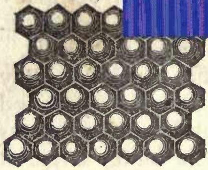
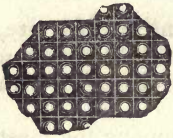
Fig. 1



sects such a number of eyes, is evidently that they may be enabled to see in all directions without moving the eye ball or head, as will be shown directly.

Magnified Eye of a Butterfly.—In the Phalena a genus of Butterflies, and in some other tribes, the little eyes are arranged into squares instead of hexagons, as shown by Fig. 106. The design of this variety in different species is unknown, but undoubtedly some purpose of convenience to the Insect is answered by it.

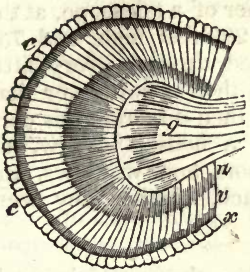
Fig. 106.



Structure of the Compound Eyes of Insects.—Naturalists have investigated with great care and considerable labor the structure of the compound eyes of Insects. The following account of the mechanism of the eye of the *Libellula vulgata,* or grey Dragon-fly, is the result of the observations of M. Duges, a French naturalist. The figures of course are magnified, some of them many hundred times.

The whole outside surface of the compound eye *c c,* Fig. 106, may be considered as corresponding to the cornea of animals. Each separate division of this part in Insects is called *corneule,* or little cornea. These are shown by the waved line on the circumference of

Fig. 107.

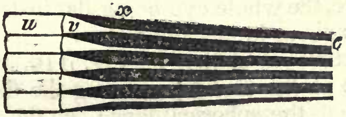


the figure. They are of a horny texture and perfectly transparent. Each corneule has the form of a truncated pyramid, the length of which, is between two and three times the diameter of the base.

These little eye glasses as shown by the figure, stand around the nervous bulb *g*, which may be considered the retina, or optic ganglion, and on which is painted the images of objects, as they are on the retina of animals; each corneule being of itself a perfect eye, and according to Duges furnished with a pupil, which he saw contracting and dilating in proportion to the quantity of light.

Fig. 108 represents some of these tubes more highly magnified, in order to show their precise forms. The

Fig. 108.



letters *u*, *v*, *x*, in this, and the last figure corresponds. The dark part is a black pigment which fills a portion of the diameter of each tube, the aperture widening at *v*, where it is filled with a vitreous humor.

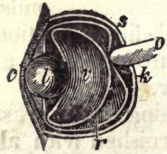
It thus appears that each eye forming these vast aggregates, consists of a distinct tube furnished with all the anatomical parts necessary for perfect vision; and thus has nature supplied the want of motion in this organ by a multiplication of their numbers, so that the Insect has a distinct eye, pointed towards the object, in whatever direction it may appear.

That there might be no doubt, that Insects have as many eyes as there are tubes in each, Leeuwenhoek, having prepared the compound cornea of a fly for the purpose, placed it a little more remote from his microscope than when he would examine an object; and looked through both in the manner of a telescope, at the steeple of a church, which was 299 feet high, and 750 feet distant, and could plainly see through every little lens, the whole steeple inverted, though not larger than the point of a fine needle: and then directing this curious optical instrument towards a house, he saw, not only the front, but also the doors and windows, and could plainly discern through each, whether they were open or closed.

Eyes of Fishes.—In the Fishes, the cornea is nearly flat, as is the case with all aquatic animals. This is an adaptation to the element in which they live, for since there is little difference between the density of the water and the cornea, there would be but little refractive power in this part, were its convexity ever so great. The refraction is therefore chiefly performed by the crystalline lens, which has great power, in this respect, its form being spherical, and its texture of great density, properties designed to bring the rays to a focus at a very short distance, the whole eye being flat instead of oblong through the axis as in land animals.

This structure is shown by Fig. 110, which represents the eye of the Perch; *c*, being the flat cornea; *l*, the spherical lens; *v*, the vitreous humor; *r*, the retina; *o*, the optic nerve; *s*, the sclerotic coat, and *k*, a part called the *choroid gland*, shaped like a horse shoe, but the use of which is entirely unknown.

Fig. 109.



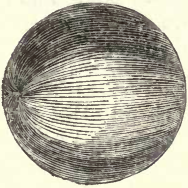
The eyes of Fishes being continually washed by the element in which they live, require no glands to secrete a fluid for moistening them; or any eyelids to prevent the dust from flying into them.

Remarkable structure of the Lens of the Cod-fish.—Sir David Brewster has recently made an analysis of the structure of the crystalline lens of the Cod-fish, to which he was led by noticing some remarkable optical appearances presented by thin layers of this substance.

He found that the hard central portion is composed of a succession of concentric, and perfectly transparent, spheroidal laminæ, the surfaces of which, though apparently smooth, have the same kind of irridescence as the shell called *mother of pearl*, and arising from the same cause, namely, the occurrence of regularly arranged lines, forming a striated surface, but so fine as to be detected only by a powerful magnifier. These lines which mark the edges of the separate fibres, composing each lamina, converge like meridians from the equator towards the two poles of the spheroid.

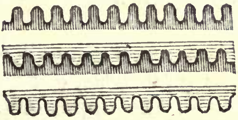
This appearance, magnified, is shown by Fig. 110, where it will be observed that these fine lines converge to a centre at the upper part of the figure. The fibres themselves are not cylindrical but flat; and they taper at each end, as they approach the points of convergence. The breadth of the fibres in the most external layer, at the equator, is about the 5,500th part of an inch.

Fig. 110.



Having his curiosity excited by this singular structure, Sir David Brewster continued his miscroscopic observations on the same substance, and by using a very high power he further discovered that these fibres are locked together at the edges by a series of teeth, resembling those of rack work, as represented by Fig. 111. He counted the teeth in a single fibre and found that they amounted to 12,500, and as he ascertained that the whole lens contained about 5,000,000 of fibres, the whole number of these teeth in a single lens amounts to the number of 62,500,000,000.

Fig. 111.



Structure of the Eyes of Birds.—The eyes of Birds are very large when compared with the head, or with those of the other animals of the same sizes.

What is said of the eyes of birds?

The chief peculiarities in the eyes of these animals, are apparently designed to accommodate their vision to a rare medium; to strong degrees of light, and a ready adjustment to objects situated at very different distances. These ends appear to be answered chiefly by the great prominence of the cornea, or front of the eye ball, which contains an uncommon quantity of the aqueous humor, so that the lens is situated far forward, or at the greatest distance from the retina. On optical principles this arrangement enables the eye to see near objects most distinctly, while at the same time the refracting power of the lens becomes susceptible of great variations.

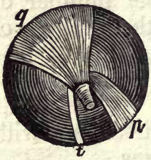
The form of the eye in Birds is preserved by a bony circle, consisting of fifteen or twenty pieces overlaping each other. By these bones the sclerotic coat is supported, and its hemispherical prominence maintained.

Nictitating Membrane.—Most Birds are furnished with a winking membrane, (*membrana nictitans,*) which they draw over the eye-ball, instead of closing the eyelids. This is a thin delicate structure, so translucent as to admit a diffused light, while it intercepts the direct rays from the eye. When not in use it is closely folded up in the inner cornea of the eye.

Fig. 112.

This membrane is represented at Fig. 112, covering one-half the eyeball. Its motion is horizontal, and is effected by two muscles, acting upon each other, by a peculiar and beautiful piece of mechanism.

Fig. 113.



The first of these muscles is called from its shape, the quadratus, *q*, Fig. 113, and arises from the upper and back part of the sclerotica, its fibres converging and terminating in a round tendon as seen in the figure. This tendon serves as a loop for that of the second muscle *p*, which is called the *pyramidalis*, and which has its origin on the lower, and back part of

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What are the chief peculiarities of the eyes of birds? How are the objects of these peculiarities answered?

the sclerotica. The long tendon of this muscle *t*, after passing through the loop of the other, which acts as a pulley, is conducted through a circular sheath to the under part of the eye, where it is attached to the lower portion of the nictitating membrane. By the joint action of these two muscles, the membrane is instantly drawn over the front of the eye-ball. Its return is effected by its own elasticity, which is sufficient to carry it back to its place in the inner cornea of the eye.

AUDITION, OR HEARING.

Next to the eye, the organs of Hearing are more complex and refined than those of any other sense. Indeed, certain parts of the mechanism of Audition, are not less exquisitely formed, or less striking and wonderful in their functions than the most admirable parts of the organs of vision.

Principles of Acoustics.—Acoustics is the science which treats of the origin, propagation and effects of sound. For an epitome of this science the author must refer to his "System of Natural Philosophy," while at present, only such a view of the subject will be stated, as is absolutely necessary, in order to understand the physiology of the Ear.

Sound is the result of vibratory motions in the particles of a sonorous, or sounding body, which motions are first communicated to the air, and by the air to the Ear.

Sound does not, like light, pass through void space, it being proved by experiment that the report of a bell, struck in a vacuum is not heard, though the blow is seen, and near the Ear.

The sounding body gives an impulse to the air in every direction, and which is propagated from one particle to another, in a circle, in the same manner that the

What is said of the organs of hearing when compared with those of vision? What is taught by the science of acoustics? What is sound? How is sound communicated to the Ear? Does sound pass through a vacuum, or not?

surface of a calm lake is thrown into circular waves by the force of a stone thrown into it.

The velocity of sound through the atmosphere is about 1100, or more nearly 1142 feet in a second. Hence we see the flash of a gun, and after an interval depending on the distance, hear the report. Thus in a thunder storm, if we allow 1100 feet per second, between the time when the flash of lightning is seen, and the thunder heard, we may ascertain very nearly the distance of the cloud.

Solids and liquids convey sounds much more perfectly, and rapidly, than air. Franklin found that a sound, after travelling above a mile through water, lost little of its intensity, and Chladni states, that according to his experiments, the velocity of sound in water is at the rate of about 4,900 feet in a second, being between four and five times more rapid than it is through the air.

In musical tones, if the intervals between the vibrations be short, the tone is *acute*, if long, the tone is *grave*. Hence in the violin, and other musical instruments, the strings designed for high or acute notes are small, that their vibrations may be rapid; while those which make the low, or grave tones are large, and sometimes wound around with fine wire, in order to increase their weight, and thus to make them vibrate slowly.

In musical tones, it is the quality, and variety of the sounds which give the hearer so much pleasure. The string of the Harpsichord when fastened to a piece of board, or to the ground, may be made to give the same pitch, or grade of tone, with respect to gravity or acuteness, as when on the instrument, but an instrument having such a quality of tone, would give no pleasure to the Ear.

The Ear is susceptible of much cultivation with respect to music, as is the eye with respect to painting. The finest and most complex strains of music are often lost upon the uneducated Ear, as the noblest works of the painter are unappreciated by the uncultivated eye. Hence tones, and pictures, which raise the most enthu-

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In what direction is sound propagated? What is the velocity with which sound passes through the air? How may we tell the distance of a thunder cloud? What is said of the propagation of sound by solids and fluids? How is grave or acute musical tones formed?

siastic feelings in one, are heard and seen by another with no sort of effect. It is true, however, that there is a natural difference in these respects, and especially with regard to music, there being some uneducated Ears which are able to appreciate the finest passages in a piece, though they never had heard good music before. This however, is seldom the case with respect to painting, deep impressions and good judgment being nearly in every case the result of education.

In treating of hearing, we shall, as we have done with respect to vision, begin with that structure which is most highly developed, and best understood, the Human Ear.

DESCRIPTION OF THE AUDITORY APPARATUS IN MAN.

The best summary on this subject we have seen, for the design of this work, is that of Mr. Roget in his "Bridgewater Treatise, on Animal and Vegetable Physiology." This, therefore, will form the basis of the following treatise.

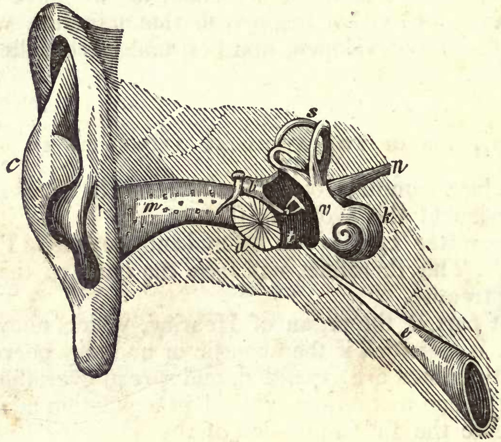
That part of the organ of Hearing, which, above all others, is essential, is the acoustic or auditory nerve, of which the fibres are expanded, and spread over the surface of a fine membrane, placed in a situation adapted to receive the full impression of the sonorous undulations which are conveyed to them. This membrane, then, with its nervous filaments, which is situated within the labyrinth, may be regarded as the immediate organ of this sense; all the other parts constituting merely an accessory apparatus, designed to collect and condense the vibrations of the surrounding medium, and to direct their concentrated action on the auditory membrane.

The principal parts of this complicated organ are exhibited in Fig. 114, as they exist in man, in their relative and of the natural sizes; these parts will therefore, afford a scale of real dimensions of those portions, which will hereafter be explained by magnified views.

What is it in musical tones that give pleasure? What is said of the ear? Can some enjoy good music without education?

External Ear.—The external Ear, *c*, is called the *concha:* from this there opens a funnel-shaped orifice, *m*, called the *meatus auditorius*, or orifice of the Ear, which leads to the internal parts. At the internal extremity of this orifice, and which it closes, is situated the *Ear-drum*, *d*, called the *tympanum*. Behind the Ear-drum there is a hollow space, *t*, called the *cavity of the tympanum*. From this cavity, a trumpet-shaped tube,

Fig. 114.



e, called the *Eustachian tube*, leads to the back part of the nostrils, or roof of the mouth. The parts marked *s*, *v*, *k*, consist of several intricate winding passages called the *labyrinth*. This part will be explained by another figure. Connected with the Ear-drum there is a chain of moveable bones marked *b*, which are also explained by another figure. The auditory nerve is seen at *n*, passing into the centre of the labyrinth.

The external Ear appears to be formed for the purpose of collecting the sonorous undulations of the air, and of directing them through the canal to the Ear-drum.

The Ear-drum is stretched across the meatus, or orifice of the Ear, like the skin of a drum, whence its name; and it performs a corresponding office; for the undulations of the air throw it into a similar state of vibration. The structure of this part is muscular, being thus designed to adapt itself to the force of the vibrations communicated to it from the external air.

The cavity of the tympanum *t*, behind the Ear-drum is always filled with air, but it would obviously defeat the design of this organ, were the air confined to this space, because unless it were in a state to expand and contract, it could not remain in equilibrium with the pressure of the atmosphere on the external surface of the drum, which of course varies, according to the rise and fall of the barometer. Hence, were this air confined, an intense internal pressure on the drum would be the consequence, whenever the external pressure happened to be partially removed, as when one ascends a mountain, or mounts up in a balloon. Against such an evil, there is an effectual guard by the communication between the internal Ear, and the atmosphere, by means of the Eustachian tube, *e*. This tube, as the figure shows, begins with a small orifice, and opens with a wide mouth, back of the nostrils. It performs the same office in the Ear, that the aperture in the side of a drum does in that instrument; that is, it forms a communication with the external air, which appears to be as necessary to the functions of the Ear, as it is for the sound of the drum. When the air-hole of a drum is stopped, the instrument not only does not sound as usual, but the head is liable to be broken, by the re-action of the confined air; and when the Eustachean tube is obstructed, as is often the case during influenza, or colds, by which this part is swollen, or its secretion is increased by inflammation, then a partial deafness is the consequence. This tube also appears to be the channel through which sound may be admitted, or perhaps the hearing is more perfect when there is an ample communication between the external air and the tympanic cavity, for it is well known that when one listens to a scarcely audible sound

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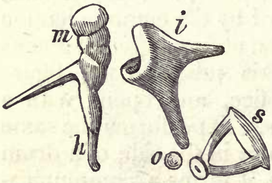
Where is the ear-drum situated? What effect do the undulations of the air have upon the ear-drum? What is the cavity within the tympanum called? What tube communicates with the cavity? What would be the effect were the air of this cavity confined? Why does one open his mouth in order to hear a distant sound?

he instinctively opens his mouth. When this tube is entirely closed total deafness is often the result.

Bones of the Ear.—Behind, or within the interior side of the tympanum, there is a chain of very minute, moveable bones, of peculiar shapes, seen of the natural sizes at *b*. One end of this chain is fastened to the tympanum, and the other, to a part called the *fenestra ovalis*, or oval window. This latter part is a membrane situated in the cavity of the tympanum, opposite to the orifice of the Eustachian tube, and covering a cell in the bone, called a *mastoid* cell, which cell is filled with air.

These bones, called the *tympanic ossicula*, or little bones of the drum, are represented separate, and twice their natural size, by Fig. 115. Their names have been derived from their shapes rather than the offices they perform. The first, *m*, is the *malleus*, or hammer, the long handle *h*, of which is affixed to the ear-drum; the second, *i*, is the *incus*, or anvil, which somewhat resembles in shape, a molar tooth, the crown of which is attached to the head of the hammer; the third, *o*, is the round, or *orbicular* bone. This is the smallest bone in the human skeleton, being no larger than a millet seed, and is situated between the long process of the anvil and the next bone in the number. The fourth and last bone in the chain is the *stapes*, or stirrup, *s*, which is fastened by its base, or widest part to the fenestra ovalis.

Fig. 115.



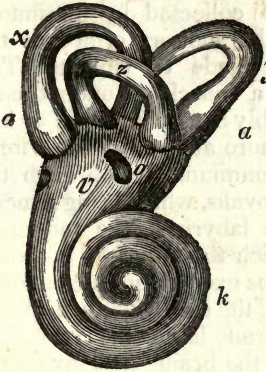
These bones are regularly articulated with each other so as to allow of motion between each two, and their office appears to be, to transmit the vibrations of the ear-drum to the fenestra ovalis, and probably also to increase the force of these vibrations.

Labyrinth of the Ear.—We have thus given a sum-

Where are the bones of the ear situated? To what parts are these bones attached? What are the names of the tympanic ossicula?

mary description of the organs of audition, as far as the labyrinth, which in Fig. 114, is marked, *v*, *s*, *k*, and is there drawn of the natural size. But in order to give any distinct conception of this part, it is necessary to represent it on a larger scale which is done by Fig. 116.

Fig. 116.



In this figure the labyrinth is detached from every other part, and separated from the solid bone in which it is embedded. It consists of a middle portion called the *vestibule*, *v*, from which, on its upper and posterior side, proceed, the three tubes, *x*, *y*, *z*, called from their shapes, the *semi-circular canals ;* while the lower side of the vestibule terminates in a spiral canal, resembling in appearance, or rather in form, the shell of a snail, *k*, and on that account is denominated the *cochlea*.

All these cavities are surrounded by solid bone, lined with a very delicate membrane called the *periosteum*, and are filled with a transparent, watery fluid, called the *perilymph*. The parts marked *a a*, are merely the swellings of the .semi-circular canals at their junction with the vestibule. Within the sac of t hevestibule at the point *o*, there are found two or three masses of chalky, or calcareous matter, suspended in the fluid by the intervention of some nervous filaments, proceeding from the auditory nerve. These exist in the Ears of all the mammalia, and therefore undoubtedly perform some important office, but of what kind is unknown. They are also found in aquatic animals, and of a larger size and greater hardness, than in others.

Where is the labyrinth of the ear situated? What part of the labyrinth is the vestibule? What are the semilunar canals? What part is denominated cocklea?

PHYSIOLOGY OF AUDITION IN MAN.

The uses of several parts of the complex apparatus above described, remain unknown. The following, however, appears to be the manner in which hearing is performed.

The sonorous vibrations being transmitted through the air to the external Ear, are collected by its sinuous canals, and directed through the auditory orifice to the Ear-drum, which is thereby made to vibrate. The action of the tympanum as a muscle is undoubtedly concerned in this effect, probably becoming more or less tense as the sound is less or more audible. The vibrations of the tympanum are communicated through the chain of bones to the fenistra ovalis, which being a membrane covering a part of the labyrinth, the motion is communicated to the fluid which the labyrinth contains. The undulations of the fluid thus excited, produce auditory impressions on the nerves of the ear, which are spread over the inside of the membrane lining the labyrinth, and by them are conveyed to the brain, thus giving the sensation called *sound.*

The tympanum undoubtedly becomes more tense, by the stimulus of sound, and hence in some persons, where this part is naturally lax, or has become so by disease, there is a difficulty of hearing low sounds, except when the drum is excited by louder ones. Thus we know a person who can distinguish ordinary conversation, when walking in the sound of the surf on the sea-shore, but who hears with much difficulty even a loud voice in a silent place.

With regard to the purposes which are answered by the semi-circular canals, and the cocklea, hardly any plausible conjectures can be offered; yet no doubt can be entertained of the importance of all these parts in audition; for, we find that when we are able fully to understand the uses of any piece of natural mechanism, every part in one way or another, serves to make the

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Are the uses of all the parts of the internal ear understood? What is the use of the external ear? What is the use of the tympanum? How does the tympanum probably act as a muscle? How are the vibrations of the ear-drum communicated to vestibule?

whole the more perfect, and we may presume therefore, that such is the case with respect to the ear.

It does not, however appear, that the preliminary steps with respect to the introduction of sonorous vibrations into the ear, as above described are necessary; nor that all the parts usually concerned in the process of hearing are required, since Sir Astley Cooper has recorded cases in which hearing remained perfect, after the tympanum was destroyed, and the little bones lost. More commonly, however, the loss of these parts produce total deafness for a time, after which, the power of hearing is often in a measure regained, and in some instances entirely. It is well known that a puncture through the ear-drum does not at all affect the power of that organ.

COMPARATIVE PHYSIOLOGY OF HEARING.

We have seen that the organs of Circulation, of Vision, and of Respiration, and Digestion all present the most simple structures in the lower orders of animals, and that all these organs increase in complexity, and perfection, as animals rise in the scale of capacity and power. The organs of Hearing follow the same law of gradation, the most complex being found in the higher orders of animals, of which we have an example in those of man. In the inferior races, Hearing is performed by means of a simple vestibule with its membranous sac, supplied with nervous filaments leading through the auditory nerve to the brain. This simple form is found in most aquatic animals, the sonorous undulations of the water, requiring neither tympanum nor bones, nor indeed any of the complex accessory parts found in the mammalia and man.

We have seen, that according to the experiment of Franklin, sound passes to a great distance through water without losing much of its intensity, and according to

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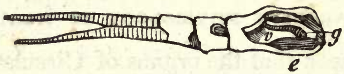
What effect does the destruction of the ear-drum have upon the hearing? What effect does the puncture of the ear-drum have upon the hearing? What is said of the continuation of the auditory organs in the lower and higher orders of animals? What does the organ of hearing in fishes consist of?

the experiments of others, its transmission through water is more than four times more rapid than it is through the air. These facts assist us in understanding why it is, that no part is required in aquatics, like the tympanum and little bones, to increase the sonorous undulations, and also why these organs in other respects, may be reduced to their utmost simplicity, since the water in which they live transmits sound with so little diminution of its intensity.

Hearing in the Lobster.—The simple auditory apparatus, as it is found in the Lobster, is represented by Fig. 117. It consists of a vestibular cavity at *v*, con-

Fig. 117.



taining a membranous sac *g*, which is furnished with the filaments of the auditory nerve. This vestibule is protected on all sides by solid matter, (as the same is by bone in the human ear,) except at one part, *e*, where it is closed by a membrane, like the fenestra ovalis, to which part therefore it corresponds. The water coming in contact with this membrane, the sound is transmitted through it, to the nerves of the vestibule and so to the brain.

The Mollusca appear to be entirely destitute of the sense of hearing, except perhaps in the highly organized Cephalopoda or Cuttle Fish tribe. In these, there exists a tubercle containing two membranous sacs, which correspond to the vestibules of other animals.

Hearing in the Frog.—In the Frog, the ear is entirely closed on the outside by a membrane, situated over a little cavity on each side of the head, but on a level

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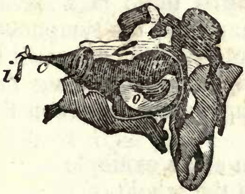
Why is it supposed unnecessary that the vibratory apparatus should exist in aquatics?

with the integuments. This membrane corresponds to the ear-drum of the Mammalia, the cavity within, containing air. From this cavity there proceeds an Eustachian tube; and from the external membrane to the vestibule there extends a small bone, shaped like a trumpet, and called the *columella*.

These parts are represented by Fig. 118; where *c*, is the columella of an elegant trumpet shape, having its base, *b*, attached to the fenestra ovalis of the vestibule, *v*, and which contains the chalky body, *o*. There is also a small bone, *i*, appended to the end or front of the columella, where this is attached to the external membrane, or ear-drum.

Fig. 118.



In the Frog, therefore, the sonorous undulations of the air, instead of passing through an aperture, as in man, strike the tympanum on the outside of the head, the vibrations of which, are communicated immediately to the fenestra ovalis of the vestibule, and through the auditory nerves spread over it, directly to the brain. In other amphibia these parts are essentially the same.

This mechanism is probably designed to enable the animal to hear both in air and water.

In the fishes there is no internal cavity containing air, as is also the case with the Lobster, the ear of which, as we have seen, is so contrived as to place the fenestra, or window of the vestibule, which contains the nerves of hearing, on the outside, so that the sonorous undulations of the water are communicated immediately to the auditory nerves.

In the Frog there is a communication from the external tympanum to the vestibule by a solid body, the operation of which, therefore, does not differ from that of the lobster; but in addition to this, there is a cavity

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What is said of the hearing of the mollusca? What description can you give of a frog's ears? By what mechanism is the frog fitted to hear both in the air and in water?

under the tympanum containing air; this part of the apparatus being obviously fitted for atmospheric hearing, as the other apparently is for aquatic hearing only.

What clear marks of design and what wonderful traces of wisdom and goodness is evinced in the adaptation of these parts to the wants and habits of these poor cold blooded animals! Truly, "an undevout naturalist must be mad."

Hearing in Birds.—In the Birds there is a cavity beyond the tympanum, as in man, and the tympanum itself, instead of being on the outside, lies concealed in a short tube, without any external ear, thus placing this class, in respect to the auditory apparatus, between the Amphibia and Quadrupeds.

The ear of man may be taken as an example of the interior structure of this organ in the whole of the other Mammalia. In Quadrupeds, the chief peculiarity in other respects is in the size and form of the external ear; and from a comparison of the relative size of this part in the various tribes, it has been inferred, that it bears a tolerably constant proportion to the degree of acuteness of hearing, and consequently that it contributes essentially to that faculty. Thus in the rabbit, where the cochlea is uncommonly long, and somewhat trumpet-shaped, the hearing is remarkably acute. In the dog and horse this part is well developed, and we accordingly find a corresponding acuteness of hearing.

In animals with long ears, there are muscles for the purpose of erecting or turning them towards the point whence the sound proceeds; and thus they have the effect of an ear trumpet, in concentrating the sonorous undulations, from whatever direction they come. Every one must have observed the employment of this faculty in the horse, which always turns his ear in the direction of the sound. Hence it is, that the leaders of coach horses turn their ears forward, while those

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What is said of the ears of birds? What is the construction of the internal ear of the mammalia? Is there any relation between the external ears of animals, and their sense of hearing? Do men ever possess the power of turning their ears?

behind them turn theirs backward. In a few instances, men, like quadrupeds, have had the power of turning their ears backwards, or forwards at pleasure.

MUSICAL EAR.

That learned anatomist, Sir Everard Home, considered the Ear-drum, with its radiated muscular fibres as a sort of monochord, or rather perhaps the string of the monochord, " of which the tensor muscles are the screw, giving the necessary tension to make the string perform its proper scale of vibrations, and the radiated muscle acting upon the membrane like the moveable bridge of the monochord, adjusting it to the vibrations required to be produced." The same philosopher says, " that the difference between a *musical Ear*, and one that is too imperfect to distinguish the different notes of music, will appear to arise entirely from the greater or less nicety with which the muscle of the malleus renders the membrane capable of being truly adjusted. If the tension is perfect, all the variations produced by the action of the radiated muscle will be equally correct, and the Ear truly musical."

This view of the subject would make a musical Ear, little more than a fine piece of mechanism, in which the mind has no participation. But we cannot believe that this is the true doctrine, for although some Quadrupeds, it is said, will listen to the strains of music, with seeming pleasure, yet it is most clearly through his *intellect* that man enjoys that high degree of gratification, which music is capable of conferring. It is therefore in the brain itself, that, what is called the "*musical Ear*" is situated, the mechanical apparatus of audition being in this respect, merely the instrument by which the sonorous undulations constituting melody are conveyed to the soul.

What was Sir E. Home's opinion with respect to the action of the ear-drum in forming a musical ear? Where is it said the musical ear is situated?

The charms of Music do not depend on the Tympanum.—That the charms of music do not always depend on the vibrations of the tympanum, is proved by the fact already noticed, that this part is sometimes entirely destroyed and still the power of hearing is retained.

The case alluded to, is detailed by Sir Astley Cooper in the Transactions of the Royal Society for 1801, of which we will here give a summary. The subject was a gentleman who stated to Sir Astley, that at the age of ten years, he was attacked with an inflammation and suppuration of the left ear, which continued to discharge matter for several weeks. In about a year afterwards the right ear was attacked with similar symptoms, and in consequence he became totally deaf, and remained so for three months. His hearing then began gradually to return, and in about ten months he was restored to the state in which Sir Astley found him.

The ear-drums were found to be totally destroyed, together with the little bones, which had escaped, with the matter during the suppuration. Hence there was a communication from the mouth, through the Eustachian tubes to the external orifice of the ear. This was shown by filling his mouth with air, closing the nostrils, and compressing the cheeks, when the air thus compressed was heard to rush out of the external orifice with a whirling sound, the hair on each side of the cheeks becoming agitated by the current. When a candle was applied, the flame was also agitated by the stream of air.

Sir Astley ascertained by minute examination, that not a vestige of the tympanum remained in the left ear, and that in the right, though there was a remnant of it, around the circumference, the centre was gone, leaving an aperture of a quarter of an inch in diameter. Yet this gentleman was not only capable of hearing every thing that was said in company, but was nicely susceptible to musical tones. He played well on the flute, and had frequently taken a part in concerts; he also sung with taste, and perfectly in tune.

How is it shown that the charms of music, or even common sounds do not depend on the vibrations of the tympanum?

Musical Ear situated in the Brain.—But if it be objected, that the above is a rare and extraordinary case, and tends to prove that the tympanum may be dispensed with, in ordinary hearing, as well as in the constitution of a musical ear; still setting this case aside, we find that those who have no ears for music, are equally, with the most enthusiastic amateurs, capable of distinguishing every kind of sound from the full peel of the organ to the evanescent tones of the Eolian harp. His sense of hearing, therefore is equally perfect, with that of a most skilful musician; and consequently there is every reason to believe that his mere physical organ is just as nicely constructed. Indeed there does not seem to be any relation between a musical ear and mere delicacy of hearing.

If these considerations be admitted, and it is believed no one will deny them, then we must admit also that the soul-stirring effects of harmony depend on the organization of the brain, and not on that of the ear. And this is the opinion of several recent physiologists of the first class. "Speech," says Broussais, "is heard, and repeated by all men, who are not deprived of their auditory sense, because they are all endowed with cerebral organization, fit to procure for them distinct ideas on the subject. Music when viewed as a mere noise, is also heard by every one; but it furnishes ideas sufficiently clear to be re-produced and communicated by those individuals only, whose frames are organized in a manner adapted to this kind of sensation."

Singular defects in certain Ears.—The late Dr. Wollaston in the Philosophical Transactions for 1820, describes several peculiarities in certain ears, which appear to have no defects in their organization, or capacity of receiving common sounds, not even in the perception of musical harmony, but are insensible to certain acute sounds. The writer himself found that his ear was insensible to any sound higher than six octaves above the middle E of the piano. In several other persons he found a similar insensibility to acute sounds of a certain kind. Thus some could not hear the chirp of a grass-hopper; others the sharp cry of a bat; and he refers to one who was insensible to the note of the sparrow.

ORGANS OF SMELL.

From nearly all bodies there escapes certain particles, which being carried along by the air, are taken into the nostrils where they excite the sensation which we call *odor*, or *smell.*

All bodies, the particles of which are fixed, are called *inodorous*, that is, they do not excite the sensation of smell.

Some bodies, it is well known, fill the air to great distances with their odoriferous particles, while in others, under ordinary circumstances there is no appreciable smell.

Every odoriferous body excites a sensation peculiar to itself, and hence has a peculiar odor.

We cannot describe an odor, except to persons who have themselves smelled that which we intend to describe; or something with which we can compare it. Thus, no one could have the least idea of the smell of camphor, or musk, who had not experienced it. The terms *aromatic*, or sweet, and rancid, or fetid, are general terms intended to include odors which are pleasant or disagreeable, and in these respects we are able to compare odors, so far as to specify what is agreeable and what not.

It is exceedingly difficult for us to conceive how matter, so rare, and minute, as must be the particles of some odoriferous bodies, can excite any sensation on the animal organs. Thus a single grain of musk will scent an apartment for years, and still not loose the least appreciable part of its weight, though tried by the nicest scales, and it is said, if a little of this drug be put into a

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How is it proved that the appreciation of harmony is owing to effect on the brain, and not merely on the ear? What peculiarities did Dr. Wollaston observe with respect to the sense of hearing? What excites the sense of smell? What bodies are inodorous? What is said of the description of odors?

gold snuff-box, for a short time, and then the box be cleansed with soap and water, still it will retain the odor of musk for years.

The sense of smell is conveyed to the brain by a pair of nerves, called the *olfactory*, which are spread on the sides of the nostrils.

Dr. Magendie says that the olfactory apparatus ought to be described as a sort of sieve, placed in the passage of the air, as it is introduced into the chest, and intended to stop every foreign body that may be mixed with the air, particularly the odors.

In all the terrestrial animals the cavity of the nostrils is divided into two parts by a vertical partition, the whole interior being lined by a soft membrane, called the *schneiderian* or *pituitary* membrane. This is constantly kept moist by glands which secrete a fluid for that purpose.

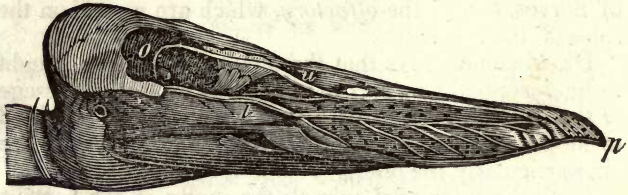
This membrane is well supplied with blood vessels, and with nerves from the olfactary pair. These nerves in carnivorous animals are much larger, than in those that live on vegetables.

In most animals the bony structure of this part of the skull is exceedingly intricate, and therefore cannot be described to the understandings of those who have no previous knowledge of anatomy. We must consequently refer those of our readers who wish to examine this point more particularly, to some treatise on that subject. The best way, however, is to take the head of some quadruped, and with a fine saw, divide the parts both transversely and longitudinally. Such an examination, assisted by a good description, will give the general student all the information he may want on this subject in a few hours.

Olfactory nerves of the Duck.—We give a single longitudinal figure on this subject, in which the olfactory nerves are peculiarly conspicuous, both from their size and mode of distribution. This is the upper mandible of a

Duck, Fig. 119, with the olfactories laid bare. They pass out of the orbit of the eye, *o*, in two large branches,

Fig. 119.



an upper one, *u*, and a lower one, *l*, the branches of each being spread over the contiguous parts, both within and without, being merely protected by the surface, except at the extremity of the beak, where there is a horny process, *p*, for this purpose.

Audubon's Experiments on the olfactory powers of Vultures.—It is the common opinion that vultures, and other birds of prey have the power of smell so acute that they can discover by this means, the effluvia of a carcass at great distances. But it now appears from the observations and experiments of that celebrated ornithologist, Mr. Audubon, that these birds in reality possess this sense in a degree far inferior to many of the carnivorous quadrupeds; and that so far from guiding them to their prey, at a great distance, it is hardly sufficient to indicate its presence when near at hand.

The following experiments appear satisfactory on this subject. Having procured the skin of a deer, Mr. Audubon stuffed it full of hay, and after the whole had become completely dry and hard, so as to emit no smell, he placed it in the middle of an open field, laying it on the back, in the posture of a dead animal. In the course of a few minutes he saw a vulture approaching for a feast; and quite unsuspicious of the deception, began the attack as usual, in the most vulnerable part. But finding nothing to his taste, it next, with much exertion tore open the seams of the skin, appearing earnestly intent on getting at the flesh, which he expected to find within, and of the absence of which, not one of his senses, it appears, was able to inform him.

Finding that his efforts after a long trial, led to no satisfactory results, and that nothing could be obtained but a bundle of hay, the bird took its flight in search of other game; "to which," says the observer, "he was led by sight alone, and which he was not long in finding."

Another experiment, the converse of this was next tried. A large dead hog was concealed in a narrow and winding ravine, about twenty feet deeper than the surface of the earth around it, and filled with briars and high canes. This was done in the month of July in a tropical climate, where decomposition took place rapidly. Yet although many vultures were seen, from time to time sailing in all directions over the spot, none ever discovered it; but in the mean time, several dogs had found their way to it, before which, it was fast disappearing.

In other experiments Mr. Audubon found that young vultures confined in a cage, never seemed to perceive that their food was near them, until it was seen.

It therefore appears that vultures are guided to their food by the acuteness of their visual, and not by their olfactory organs, as has heretofore been supposed.

The above results have been fully verrified by Mr. Bachman, and a detailed account thereof published in Loudon's Magazine of Natural History.

Organs of Smell in Fishes.—It has been doubted by some physiologists whether water is capable of conveying odoriferous particles, and consequently, whether fish had any use for olfactory organs. But almost every angler knows that at least, with some sorts of fish, he has much better luck when his bait is scented with some strong odoriferous drugs, as assafœtida, musk, or camphor. It is well known, indeed, both by other experiments, as well as by dissection, that fishes are endowed with organs of smell.

What were the results of Audubon's experiments on the smell of vultures? What is said of the organs of smell in fishes?

ORGANS OF TASTE.

It is well known that the tongue is the principal organ of taste; though the lips, the palate, the internal surfaces of the cheeks, and the upper part of the esophagus, all participate in this favorite sense.

The organs of this sense are much the most abundant on the tongue, where they may be seen, especially towards the end, in the form of *papillæ*, or minute elevated protuberances.

If these be touched with a fluid, that is strong to the taste, such as vinegar, they will be seen to rise by the stimulus, an effect which probably accompanies the sensation of taste at all times.

The *lingual* nerve, or nerve of the tongue, is that which is chiefly concerned in conveying the sense of taste to the brain. But Magendie says, that after the most careful examination of this part by dissection, assisted by the most delicate instruments, he was unable to trace these nerves to the papillæ. Still the sense of taste must be attributed to the filaments of this nerve.

The primary use of taste is to guide animals in the selection of their food, and warn them against the introduction of noxious articles into the stomach.

In all the inferior animals, this sense, together with that of smell, is generally a sufficient guard against the use of noxious food. In these, therefore, the original design of taste is still answered. But in man, this sense has been so abused and perverted, by the introduction of stimulants, and the endless admixture of different articles of food, that the simple action of this part, seems to have been superseded almost entirely by acquired taste. Hence man, in his present state of civilization, and luxuriousness, has no sense by which he can determine with any degree of certainty, what is wholesome and what is poisonous. In the savage state, the sense of taste and

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What part of insects constitutes the organ of smell? Where is the organ of taste situated? What is the primary use of taste? In what animals is this design still answered? What is said of the power of man to detect poisonous articles by the taste?

smell are much less vitiated, than in civilized man; and hence the men of the forest, it is said, are guided, in a considerable degree by these senses, in the choice of their food, especially in times of scarcity, when they are obliged to roam in search of new articles.

ORGANS OF TOUCH.

By the sense of *touch* we are enabled to know the external properties of bodies.

Physiologists make a distinction between *tact* and *touch.* Tact, with some few exceptions, is generally diffused through all our organs, and particularly over the skin. It exists in all animals, while touch exists chiefly in the fingers of man, in the *antennæ* of insects, and in the noses of certain quadrupeds.

In the exercise of these functions, tact is considered passive, as when any part of the system comes into contact with another body, a sensation of its presence is given, without the exercise of volition. On the contrary *touch* is active, and is exercised voluntarily for the purpose of conveying to the mind a knowledge of the qualities, or properties of the surfaces of bodies; as when we feel a piece of cloth to ascertain its quality, or a polished surface to prove its smoothness.

Anatomy of the Skin.—The sensation of tact, and touch is conveyed to the brain by means of nerves situated in the skin.

The *skin* consists of three parts called the *cuticle,* or *epidermis;* the *rete mucosum;* and the *corium,* or *cutis vera,* or true skin.

The *cuticle* is the external layer. In its structure it is membranous and dry, having neither nerves, veins, nor arteries. It has therefore no sensation, its office being merely to protect the true skin from external injury. The cuticle is that thin membrane which is raised by a

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What is the difference between touch and tact? In the exercise of these functions which is active and which passive? How are these sensations conveyed to the brain? What parts compose the skin, and what their names? What is the cuticle and where is it situated? What is the use of the cuticle?

blister, and which when removed, leaves the true skin exposed. The pain consequent upon such exposure, is the best test of the importance of the office which this membrane performs. It is full of minute pores, through which the perspiration escapes.

The next layer of the skin is the *rete mucosum*, or mucous web. It is in this that the coloring matter of the different races of men exists. In the African, it is black, in the American and European, white, and in American Indians, copper colored.

The *corium*, or true skin, lies next. This consists of a tissue of dense fibres intersecting each other in all directions, the nerves and blood vessels, passing between them. It is a thick and firm covering for the protection of the flesh, and the larger nerves, and blood vessels, some of which are immediately under it.

The composition of the true skin is chiefly gelatine, and hence it is used in the manufacture of *glue*, and the substance called *sizing*, used by paper-makers. When this gelatine is hardened by tanning, the skin becomes *leather*, and is used for shoes and boots. In addition to these, there is the *corpus papillaræ*, which may be considered as a part of the true skin, being formed by the extremities of the nerves and vessels, which have passed through that part. These are little protuberances, and are seen distinctly in the true skin, after the cuticle has been removed by a blister. When the parts are relaxed, they are not so apparent, but become erect, rising a little above the surface, when the skin is stimulated, or touched.

It appears to be in these papillæ that the sense of touch resides, these being furnished with nerves appropriated to this particular sensation. In most cases the ends of the fingers, but sometimes the lips, are employed to convey information by the touch.

In what part of the skin do the colors of the different races lie? What is the corium, and where is it situated? Where is the sense of touch situated?

PART VI.

MENTAL AND PHYSICAL EXERCISE.

THE BRAIN.

Preparatory to treating of the Sensorial Functions, we gave a summary account of the nervous system, as it exists in various animals, with a figure of the ganglion; reserving more particular descriptions of the brain and its functions as they are found, in the human species, for the purpose of connecting them with observations on Physical and Mental Exercise.

Size of the Brain.—Aristotle and Pliny both assert that the brain of man is, not only comparatively, but absolutely larger than that of any other animal. At the present time, only two exceptions to this assertion are known. The brain of the Whale, and that of the Elephant are larger in bulk than that of the human species. Comparatively, however, the human brain is much larger than that of any other known animal. By analogy, therefore, we might infer that in man, the largest development of this organ, would, other circumstances being equal, insure the most capacious intellect, and perhaps this may be considered as generally true. Says Magendie, "the volume of the brain, is generally in

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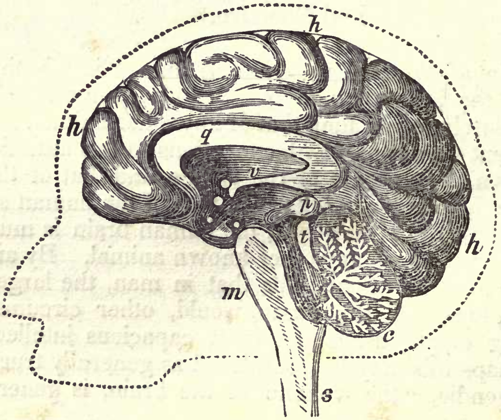
What is said of the absolute size of the human brain? What is said of the comparative size of this organ in man?

direct proportion to the capacity of the mind." "We ought not to suppose, however, that every man having a large head is necessarily a person of superior intelligence, for there are many causes of an augmentation of the volume of the head beside the size of the brain; but it is rarely found that a man distinguished by his mental faculties has not a large head. The only way of estimating the volume of the brain in a living person, is to measure the dimensions of the skull. Every other means, even that proposed by *Camper* is uncertain."

Dimensions of the Brain—The whole substance of the brain, and spinal marrow, are continuous, forming but a single piece. But the different parts of this organ are supposed to perform different functions, and they present also a variety of appearances, and hence have received different names.

That portion of the brain which fills the upper part of the skull and extends from the orbit of the eye, to the most prominent parts of the hind head is called the *cerebrum*, or encephalon.

Fig. 120.



Is there any proportion between the size of the brain and the intellect?

This is divided into two equal parts, longitudinally, called the right and left *hemispheres* of the brain *h h h*, Fig. 120, which represents the right hemisphere. The *medulla oblongata*, *m*, or oblong marrow, is that portion of the spinal chord which is contained within the skull. Its continuation downwards, *s*, is called the *medulla spinalis*, or spinal marrow. The part *c*, is the *cerebellum*, or little brain, so called to distinguish it from the cerebrum, above described. The tree-like figure, shown by dividing it through the centre is called the *abor vitæ*, or tree of life. The *corpus callosum*, or hard body, *q*, is a white medullary part, which joins the two hemispheres together; *v*, marks one of the *lateral ventricles* of the brain. The *pineal gland p*, was supposed by Des Cartes to be the seat of the soul.

It is not within the scope of this work to enter into a minute description of the different parts of the brain; our object being to give a general, rather than a particular account of its structure and functions.

All the nerves are considered as originating either directly or indirectly from the medullary substance, that is, from the medulla oblongata, or the spinal chord. Those which pass through the bones of the skull, are however, called *cerebral* nerves, while those which arise from the spinal marrow are called *spinal* nerves. Among the first are the optic and olfactory nerves.

The brain receives a larger quantity of blood than any other organ of the same size. The arteries for this purpose, are four in number, and are supposed to convey to the brain an eighth part of all the blood which flows from the heart.

PHRENOLOGY.

Physiologists have been at great pains to ascertain what parts of the brain are the particular instruments of

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What part of the brain is the cerebrum? What are the hemispheres of the brain? What is the medulla oblongata? What does the continution of this part form? What is the situation of the cerebellum? From what parts do the nerves arise? What is said of the quantity of blood sent to the brain?

the different functions of life, as those of sensation, of intellect, of voluntary motion, and of the passions. But aside from the more recent investigations of Phrenologists, and the light which that science has been supposed to have thrown upon this most difficult of subjects, it must be confessed that these attempts have not been crowned with much success. All that experiments and observations appear heretofore to have determined on this point, is, that the hemispheres of the brain are the instruments of the intellectual faculties; the central parts of the brain, and the medulla oblongata, are those principally concerned in sensation, and that the cerebellum is the chief sensorial agent in voluntary motion.

Phrenology wants more facts.—With respect to the foundation of Phrenology, as being based upon the anatomical structure, and natural divisions of the brain, the author of this work has nothing to offer, having had no recent opportunities of examining that organ with such views. Nor will he venture to affirm that this science will not ultimately be, in one way, or another, of some use to mankind. But he must be allowed to say, that so far as the principles of this science have yet been developed, its practical usefulness in directing parents to educate, or employ their children according to their different capacities, or inclinations; or of enabling them to counteract their evil propensities; or even of pointing out with any degree of certainty the peculiar intellectual powers of an adult, by an examination of the cranium, Phrenology has not, at least, in this country answered the former promises and expectations of its advocates. It is true, that George Combe, Esq., of Edinburgh, and others, have collected together many facts on this subject, and from which it would appear that this science might, with certain modifications be ultimately placed on a permanent foundation. But a multitude of facts, and severe critical observations, are still wanting, to induce the great mass of well-educated

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What part of the brain is the instrument of the intellectual faculties? What part of the brain is chiefly concerned in sensation? What part is the agent of voluntary motion?

people to form their opinions on a matter which is held out to them to be of such high importance; and more still, to induce them to trust to its guidance, the education of their children, or any of the important concerns of life.

Mr. Roget's opinion.—But without making further observations of our own, we will merely cite the opinions of two or three individuals, which have been formed with a knowledge of the facts, and whose decisions are not of less weight than those of any cotemporary writers.

"Although," says Mr. Roget, "the brain is constructed with evident design, and composed of a number of curiously wrought parts, we are utterly unable to penetrate the intention with which they are formed, or to perceive the slightest correspondence which their configuration can have with the functions they respectively perform. The map of regions which modern Physiologists have traced on the surface of the head, and which they suppose to have relation to different faculties, and propensities, does not agree either with the natural divisions of the brain, nor with the metaphysical classification of mental phenomena."*

Dr. Bostock's sentiments.—"The view," says Dr. Bostock, "which I have taken of the connection that subsists between the physical structure of the nervous system, and the mental faculties, naturally brings me to a subject, which has of late attracted a considerable degree of attention among anatomists and physiologists, viz. the dependence of the character and disposition upon the peculiar shape and organization of the brain. Certain facts, which seemed to favor this opinion, had long been noticed; persons of observation were in the habit of associating the idea of superior intellect with a capacious and prominent forehead, while the contrary form was equally conceived to indicate a deficiency of

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* *Animal and Vegetable Physiology*, Bridgwater Treatise. Vol. ii. p. 565. London, 1835.

It is proper to remark, that Dr. Roget, is the author of the Article "Cranioscopy" in the Encyclopedia Brittanica, and therefore has not given this opinion, without knowledge.

mental powers. * * * When the sculptors of antiquity formed the statues of their gods, or heroes, to which they were desirous of imparting the character of high intelligence, they endeavored to accomplish this by giving a peculiar form to the head." * *

"The arguments which have been urged in favor of the science of Cranioscopy,"* continues Dr. Bostock, "are partly anatomical and partly physological. In the first place, it is said that the brain exhibits a very elaborate structure, and a very complicated organization, and it is therefore reasonable to conclude, that its different parts must be subservient to the exercise of different functions."

"Secondly, both metaphysicians and physiologists have been in the habit of referring all the impressions which we receive through the intervention of the nerves to some central part of the brain, but the great diversity of opinion which exists respecting the part which ought to be regarded as this common centre, affords us at least a strong presumption of its non-existence, while on the contrary, if we suppose that there actually is such a central spot, we are at a loss to assign any use to the remainder of the brain."

"Thirdly, we are in possession of a number of observations upon the partial loss of the mental faculties, in consequence of disease or injury of the brain, and although we are not able to trace out the connection between the situation of the injury received, and the defect of the mental powers, yet it favors the opinion that these faculties are distributed over the different parts of which, the brain is constituted.

"Fourthly, the analogy of the nerves that are connected with the external organs of sense is adduced by the cranioscopists in favor of their doctrine. Each of these nerves, in conveying their respective impressions, must exercise a different office, and in the same way, the different convolutions of the brain are supposed to be the organs of the respective mental functions.

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* Dr. Bostock remarks, that this being the term originally employed, and being much more appropriate, than Phrenology, he continues to use it.

"Fifthly, it is argued that the state of the brain in regard to its perfection, and full development, corresponds to the state of the mental faculties at the different periods of life, and also to their degree of perfection among the inferior animals, so as to indicate a necessary connection between these circumstances.

"Sixthly, the brains of different individuals actually differ in the proportionate form and size of their parts, and it is therefore reasonable to presume, that this may be the cause of the difference which is admitted to exist in the faculties of different individuals.

"Seventhly, the exercise of the mental powers, like those of the physical functions is attended with fatigue; but it is found by experience, that the fatigue only extends to that particular power which has been exercised: it may, therefore, be presumed that its action is confined to a certain portion of the brain only.

"Eigthly, proceeding upon the principle, that the dispositions, and mental faculties are, to a certain extent, innate, and observing that they exist in different individuals in different proportions, it follows that they must be attached to different organs.

"The above," says Dr. Bostock, "appears to me to exhibit a fair statement of the nature of the arguments which have been employed, to prove the antecedent probability of the doctrine of cranioscopy. But its advocates are aware that its merits must principally rest upon the degree in which it is found to correspond with well ascertained facts, and correct observation, and with the power which it actually affords us of acquiring a knowledge of the character and disposition of individuals, by an examination of the skull. It is, therefore, by an appeal to experience, that the supporters of cranioscopy, and Dr. Spurzheim in particular, attempt to establish their opinion, and they have accordingly brought forward a number of facts of this description, which are supposed to form a sufficiently firm basis for their system. They consist of the results which were obtained by examining the heads of various individuals of all ages, ranks, and conditions, minutely noticing the deviations from average form, especially with regard to the size and situation of the eminences, or protuberances which they exhibited. The examination has also been extended to the inferior animals, and the same principles have been applied to their skulls, both as to what respects their general form, and the proportionate size of their individual parts, whether indicating a generic, or an individual difference.

"In estimating the value of these arguments, I shall arrange them in two divisions, as they relate to general considerations of probability, or as they depend more upon particular facts.

"And with respect to the first point, I think it will be admitted that there is none of them which possesses more than an indirect application to the question in discussion. Admitting that the perfect organization of the brain is a necessary intermedium for the exercise of the mental powers, we may conclude, that every part of this organ must have a necessary connection with the exercise of these powers, as every part of the eye and the ear has a reference to the production of vision and of sound. In consequence of our knowledge of the physical laws of light, and the undulations of the air, we are enabled to trace out the mode in which the several parts of the eye, and of the ear co-operate to produce the ultimate effect. Had we the same knowledge of the mode in which the mind operates upon the brain, we should probably have it in our power to detect the same kind of co-operation of all its parts and structures to the production of perception and thought. But on this point we are in total ignorance, and therefore, although we may go so far as to assert, that a perfect brain, in a certain sense, is essential to a perfect mind, we are unable to say in what way it is so.

"The only anatomical argument which is of so tangible a nature as to allow of any thing approaching to direct deduction, is derived from a consideration of the degree in which an injury of the brain produces a corresponding injury of the mental powers. Upon this point I have already stated my opinion. and I have only to add, that while the connection is not of that nature which indicates the relation of cause and effect, so I should be still less disposed to allow, that the facts which we possess are of that distinct and direct nature, which can enable us to connect particular injuries of the brain with corresponding injuries of particular faculties.

"The position that the size of an organ is an indication of the degree of its power, or capacity, a position which may be regarded as almost the fundamental principle on which the whole doctrine rests, is in direct contradiction to fact. To revert to the case of the eye; it may be asserted that this perfection of this organ, either when considered with respect to the different species of animals, or to the different individuals of the same species, does not bear the least relation to its size, but depends entirely upon the nature of its organization, and, except in those cases where the exercise of an organ is connected with mechanical force, as in muscular contraction, bulk has no relation to the perfection of a part. * * * *

"And even were it proved, as a general principle that distinct parts of the brain were appropriated to distinct mental functions, we may still be permitted to doubt whether the cranioscopists have been fortunate in their division and appropriation of the functions which are supposed to possess these distinct localities. If we consider the subject theoretically, we might presume, that there would be a separate organ corresponding to each of the external senses, as the impressions are themselves distinct in their nature, and might be supposed to require some different modification of the nervous matter for their perception. And again, with respect to the intellectual powers, there are some which appear so distinct from the others, that we might apply to them the same mode of reasoning, and suppose it probable that they might possess their appropriate organs. The faculty of memory might be supposed to require a different modification of the nervous power from that of the imagination; and this again from that of abstraction or volition. But we do not observe any classification or division of this kind in the faculties that are enumerated by Dr. Spurzheim, or his disciples. Some of them are complex feelings, resulting from the union of primary perceptions with ideas; others appear to be a combination of ideas only; some may be regarded as the obvious result of association, and others again as the effect of association operating through the intervention of education, or of the accidental circumstances in which the individual has been placed.

" And with respect to what may be regarded as the practical application of the art, or science of cranioscopy; it may be objected, that the convolutions of the cerebrum are not what one should expect to be the seat of the ultimate operations of the organ. They are not the part in which we behold that elaborate and complicated structure, the existence of which has been supposed to form so powerful an argument in favor of the doctrine, while this view of the subject still leaves unexplained the uses of the more minutely organized parts, that are situated in the interior of the brain."

Dr. Bostock further remarks, that the question whether this science has any foundation or not, must be decided by an appeal to facts. "These facts are of two kinds, almost exactly coinciding in their object. We must obtain skulls that are marked by some peculiarity of form and shape, and must then endeavor to learn what was the natural character of the subject; or we must take the cases of those who have shown some decided peculiarity of disposition and character, and examine the figure of their skulls. A sufficient number of these observations, carefully made and impartially recorded, cannot fail to decide the question, whether there be any ground for the doctrine of the appropriation of the different parts of the brain to distinct faculties; and more particularly, whether we have it in our power to ascertain their seat by an external examination of the cranium. On this point, I must give it as the conviction of my mind, that the facts hitherto adduced, are altogether inadequate to the end proposed; that they are frequently of doubtful authority, and of incorrect application; and that nothing but the love of novelty, and the eagerness with which the mind embraces whatsoever promises to open a new avenue to the acquisition of knowledge, could have led men of talents and information to place any confidence in them."*

* An Elementary System of Physiology, by John Bostock, M. D., F. R. S., L. S. G. S. H. S. M. R. I., London, Vol. III., p. 264—5—6.

We have added this long extract from one of the highest physiological authorities of the age, to that of Dr. Roget, for the purpose of showing those into whose hands this volume may happen to fall, that there is still a doubt among the most competent judges in Europe, not only whether Phrenology is likely to be of any practical utility to man, but even whether it has any foundation in nature. At the same time, as it is acknowledged by the advocates of its doctrines themselves, that it must stand or fall on the facts which can be adduced for, or against it, we can see no objection to their accumulation, provided in the mean time, the public curiosity can be so suspended as to prevent the waste of too much time in studying it, or the adoption of a system, which does not at present appear to be of any great practical use to the rising generation, whatever it may ultimately become.

Double Organs of the Mammalia.—In man, as well as in all the other vertebrated animals, every organ subservient to the sensorial functions, and most of those concerned in voluntary action, are double; that is, there is a symmetrical organ on each side, whose powers and functions are exactly alike. Thus we have two eyes, two ears, two arms, two legs, &c. The same law holds with respect to the brain, this part, as we have shown, being divided into two equal parts, called the right and left hemispheres; so that in fact, we have two brains, and a double set of nerves, as well as double eyes and ears.

In the sensorial functions these two parts constitute, in action, only a single organ of sensation; thus the action of the two eyes convey to the mind only a single impression, and of the two ears only a single sound. This effect is produced by a free communication which exists between the two divisions of the brain, by means of medullary substances, called the *commissures* of the brain, and which pass directly from one hemisphere to the other. The principal commissure is the *corpus callosum*, shown at *g*, Fig. 120. In the functions of most of the

What is said of the double organs of the sensorial, and muscular powers? In sensorial action is the effect double or single?

voluntary powers, no necessary use appears to be made of this communication; since we can employ the muscles of one side, without the necessary action of those of the other, or we can use them both at the same time. Thus we can throw up one hand, or both, at the same instant.

Insensibility of the Brain.—The brain, as we have seen, is the source of every sensation; the common sensorium through which we derive every pleasure, and feel every pain. And yet this wonderful organ, so sensible to mechanical impressions that a little blow, even through the bones of the skull, will often produce instant death, is itself entirely insensible! "That part of the brain," says Sir Charles Bell, "which if disturbed or diseased, takes away consciousness, is as insensible as the leather of our shoe!" It may be touched, or a portion of it torn off without sensation, and yet, to its proper office, it is exquisitely sensible.

OF THE MUSCLES.

We have designedly omitted to treat of the muscles, until we came to that part of our work, where they could with propriety be described in connection with an account of their functions, the exercise of which is one of the principal means by which we are to continue in the enjoyment of health, both corporeal and mental.

The muscles are the red fibrous parts of animals, which are situated immediately under the skin. They constitute all those parts commonly called *flesh.* Their number in the human body is about 400. They consist of distinct portions, or separate bundles of fibres, which are susceptible of contraction and relaxation, at the will of the animal; for which reason they are called *voluntary* muscles, in order to distinguish them from the heart, and other muscular parts over which the will has no control. Every muscle of course, is furnished with its appropriate set of nerves.

What are the muscles? What do they constitute? What do the muscles consist of? Why are they called voluntary muscles?

Each muscle is distinguished into three parts, called the *origin*, *venter* or swell, and the *insertion* or termination.

The *origin* is that part by which the muscle is attached at its upper end; the *swell* is the thickest or most conspicuous part, and that which makes up the chief bulk of the whole; the *insertion* is the smaller, or tendinous part, being that by which it is attached at the end opposite to the insertion.

These three parts are shown by Fig. 121, of which *a* is the origin, *b* the swell, and *c* the tendinous insertion. The *tendons*, in which most of the muscles end, are strong, white glistening cords, known in the feet of animals under the name of *sinews*. The tendon in which the muscles of the leg terminate, and which is fastened to the bone of the heel, is a good example of this part of the human frame. It is called the *Tendo Achilles*, and is said to have been so named, because as fable reports, Thetis, the mother of Achilles, held him by this part when she dipped him into the river Styx, to make him invulnerable. Hence that famous hero was said to be proof against all weapons, except in the right heel.

Fig. 121.

Names of the Muscles.—Every part of the human body which we call *fleshy*, is covered with muscles, some parts having several layers, one over the other. They all have distinct names by which they are discriminated by anatomical writers. Most of these names are derived from those of the parts where they are situated.—Thus the muscles of the breast are called the *pectoral* muscles, from *pectus*, the breast; and those extending from the shoulder to the elbow, are called the *brachial* muscles, from *brachium*, the arm. Some are however named from their shapes, as *long*, *broad*, or *triangular*.

What are the three parts into which a muscle is distinguished? What are tendons? What are the names of the muscles generally derived from?

The action of the muscles depend upon the Brain.—We have said that the muscles have the power of contraction, and relaxation, at the will of the animal. We can by no means trace the connection between the action of the brain in willing, and the action of the muscle in contracting. We know that if all nervous communication between the brain and the muscle be cut off, there will no effect be produced by the action of the brain; that is, we may will to raise the arm, but the muscles remain inactive, without the intervention of the nerves. This proves that the nerves, in some way, transmit to the muscles the mandate of the brain; but how this is done, is a mystery which has never been solved, and most probably will always remain beyond the limits of human knowledge.

Muscular contraction.—When a muscle contracts, the swell becomes enlarged or thickened, and the two ends approach each other. By grasping the thick part of the arm, above the elbow, and bringing the hand towards the mouth, the bulk of the part grasped, will be felt to enlarge, and grow hard, as though it actually contained more matter than before the contraction.

In this act, the absolute bulk of the muscle is however supposed not to change, though its shape is considerably modified, a part of the bulk towards the extremities, being thrown into the centre; hence the increased hardness, and swelling of this part. The contraction of the muscle appears to consist in the shortening of all the fibres individually, by which, the whole bundle is diminished in length. On the contrary, relaxation appears to be simply the want of contraction, or a passive state in which the muscle ceases to act.

During sleep all the muscles are in a relaxed and passive state, but when awake we can take no position, except the recumbent one, in which, more or less of the organs are not in an active state. In the standing pos-

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Can we trace any connection between the action of the brain in swelling, and the action of the muscle in contracting? When a muscle contracts, how is its shape altered? In what does the contraction of a muscle consist? In what does relaxation consist?

ture, the muscles of the lower limbs and back are perpetually active, in order to keep the upright position; for the instant they are relaxed, as from faintness, or a fit, we fall to the ground.

Use of the Muscles.—Some of the uses of the muscles are obvious, from what has just been said. They are also the grand organs of motion, by which the system is moved from one place to another, constituting the instruments of locomotion. It is by the muscles, indeed that all the motions of the body, whether general, or local are performed: not a finger moves ever so slightly without the contraction of some fibres; nor is a word spoken, or any sound of the voice heard without a similar motion of the muscles. Even the act of respiration is carried on by these moving powers, and therefore life cannot be sustained, even for a moment without their action.

Mechanism of the Muscles.—In the muscles concerned in locomotion, and in the other voluntary motions of the body, the rise or origin of the muscle is from one bone, and the insertion into another, the thick part being between these two points, and the motion is performed by the intervention of a joint.

The bones, must therefore, be considered as levers, acted upon by the muscles; the part where the tendon is inserted representing the power; the joint itself the fulcrum, and the part that is moved constituting the weight.

Levers are divided into three kinds according to the relative position of their three essential parts, the *weight*, the *power*, and the *fulcrum*. In the first kind, the fulcrum is between the weight and the power, or moving cause; in the second, the fulcrum is at the end of the lever, the weight being between it and the power; in the third, the power is in the centre, between the weight and fulcrum.

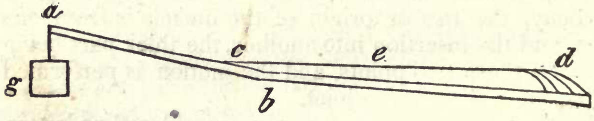
When are all the muscles relaxed? What are the uses of the muscles? Considering the bones and muscles in a mechanical relation, what part is the lever? What part the power? What the fulcrum? What the weight? How do the three kinds of levers differ from each other?

So far as mechanical advantage is concerned the last is by far the less effective, and it is the application of this principle by which the levers are moved by the muscles. We shall see however, that it is not mechanical power alone which is created in the construction of the limbs, and that all the circumstances considered, this is the only kind of lever which could be employed consistently with the perfection of our organs of motion.

Muscular action of the Arm and Hand.—The motion of the fore arm may be taken as an example of the effect of muscular contraction, and the manner in which it is produced in the animal system. When we raise a weight by bending the elbow joint, this is effected by muscles situated below the shoulder with the tendons inserted into the upper sides of the bones of the fore arm just below the joint.

Let *a b*, Fig. 122, represent the bones of the fore arm, *b d*, the bone of the arm, *d* the muscle, *e* the tendon, *c*

Fig. 122.



the insertion of the tendon into the radius, and *b* the elbow joint. It is plain that the contraction of the muscle, makes *c* approach towards *d*, which, as *d* is a fixed point is effected by bending the joint *b*, raising up the point *c*, and thus giving great velocity of motion to *a*, and the weight attached to it.

"The consideration of the manner in which the muscle acts in this case, proves that the mechanism of the animal body is calculated to produce a great loss of absolute power. It is an established position in mechanics, that in the action of levers, the power is to the weight as the distance between the weight and the ful-

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What kind is applicable to the bones? Explain Fig. 122, and show why much mechanical force is lost in that arrangement? Why is muscular power thus sacrificed?

crum, is to the distance between the power and fulcrum. In the present case, therefore, the power of the muscle is to the effect produced by it, as *a b* is to *c b;* and supposing *c b* to be one twentieth of the length of *a b*, then one twentieth only of the power of the muscle is exerted in raising the weight, the rest being expended in acting against the disadvantage of the position."*

We shall, however, find that it is a general fact, or law of the animal economy, that muscular power is always sacrificed to convenience. Had the object been to raise the weight with the least possible power, the muscle would have been placed on the fore arm, and the tendon inserted into the lower part of the arm bone, but in this case the awkwardness of the limb would have much more than counterbalanced the supposed advantage of saving the muscular power. This remark applies with still greater force to the fingers, which are now moved by the contraction of muscles placed on the fore arm, and from which small delicate tendons proceed along both sides of the hand, to be inserted into the several ranks of bones. Now had this order been reversed, and the muscles placed on the fingers, by which the greatest mechanical advantage would have been gained, the consequences would have been, a hand so clumsy as to have been nearly useless, and not only so, it would have been, when compared with its present delicate and beautiful form, an absolute deformity.

Motions of the Radius and Ulna.—Besides the leverage motions of the fore arm above described, the two bones composing it, called the *radius* and *ulna*, have movements peculiar to themselves.

In Fig. 123, *a* is the radius, and *b* the ulna, both of which are articulated to the humerus, as formerly shown in Fig. 65.

Suppose the muscle of the hand had been so placed as to have given that organ the greatest mechanical power what would have been the result in its form and usefulness?

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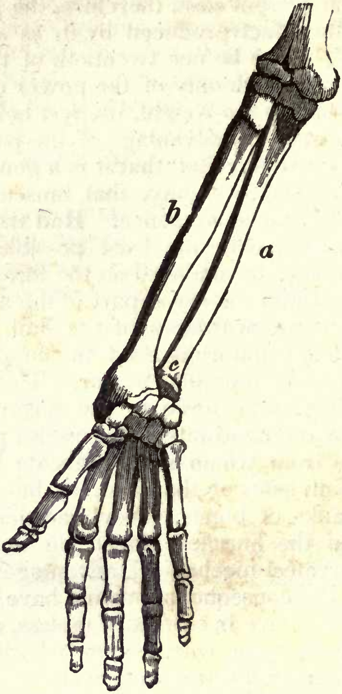
* Bostock's Physiology, vol. i. p. 186.

Fig. 123.



The easy motions of the hand, which might be supposed to belong to the wrist, are in a great proportion owing to the motions of the radius and ulna. The up and down action of the hand, when the lower ends of these bones are still, belong to the wrist, which is composed of eight bones; but the rolling motions of the hand, by which, the palm is alternately turned up and down, are caused entirely by the slight movements of the radius on the ulna. The ulna projects beyond the head of the humerus, forming, when the arm is bent, the point of the elbow. The radius has a small round

When the palm is turned up and down, what bones are concerned in the motion?

head on which it turns, without any motion of the humerus; and as the bones of the wrist are attached to the lower end of this bone alone, and not to the ulna, *c*, when the radius revolves, the whole hand turns with it. This alternate rolling motion is called *pronation* and *supination*.

Motions of the Fingers.—The motions of the fingers do not merely result from the actions of the large muscles, which lie on the fore arm, these being concerned more especially in the stronger actions of the hand.

The finer and more delicate motions of the fingers are performed by small muscles, situated in the palm, and between the bones of the hand, and by which the fingers are expanded, and moved in all directions with wonderful quickness.

These are the organs which give the hand the power of performing all its nicest motions, and by which we are enabled to execute our finest works; such as engraving, writing, sewing, and painting; in all these cases the motions are directed by the will, while the instrument is guided by the eye.

The Thumb.—The *thumb* is the antagonist to the fingers. On the length, strength, free lateral motion, and perfect mobility of the thumb, depend the power of the human hand. Without the fleshy ball of the thumb the power of the fingers would avail nothing; and accordingly, the large ball, formed by the muscles of the thumb, is the distinguishing character of the human hand and especially that of an expert workman.*

The Fingers of different lengths.—Although the fingers are of different lengths, yet when they are doubled into the palm, their ends become parallel. This is owing to their difference of length being chiefly in the

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To what bone is the wrist attached? By what organs are the finer and more delicate motions of the hand performed? What is said of the importance of the thumb to the perfection of the hand?

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* Bell on the hand.

first rank of bones; in consequence of which, the middle joint is carried a proportionate distance from the palm, so that in doubling each point comes to the same line.

This difference in the length of the fingers, though we are seldom aware of it, serves to adapt the hand to a great variety of uses, which would have been awkwardly performed had they all been of the same length. In writing, for instance, did the little finger project an inch and a half beyond its present place, how awkwardly should we perform. In grasping any small article with the whole hand, a similar awkwardness and difficulty would be experienced.

"Nothing," says Sir Charles Bell, "is more remarkable, as forming a part of the prospective design to prepare an instrument fitted for the various uses of the human hand, than the manner in which the delicate and moving apparatus of the palm and fingers is guarded. The power with which the hand grasps, as when a sailor lays hold to raise his body in the riging, would be too great for the texture of mere tendons, nerves, and vessels; they would be crushed, were not every part that bears the pressure, defended with a cushion of fat, as elastic as that which we have described in the foot of the horse and camel. To add to this purely passive defence, there is a muscle which runs across the palm, and more especially supports the cushion on its inner edge. It is this muscle which, raising the edge of the palm, adapts it to lave water, forming the cup of Diogenes." Thus does anatomy prove that the human hand was designed for laborious employments.

Says Ray, "Some animals have horns, some have hoofs, some teeth, some talons, some claws, some spurs and beaks;—man hath none of all these, but is weak and feeble, and sent unarmed into the world—but a hand with reason to use it, supplies the place of all these."

Thus we see that the "lord of the creation," through

What is said of the different lengths of the fingers in making the hand a perfect instrument? What prevents the nerves and tendons from injury when we grasp firm a hard body, as when a sailor climbs a rope?

the special benificence of his Divine Maker, has not only been endowed with the attributes of reason, judgment, and discretion, but has also been given the most perfect of all mechanical instruments, by which to carry into effect the plans which his intellect might suggest. No created being, except man, can with any instrument furnished him by nature do so much as to draw a pair of parallel lines, or even a single straight line. But man by the exercise of his reason, assisted by his hands, builds palaces, erects monuments, constructs ships, and with the same instruments manufactures watches; and with still more delicate touches, imitates nature herself with such art, as almost to appear the author of a new creation.

All these powers, so far from fostering the pride and self-sufficiency of man, ought to be a reason why he should render to the Giver of such endowments, perpetual obedience, thanksgiving, and praise.

CONNECTION BETWEEN THE NERVOUS AND MUSCULAR SYSTEMS.

Every person of common observation, has noticed the great difference which exists in the human species, with respect to muscular firmness and strength, and nervous irritability and weakness of the bodily powers. Some persons are strong and vigorous in their muscles, and are capable of exerting a great degree of strength and of continuing it for a long period; while others, perhaps of equal size and weight, are absolutely incapable of putting forth such bodily powers, or can do so but for a moment, when they become utterly exhausted.

We find that persons of great muscular firmness are not generally subject to what is called "nervous excitement." They are not easily thrown into trepidation; they keep cool and quiet on all occasions; while those with the lax muscular fibre are easily thrown into excitement, any sudden event being sufficient to bring on general agitation, or even convulsions of the whole system.

What is said of the goodness of the Creator in providing man with an instrument to execute the projects his reason might suggest.

The muscles furnished with two sets of nerves.—The cause of such differences in the temperaments, dispositions, and muscular powers of these two classes of individuals, as above described, appear to be accounted for by a comparatively recent discovery of Sir Charles Bell, who has found that the muscles are furnished with two sets of nerves, one set being chiefly concerned in muscular motion, and the other, in sensation.

In the seventh edition of his anatomy, Sir Charles gives the following explanation of the uses of these two kinds of nerves.

"The muscles," says he, "have two nerves, which fact has not hitherto been noticed, because they are commonly bound up together. But whenever the nerves, as about the head, go in a separate course, we find that there is a sensitive nerve and a motor, [or moving] nerve distributed to the muscular fibre, and we have reason to conclude that those branches of the spinal nerves which go to the muscles consist of a motor, and a sensitive filament."

"It has been supposed hitherto, that the office of a muscular nerve is only to carry out the mandate of the will, and to excite the muscle to action; but this betrays a very inaccurate knowledge of the action of the muscular system; for before the muscular system can be controlled under the influence of the will, there must be a consciousness, or knowledge of the condition of the muscle."

"When we admit that the various conditions of the muscle must be estimated, or perceived, in order to be under the due control of the will, the natural question arises, Is that nerve which carries out the mandate of the will capable of conveying, at the same moment, an impression retrograde to the course of that influence which is going from the brain to the muscle? If we had no facts in anatomy to proceed upon, still reason would declare to us, that the same filament of a nerve could not convey a motion, of whatever nature that motion may be, whether vibration, or motion of spirits, in opposite directions at the same moment of time."

"I find that to the full operation of the muscular power, two distinct filaments of nerves are necessary, and that a circle is established between the sensorium and the muscle; that one filament or single nerve carries the influence of the will towards the muscle, which nerve has no power to convey an impression backwards to the brain; and that another nerve connects the muscle with the brain, and, acting as a sentient nerve, conveys the impression of the condition of the muscle to the mind, but has no operation in a direction outwards from the brain towards the muscle, and does not therefore excite the muscle however irritated."

Thus we are, it would seem, furnished with a double apparatus by means of distinct nervous filaments, one for muscular action, and the other for sensation,—the one to carry our commands from the brain to any muscle which we would have contract; and the other to bring back an account of the condition of said muscle, and inform us whether the contraction is too great or too little, or whether the direction of the lever which the muscle has been concerned in moving is precisely such as to answer the purpose intended. Thus as the painter goes on with his work, these sentient nerves constantly warn him precisely how much muscular movement is required in his hand to place his colors according to his taste; while the nerves of contraction move the muscles exactly as the will directs them, and as these different kinds of information are conveyed from and to the brain, in an instant, or "as quick as thought," so we are insensible of the lapse of the least portion of time, between the mandate from the brain and the action of the muscles.

The same process takes place in every action which we perform. When we direct our eyes towards a landscape, for instance, and having examined one group of objects, move them ever so little towards the next, this is not done without the action of the sentient nerves, which inform the brain exactly, of the situation of the muscles of the eyes; which muscles in their turn, are directed how to move the orbits. Thus if we wish to turn the eye from right to left, or upwards, or downwards, or alternately in all these directions, the *straight* muscles, (Fig. 104,) are thrown into alternate contraction, and relaxation, at the mandate of the brain. Meantime the visual portion of the eye furnishes us with a picture of the landscape, the different parts of which we thus examine by means of the mechanical portion. Is it not plain, that infinite wisdom and Almighty power only, could have devised and constructed such machinery as this?

Personal temperament, and disposition, accounted for.—It is on the same principles, that we can account for the difference which we observe in persons, with respect to their temperaments, or dispositions, as already stated. When we see a person of feeble muscular powers, easily thrown into agitation, turning pale, or fainting by slight causes, and morbidly sensitive to every nervous impression, we may conclude that in such persons the sentinet nervous system predominates; or, in other terms, that the nerves which carry impressions to the brain, are either more highly developed, or are in a more sensitive state, than those concerned in muscular contraction. In such persons the flesh is commonly soft to the touch, and has a pallid hue. On the contrary, in persons where there is great muscular power, as indicated, not only by the strong outlines of the muscles themselves, but also by the capability of enduring great, and continued bodily exertions, and by a temperament void of excessive sensibility, being able to bear strong nervous impressions with little indication of nervous feeling; we may conclude that in such persons the motor nerves, or those concerned in muscular contraction, predominate over those subservient to sensation. In such persons the muscles are commonly rigid to the touch, even when relaxed, presenting a striking contrast with the morbid softness of these parts, in persons of excessive nervous mobility.

Natural Disposition may be modified.—Although, as we have supposed, and the fact cannot be doubted, that there is a natural difference in different persons, with respect to the distribution of the sentient and muscular nerves, still it is also true, that the resulting dispositions can be modified, and in a great measure controlled by external circumstances.

In persons where the two different nervous powers are naturally in the most perfect equilibrium, the one may be made to predominate completely over the other, by the habits, the occupation, or perhaps the condition in life into which the person happens to be thrown. Excessive study, a sedentary life, luxurious living, especially in respect to drinks; habitual melancholy, or a general disposition to give way to the love of ease and indolence, will, either of them, in a longer or shorter time, induce a nervous temperament, though the natural organization of the two systems might have been as perfect as ever a human being enjoyed.

On the contrary, persons in whom the nervous disposition might have naturally inclined to laxity of muscular fibre, and excessive sensorial irritability; by the habitual practice of rigid temperance, moderate study, if at all, an active life, requiring the constant use of the muscles, together with a train of circumstances in life calculated to inspire cheerfulness and hope—by these means, such persons would undoubtedly overcome the natural predominance of the nervous system, and induce a permanent state of muscular firmness, which would produce a highly gratifying contrast with that which an opposite mode of living, or train of circumstances, would have produced.

Force of Muscular contraction.—The force with which the muscles contract, depend on the size and condition of the muscle, and on the energy of the brain; that is, the degree of excitement which exists during the time.

The same muscle, or same limb, varies greatly in the strength which it is capable of exerting. If a man, naturally and habitually powerful in his muscles, should suffer them to remain inactive for a considerable length of time, they will become absolutely incapable of those strong contractions, which had they been habituated to constant action, they would have performed with ease. This is a fact that has fallen within the experience of almost every person, and is accounted for in the popular way, by the common observation, that "if we do not employ our muscles, they will lose their strength," which indeed accounts for the fact, but not for its cause. The cause appears to be, that the action of a muscular part, excites the blood vessels to throw into it a greater portion of their contents than they otherwise would, so that such parts are better nourished than those that remain inactive. Thus the arm with which a blacksmith uses his hammer, whether the right, or left, is by far more powerful than the other. The muscles of this limb are also larger than those of the other, and are much more tense, and rigid to the touch—a positive proof of the tendency of muscular motion to produce strength and vigor.

The Roman gladiators understood practically the great advantages of employing their muscles, in order to gain the most perfect use of their limbs, together with the utmost physical power. Hence they put forth continued exertions in walking and other exercises, and performed feats of strength, which in the present age would appear incredible.

In more modern times men have occasionally appeared, who from the size and condition of their muscles, were capable of exerting degrees of strength which astonished every beholder. Sir David Brewster, in his "Natural Magic," has collected and stated a number of instances of this kind.

Thomas Topham.—One of the most powerful men of modern times, was the famous Thomas Topham, of whom many ludicrous anecdotes, illustrative of his enormous muscular strength, are related; such as the rolling up of pewter dishes with his hands, as others do sheets of pasteboard; crushing the bowls of tobacco-pipes, by the lateral pressure of the fingers of one hand, &c. He took an iron kitchen poker, a yard long and three inches in circumference, or an inch in diameter, and holding it in his right hand, struck it upon his bare left arm, between the elbow and the wrist, until he bent the iron nearly to right angles. He took another poker, and holding the ends of it in his hands, put the middle over his neck, and then brought the two ends together before him; and afterwards undid the mischief, by making it straight again with his hands, as others do a piece of wire. He lifted a stone, weighing 800 pounds, with his hands only, standing in a frame above it, and taking hold of a chain to which it was fastened.

These feats illustrate the force of muscular contraction, depending merely on size and condition; since in such cases there is no uncommon nervous excitement, or cerebral energy. But where there is strong mental excitement, as in mania, or delirium, the other circumstances being equal, there is a still greater exhibition of muscular power, as the keepers of Retreats for the insane have often found to their sorrow, and sometimes to their horror and dismay.

No one, except by experience, can have the least conception of the efforts of muscularity, which a delicate and slightly made female is capable of exerting, when in a state of maniacal rage. In some instances, men of ordinary physical powers are mere "smoking flax," before the muscular velocity of these most pitiable objects; and even the strongest men are sometimes foiled in attempting to prevent them from committing some outrageous act on which they are determined.

Such acts are rather the effects of muscular velocity, than of strength; for the efforts are soon exhausted, after the limbs are brought into a situation where a quick movement is no longer of any avail.

Method of increasing the Muscular powers.—There is no doubt but the power of the muscles may be greatly increased by a certain restricted course of exercise and diet, to which the subject confines himself for a given length of time. The English boxers go through such a course in order to prepare themselves for public performances, and we can see no reason why others should not imitate their example so far as the training is concerned, in order to gain that perfect health which it is said these men enjoy. There are few, however, who would submit to such discipline without some special motive, other than the enjoyment of ordinary health. But that the reader may observe how these men deny themselves, for the purpose of acquiring mere muscular power, and that for no laudable purpose, we will give a few of the rules of *training.*

There are *Professors of Sparring*, whose sole business it is, to teach the art, by learning their pupils the manner and time of striking, as well as the modes of defence ; and the means of gaining muscular strength by diet and exercise. While training, they are directed to eat beef and mutton, rather *under* than *over* done, and this without any seasoning, or sauce, the only addition to these two articles of solid food, being bread or biscuit. Neither veal, lamb, pork, fish, milk, butter, cheese, puddings, pastry, or vegetables of any kind are allowed. The beef and mutton must be fresh, that is, not salted, and may be cooked by *roasting*, *broiling*, or *boiling*, alternately, or as best suits the appetite of the trained.

The strictest *temperance* is *absolutely insisted* on, by all regular trainers, good home-brewed beer, or ale, being recommended as the ordinary drink at meals. Those who do not like the beer are allowed a little red wine and water, with their dinners, but not to exceed in quantity eight ounces, or half a pint per day, *spirits of every kind being strictly prohibited.*

Eight hours *sleep* are considered necessary, but this is left to the previous habits of the person, and may be varied according to the amount of exercise during the day.

The breakfast hour is eight o'clock ; dinner at two ; supper being entirely omitted, or to consist of a little bit of cold meat at eight ; after which, a walk is taken, and they retire to bed at ten.

Much exercise, consisting of sparring and walking, is taken during the whole time, of training, and undoubtedly the high degree of cheerfulness in which men thus situated indulge, contributes greatly to the good effects of the comparative temperance to which they are restricted, at least for a considerable time.

Dr. Kitchener says, that " by this mode of proceeding for two or three months the constitution of the human frame is greatly improved, and the courage proportionably increased. A person who was breathless, and panting on the least exertion, and had a certain share of those nervous and billious complaints, which are occasionally the companions of all who reside in great cities, by such means becomes enabled to run with ease and fleetness."

"The restorative process having proceeded with healthful regularity, every part of the constitution is effectually invigorated, and a man feels so conscious of the augmentation of his powers, both bodily and mental, that he will undertake with alacrity a task which before, he could not but shrink from encountering."

About two months is considered the average time necessary to fit a man for the *ring*, or for public exhibition as a boxer by the above means; and it is particularly worthy of observation, that alcoholic liquors are discarded by these men, for no other reason than that experience has taught them, that its effects are to weaken the muscular powers and destroy the courage of their pupils. Therefore, he who has much labor to perform, or a battle to fight, ought never to drink spirits.

PRACTICAL INFERENCES FROM THE FOREGOING PRINCIPLES.

Connection between the Brain and the Muscles.—The intimate connection which exists between the muscles and the brain—between the nervous system generally, and those parts by which the motions of the human frame are produced, and which connection has been illustrated by a reference to the voluntary muscles,—indicate, in a most decided manner the mutual dependence which subsists between them; and tend to show as clearly as the nature of the case will admit, the necessity of employing both the nervous and muscular functions at the same time, in order that both should be in a healthy state. And especially do these principles show, that the nervous system cannot long be employed alone without a derangement in the functions of both.

It has been our chief object in the foregoing sections, to show the connection which exists between the nervous system and the voluntary muscles, but this may be taken as an example of the existence of the same relation between that system and all the muscular fibres in the body, whether voluntary, or not. Thus the heart, and the muscles of respiration, are equally, with the voluntary muscles dependent on the action of the brain. The organs of mastication, and digestion are also under the same influence.

In every series of actions, therefore, which take place in any part of the whole system, there is a mutual sympathy and dependence on some other part.

MUSCULAR EXERCISE OF THE CLERGY AND OTHER LITERARY MEN.

And now we come to the more especial object of this part of our work, which is, to show that *the vigorous functions of the brain cannot long be sustained, without a corresponding exertion of the muscles, and that this exertion absolutely requires that the brain should be more or less excited.* We intend that these doctrines should apply more particularly to students and literary men, and we shall begin by showing the duty of ministers of the gospel in respect to bodily exercise. The present condition of the clergy and other literary men of our country, points to the vast importance of seeking some remedy against the consequences of literary pursuits, and sedentary habits, on their corporeal and mental functions. Not only ministers of all ages, but students, only a few years advanced in their studies, are constantly "*breaking down*," as it is termed, under the pressure of their literary burthens; many of the first class being obliged to go to Europe, or otherwise suspend their labors in order to recruit their worn out frames, and rest awhile from their cerebral occupations; while perhaps an equal number of the last, find themselves under the necessity of retiring entirely from the field of literary pursuits and of seeking some employment, in which less is required of the nervous, and more of the muscular system; and thus the literary or ministerial services of many young men of great promise, and whose labors and influence would be highly important to the church, or the interests of education, are in a great measure, lost to the country.

Causes of these failures.—With respect to the causes of these calamities, for such they certainly are, both with respect to individuals, and the nation, there can be only one opinion. *They are brought on by too much mental and too little muscular labor.* Thus the balance of the system, which as we have seen, requires a due proportion between the exercise of the nervous, and muscular powers, is lost,—the equilibrium of health is destroyed in consequence of the predominance of the sentient, over the muscular principle.

Obvious effects of too much mental labor.—In such subjects, it will be found that after a while, the flesh becomes soft and flabby, while the muscles can only be made to perform their ordinary functions with difficulty,—all continued, or violent exercise is instinctively avoided and even a walk of a mile or two, at the urgent request of a friend, and which once gave so much pleasure, is now undertaken with reluctance. Fatigue, even after walking but a few hundred yards becomes the prominent feeling, and the man often returns home, after a short trial, for fear that he shall not be able to do so, if he continues his walk. Having returned, perhaps out of breath, he seats himself and concludes, that exercise, since it brings on fatigue, is not only useless, but hurtful to him; and thus if he cannot be made to change this opinion, consigns himself to the nearly hopeless condition of a confirmed " literary dyspeptic."

Meantime the nervous system increases in susceptibility in proportion as the muscles lose their contractile powers, and fall into a state of weakness. The subject becomes exceedingly sensitive to nervous impressions. Occurrences of little consequence, and which in his former condition would have produced no sensation, now affect him very unpleasantly. He becomes irritated and vexed at every little mishap in the affairs of life. His friends, he begins to imagine do not behave towards him as formerly; they have deserted him in his affliction; and his own family are wanting in that kindness, which was formerly shown him, and which his present weak condition now particularly demands. At the same time he finds it exceedingly difficult for him to proceed with his literary labors. His head often feels as though there was a rush of blood upon the brain ;—his intellect becomes clouded, and he cannot keep along with the thread of his subject, or pursue his studies as formerly. Sometimes he throws down his pen, in utter despair, and thinks he would willingly change places with any laborer he happens to see in the street.

There are but a few of the feelings, and troubles, and perplexities, which a student suffers, when he allows his nervous to gain the ascendency over his muscular system, and unless some remedy be sought, will most probably end in palsy or apoplexy, or at least, in such a condition of the system, as to render it incapable of any useful employment, for a length of time, depending more, or less on that, during which it has remained in such a condition.

Clergymen not allowed exciting exercise.—The cause of these affections we have said, is an undue proportion of mental labor, when compared with that of muscular exercise.

With respect to clergymen it is well known that there exists an artificial difficulty in their indulging in that kind of exercise which is most congenial to mental and muscular vigor, owing to the habits and opinions of society. For it is a law of the system, which applies to ministers equally with others, that no exercise is effectual in restoring, or maintaining, the equilibrium between the nervous, and muscular systems, *unless the brain is at the same time excited*. By this we mean, that the exercise must be of that kind in which the mind, for the time, takes a strong interest. This is absolutely necessary, nor is it we believe possible, for any one who has lost his muscular energy by studious and sedentary habits, to regain it by any kind of exercise which does not give pleasure, or to use a more common phrase, "carry the mind along with it."

Nor is it in the power of students generally, to retain their vigor of mind, and body, for any considerable length of time without the use of some such exercise.

The principles we have already drawn, from the fact, that every muscle has distributed to it, one set of nerves for muscular action, and another for cerebral impressions, proves beyond all doubt, that this is the case. The vigorous and healthy action of the muscles absolutely require that the brain, at the same time, should be under excitement, otherwise the nervous influence from which muscular contractility is derived, will not be supplied.

Now the great obstacle to clerical amusements appears to arise from the circumstance, that the feelings and prejudices of the public, to a considerable extent, at least, will not allow those men to partake of such gymnastic sports as people generally may indulge in, and which of all others, is the kind of exercise they most require.

We are far from desiring to see the dignity of the clergy lowered, and we should regret as much as others, to see them doing acts, which would in the least degree tend to lessen the respect which they have, and ought to maintain from the public. But it seems absolutely necessary that something should be done on this subject. Not a year elapses, but a number, often of the most devoted and useful members of the sacred office, in different parts of our country, are under the necessity of leaving their people, being literally "worn out" with their clerical labors. This, it is well known, is the case, in a greater, or less degree, with all the orthodox denominations, the ministers of which, are expected every sabbath in the year, at least, in many parts of the country, to produce two well written sermons, besides a semi-weekly lecture; and to perform other parish duties requiring as a whole, almost unremitted mental labor from one year's end to another.

Men incapable of constant mental labor.—Now the facts clearly prove that human beings, taken as a body, are incapable, under such circumstances, of sustaining such mental burthens; they sink down under them from debility and exhaustion, and one after another, even in the prime of life, and in the midst of their usefulness, disappear from public scenes, and in not a few instances, find that they have done so too late.

Clergymen are still men, and like others, are subject to the laws which govern vital and corporeal action;

and it is therefore plain, either that the public must dispense with a portion of their services, or that they must be allowed to indulge in recreative exercises ; otherwise they will inevitably sink under their mental labors, and many of them at least, go down to premature graves.

Former condition of the Clergy.—The condition of the clergy in this country, is entirely different from what it was within the memory of many of them, who are still able to perform their clerical duties ; and who have lived to see several generations of their younger brethren come forward, and pass away, while they, themselves, have continued their labors until the present day.

A great proportion of our ministers, no longer than fifty years since, were settled on farms, with salaries of from two, to three, and seldom four hundred dollars per year. They were therefore under the necessity of laboring with their hands, in order to maintain their families. Besides, their flocks were often so scattered as to occupy a considerable portion of time, and some bodily exercise, in order to visit the several families even once a year. At these visits, the minister always received presents of provisions from his parishioners, but in case the visit was not made, the present was not given ; a good old custom, which always insured every family in the parish, a personal acquaintance with their minister.

At that period too, the mental labors of the clergy were not more than about one third what they are at the present day, especially in towns. They preached two sermons a week ; in addition to which, an extra sermon once a month, or once in two months, preparatory to the communion, made up their stated labors.

Here, it is obvious that the exertions of the mind were not disproportioned to those of the muscles, and hence the clergy were then among the longest lived individuals of their parishes, as is proved by the living witnesses of that body which here and there still remain.

It is unnecessary further to contrast the parochial labors of the clergy of the present day, with those of their fathers in the church. It is well known that the increase of population, as well as a more advanced state of education, have rendered it necessary to increase these labors more than two fold. At the same time, as their fathers required no extra exercise—no relaxation from their parochial duties, the public appear to have grown up in the belief that their sons do not; and that it would be derogatory to clerical sobriety and dignity, for them to indulge in any sort of pleasant unbending of their minds.

Different effects of Exercise.—Sawing and splitting wood, with perhaps a little work in the garden, and riding on horseback a few miles, or walking the streets for an hour or two, form the chief amusements, and the chief muscular exercise of the most laborious, and, in the estimation of the great majority of the people, the most useful body of men in community. Even this small amount of exercise is seldom taken regularly, and if so, is of very little use to the subject, as there is no other object in view, but merely to perform a duty. The thread of the next discourse frequently remains unbroken, and often the individual hurries home, while the ink of his last paragraph is hardly dry, to record some new idea, or write down what he has made ready in his mind during his absence.

To one whose body and mind begins to suffer, in consequence of confinement to his study, and perpetual mental exertions, nearly all who have experienced its effects, will allow that such exercise is of little or no use. Such an one wants a motive; he wants cerebral excitement to co-operate with, and invigorate muscular action; and it will astonish those, who, for the first time notice the different effects on their own feelings, of forced muscular exertions, and that sanitive exercise which is produced when the mind is intensely fixed on an object, the attainment of which requires the strongest corporeal exertions. The one induces fatigue of the body, without at all relieving the mind; while the other, so far from producing fatigue, brings the whole system into a highly pleasant state of freedom, and elasticity; while the mind, sympathising with these pleasant sensations, becomes invigorated, and is again ready for the performance of its proper functions.

Continued muscular efforts require cerebral excitement.—The principles of physiology which we have already explained, show most decidedly, that continued corporeal exertions may be maintained under the stimulus of the mind, which the same individual could not possibly sustain under coercion.

We see the exercise of this principle every day. A boy with his kite or gun, will exert all the powers of his muscles for five or six hours, or even for the whole day, and still hardly complain of, or feel fatigue; while the same amount of muscular power exerted against his will, could not possibly have been sustained, though his life might depend on the performance.

Dr. Darwin's case.—A case mentioned by Dr. Darwin, illustrates our subject. A young man full of desire to see his female friend, who was fifty-five miles from him, decided to undertake the journey on foot the next day; and which, under the stimulus of hope and expectation, he performed without difficulty. Having arrived at her residence, he found that she was attending a ball in the vicinity, to which place of course he repaired without delay. Here were new causes of excitement; the object of all his thoughts, he now saw dressed in gay attire; the music, the friends, the dance, all tended to make him forget his long journey; and as though fresh from the neighborhood, he joined in the pleasures of the evening, and danced most of the night with his wonted vigor and vivacity, and all this without fatigue.

Now had this performance been commenced by compulsion, that is, had this person been made to take the same number of steps at the command of a master, and then in the ball room had he been compelled by the whip, to use the same gestures that he did with his lady, at the sound of the music, what think you would have been the consequence? Undoubtedly he would have sunk down and died from exhaustion, under such treatment.

In armies, it is well known that long marches can be endured under the excitement of music; while without this, many of the soldiers would be unable to perform the duty required, and would be left behind even in the country of the enemy. In forced marches therefore, the commander who understands this, divides his music, so as to keep a part of the band constantly playing such airs as to accommodate the pace of the marching soldiers.

The same principle is involved in the attempt of an adult, to follow a child of three or four years old, whereever it chooses to go for a whole day; taking a similar number of steps, and using similar gestures. A healthy, active child, if entirely unrestrained, will soon convince the unthinking adult who undertakes such a task, that he has a day's work before him which he little expected; nor do we believe it in the power of many persons to perform such a feat. The reason is obvious: the child is constantly excited by his play, and by a succession of new objects, and new motives; while the adult, having no mental excitement, by which the nervous influence is sent from the brain to the muscles, their contractions are merely mechanical, and therefore they soon become exhausted.

A parallel case is, where two men of equal muscular powers go out on a sporting excursion, the one a keen, and ardent sportsman, and the other going as a mere spectator. The former having a motive, and being constantly intent upon his game, but not thinking of himself, will traverse bogs, bushes and briers, for miles, without being aware of distance, or time, or place, and without feeling the least fatigue; while the spectator, trying to keep with his companion, without any other motive than doing so, soon becomes so exhausted as to be incapable of further action, often wondering at the same time, how it is possible for his companion to go at such a rate, through such walking, and for so long a time, without complaining of fatigue.

NATURE REQUIRES EXCITING EXERCISE.

It is in vain to plead *natural* gravity, or a want of disposition to indulge in those exercises which relax the mind of the studious, as an excuse for denying them to others, or not adopting such for ourselves. Nature, whose laws we profess to follow in this matter, makes no such excuse. On the contrary, unless the system be worn out with age, or sickness, there exists in the feelings of every person, a natural disposition for play, both in the mind and muscles; and where the restraints of society, or circumstances are removed, we may every where observe illustrations of this law of nature. Hence at watering places, at the sea-shore, or any other place devoted to public amusement, and relaxation, persons of the most erect gravity at home, and even members of the sacred office, throwing off the mantle of restraint, which had, perhaps, for a quarter of a century, hid their natural dispositions, not only from all their associates, but almost from themselves, again become boys, and play all sorts of recreative games with as much interest, and nearly with the same agility as they did twenty or thirty years before.

Men bound to use exercise which conduces to health.—Now we do not make the above remarks by way of accusation, or for the purpose of hinting that such indulgences involve either hypocrisy or levity. On the contrary, such facts illustrate and confirm the principles of organic life which we have attempted to establish with the best intentions, and for the best of purposes. They show that nature is averse to the solemn restraints of society; and that exciting exercise, because it is most agreeable and most natural, is the only kind which relieves the body and mind, when the first has become torpid from too little, and the last from too much exercise. And for the purpose of verifying those principles, we would call upon those who now and then yield to the mandates of nature, (whatever may be their acquired gravity,) and reckless of muscular power, or mental reputation, enjoy for a time, some sort of exciting play, to say whether the effects are not only congenial both to body and mind, and whether they do not believe that under such amusements, frequently repeated, a man would perform a greater amount of mental labor, and continue longer in health, and in life, than he would, to proceed in the usual manner, of either taking no exercise at all, or only that in which the muscles are compelled by force to perform their duty, as is the case with most literary men?

If this is so, and which we are confident that not a man who has made the trial, will deny, then is it not the moral, and even religious duty of every student to so far coincide with the dictates, and laws of nature, as to employ every means, which are not immoral in their tendency, to enable him, by the preservation of his health and life, to do every good in his power for the benefit of his fellow man?

Says the pious and learned Dr. Cheyne, "The studious, the contemplative, the valetudinarian, and those of weak nerves, if they aim at health, and long life, must make exercise in a good air, *a part of their religion.*

A man who believes himself to be a useful member of community, and who becomes conscious that his occupation, whatever it may be, requires relaxation, and that if he does not indulge in it, his health will suffer, and his life will be endangered, would certainly be considered by himself and by others as wanting in a moral duty, if he neglected such relaxation. Under such circumstances, no one would doubt what would be the duty of a mechanic, both with respect to his family and his country; and if the same moral rule holds with respect to literary men and ministers, then they are as much bound to employ brain exciting means to preserve their mental vigor, as the mechanic is to relax from his labor, for it has been shown, we think, that no other means will effectually answer this purpose.

Effects of incessant mental labor.—On this subject, the author of this work speaks from experience, and therefore *knows* that he tells the truth. For, having tried the ordinary routine of exercise, such as wood sawing, gardening, &c., he has been compelled, against his former prejudices to resort to "field sports," with his pointer and gun, not only as the means by which he has been enabled to continue in a sedentary and studious profession, but also to preserve himself from the dreadful consequences of nervous excitability, and especially from the most horrid, and appalling of all sensations, that which attends palpitation of the heart, from an accumulation of the nervous influence. The most acute pain is a comfort, and even a pleasure, when compared to a feeling from which the sufferer cannot avoid the belief that his heart swells to twice the natural size, occasionally turns over, backwards, and forwards, and is every instant in danger of bursting open and spilling its vital contents into his chest: at the same time he feels that his pulse beats half a dozen strokes in a moment and then stands still, until forced by the stimulus of the blood to begin the same rapid motions again. And yet all this, and even more than we dare to describe to the literary invalid, is according to the woful experience of the one who writes this, the consequence of study at the rate of fourteen hours per day, for a series of months. And yet all these symptoms were unfelt and forgotten during the most violent exercise in which the mind was intensely interested, viz. field sports.

Mere attention to diet of little use.—A spare diet, omission of dinner, vegetable food, bran bread, and indeed all the remedies which the science abstemiousness can suggest will never prove antidotes to these fearful sensations. A laborious student, like a laborious workman, requires nutriment, nor can he sustain himself in his literary pursuits without it. It is true that where the muscles are little exercised, the quantity of solid food may be diminished; but he who goes to work at a difficult piece of composition with a hungry stomach, will never finish it to suit himself until this sensation is satisfied.

An easy and comfortable state of the animal system is absolutely necessary for the student, and so far as we know, this is only to be obtained by a generous diet, and exciting exercise, according to the wants and feelings of the subject.

As to the use of medicines, diet and rules of conduct, without muscular action, for the alleviation of nervous palpitation, they are worse than useless, because they offer false hopes to the sufferer, and prevent his seeking the proper remedy in season. And we hereby warn those into whose hands these remarks may fall, and who are thus afflicted, never to be caught by such chaff, as *bran bread*, and its adjuvants as a remedy for what can only be cured by muscular motion. You may starve yourselves to skeletons and my friends, still your horrid sensations will increase, until you adopt some exciting muscular exercise as a remedy. Let your stomachs take care of themselves, and never think of what you eat, or drink except at the moment, only taking the precaution to be temperate in both, and by the use of such exercise, repeated every day and increased according to feelings and circumstances, of which you are the best judges, you will gradually rid yourselves of all that train of symptoms incident to nervous excitability, which have been brought on by sedentary and mental habits.

It is not denied that there are great differences in the amount of literary labor which different men are capable of performing under the same circumstances. We are perfectly aware that there are Thomas Tophams in the mental as well as in the muscular departments of human exertions. But we write for those who labor under the common laws of the animal economy,—those laws which ordinarily govern the actions and powers of human beings; and not for those, whose iron constitutions are equally unhurt by any amount of cerebral, or muscular performances which it is in their power to accomplish. These are exceptions to the general laws which govern our species and to such we have nothing to say, because, not suffering from their labors they require no remedies.

Cheerfulness a remedy.—The best tempered men, after long confinement to study, and who take no pains to cultivate a cheerful acquaintance with their friends, are observed to grow more or less morose, in their dispositions, until they finally contract such a habit of being out of humor, especially at home, as to become such disagreeable companions, that their former friends, if they call upon them at all, do it as a matter of duty, and not for the purpose of having a few moments of enlivening conversation, as formerly. Of this disposition, the subject himself oftens becomes sensible, which discovery, instead of showing him the necessity of relaxation, and joining in cheerful society as a remedy, too often only proves a source of vexation, which increases, rather than alleviates the evil.

Now both moroseness and cheerfulness are often acquired habits, arising from the circumstances in which the person is placed. Let one, for instance, to whom nature has given a pleasant disposition, be so situated in life, as to be constantly perplexed with its cares, or let him be under the necessity of pursuing studies, which do not interest his mind, and which, therefore, are a source of vexation to him ; and the contracted brow, will become habitual ; and the vexed spirit which it indicates will finally become so far a second nature, as to be retained, even long after the circumstances, which produced these unhappy results have ceased. Such is the force of habit.

On the contrary, we often see those whose dispositions are far from being naturally pleasant, but who, mixing with enlivening society, and being placed in such conditions in life as to escape its corroding cares and perplexities, finally become agreeable, and even courteous companions, having acquired happy dispositions, in consequence of being constantly pleased with their own conditions and circumstances.

But whatever their conditions in life may be, it is undoubtedly the duty of all persons to cultivate cheerful and happy dispositions. Christians in an especial manner are called upon to rejoice—to set examples of a happy state of mind, and to show by their countenances, and actions, that they are contented with the lot in which Providence has cast them. A sour, *crabbed* Christian, presents a combination of elements so heterogenous, that the world are always doubtful whether they ever exist in the same person. How indeed, do such adorn the doctrines they profess?

It is true, that there are afflictions, under which, for a time, a happy countenance would betray a want of common feeling, and therefore would be unbecoming and improper; but under all the ordinary cares and perplexities of life, of which every one has more or less, we are bound by the duties we owe each other, as well as ourselves, to preserve and cultivate a cheerful spirit and disposition, and aside from levity of conversation, or action, we cannot see the immorality, or impropriety of so far giving way to the dictates of nature as to carry our pleasantries even to mirth, let our ages, or professions be what they may.

Laughing a proper and healthful exercise.—Man is the only *laughing* animal which the whole terrestrial creation affords; and in the young, the indulgence of this natural propensity, in proper places and under proper circumstances, is universally approbated; youth being considered by all, as the appropriate season of innocent merriment. But there are those who look upon the action of the risible muscles, as being incompatible with the gravity and solemn dignity of certain ages and professions; and therefore believe that such, ought always to suppress their lively and facetious thoughts, and expressions, lest they should excite laughter in others, or give way to it themselves.

Now we have no desire that any one should do violence to his conscience in this respect, but while, aside from improper levity, we cannot imagine from what source moral evil would come in consequence of the exercise of the muscles of risibility in any human being whatever, it is certain, that the act of laughter, conduces to the health of the system, by the motion it gives to certain muscles, as well as by the attendant relaxation of the mind; and therefore as a mere secular action, is a very proper exercise for people of studious and sedentary habits.

The muscles concerned in moderate laughter are chiefly the diaphragm, and those between the ribs; but when the action becomes violent, those of the back and chest are thrown into motion, and the whole frame is shaken;—the lungs being at the same time alternately filled with, and exhausted of air, by rapid muscular actions, which sometimes amount nearly to convulsions, thus calling into contractile motion, all the muscles of the trunk, and agitating the entire assemblage of the visceral organs, thus, perhaps, detaching any adhesions that might be incipient in these parts, and at any rate, giving vigor to the actions of the pipes, and strainers, the secreting and the absorbing surfaces, the functions of which are so necessary, that not only health, but even life itself depends upon them.

"*Laughter*," says Dr. Willich, "is sometimes the effect of joy; but it frequently arises from a sudden disappointment of the mind, when directed to an object, which, instead of being serious, and important, terminates unexpectedly, in insignificance. Within the bounds of moderation, laughter is a salutary emotion; for, as a deep inspiration of air takes place, which is succeeded by a short, and frequently repeated expiration, the lungs are filled with a great quantity of blood, and gradually emptied, so that its circulation through the lungs is thus beneficially promoted. It manifests a similar effect on the organs of digestion. Pains in the stomach, colics, and several other complaints that could not be relieved by other means, have been frequently removed by this. In many cases where it is purposely raised, laughter is of excellent service, as a remedy which agitates and enlivens the whole frame. Experience also furnishes us with many remarkable instances, where obstinate ulcers of the lungs, or liver, which had resisted every effort of medicine, were happily opened and cured by a fit of laughter artificially excited."

In cases, however, where the conscience is against the practice of laughing, little good may be expected from it.

DIFFERENT KINDS OF MUSCULAR EXERCISE.

There is a great difference in the amount of exercise which men require, depending very much upon constitution and habit. There is also a selection to be made with respect to adaptation to the mind, since what would prove exhilarating to some, might be mere drudgery to others. Those who require muscular recreation, ought therefore to select such as combine excitement with convenience; the same being adapted, with respect to its greater or less violence, to the constitution and habits of the individual.

MANUAL LABOR.

In schools for manual labor, there may be introduced employments which to some, will in a degree answer the purposes required. But these must be varied, so as to give motion to the muscles in different parts of the body. Plaining, sawing, turning the lathe, turning the auger, and chopping with the axe, will in succession, bring all the voluntary muscles into play. But as we have seen, unless the subject can contrive to make these employments exciting to the mind, very little advantage will be gained from them. If therefore the student confines himself to such kinds of exercise, he must undertake the construction of some article of furniture, requiring the products of these different branches of labor; and if several will undertake the construction of the same article, there will be produced some degree of excitement during the progress of the work, by a comparison of the different specimens produced. But if the labor is not sufficiently active to induce general and profuse perspiration, especially in the warm season, little good to the debilitated student may be expected from it.

SCIENTIFIC EXCURSIONS.

Excursions into the country on foot, especially among woods and mountains, in search of insects, or Botanical and Mineralogical specimens, to those who are fond of natural history, produce considerable energy of feeling and action; and during the warm season, for those who live in cities especially, is a far more rational and healthful mode of spending a few weeks, than the more common one of lounging about watering places, where it is often found that there are neither wholesome lodging, wholesome excitement, nor wholesome exercise.

FIELD SPORTS.

Sporting with the dog and gun, and especially with a well trained pointer, affords to those who have learned to "shoot on the wing," the most exciting and healthful exercise. In whatever light people who are ignorant of this mode of employing their mind, and muscles, may look upon those men who are exhilarated by such "boyish sports," it is certain that those who have enjoyed the fine flow of spirits which such occasions excite, and especially the invigorating consequences thus produced on the animal system, are seldom induced to think that such exercise is incompatible with the gravity of age, or office ; but more generally continue the practice, so long as the eye sight enables them to see the game distinctly.

To the lovers of the dog and gun, partridge, quail, and woodcock shooting, are considered the most exciting, and healthful of all muscular exercises ; but it is too violent for those whose systems are not prepared to undergo considerable fatigue, though the literary dyspeptic will find after a few experiments, that he can traverse woods, bogs, and mountains, with a degree of facility and pleasure, which will be a matter of surprise to himself. Students of athletic constitutions, are sometimes compelled to employ exercise of proportionate violence ; the ordinary routine of riding, sawing wood, &c., being insufficient to produce the effects required, even though they might excite the brain.

A gentleman well known to the author, who left an active, for a sedentary and mental employment, found that sawing and splitting all the wood for his family, did very little towards preventing his nervous, from predominating over his muscular system. The effect of this exercise was to fatigue the muscles of his arms and fingers, so that it was often difficult for him to resume his pen on this account. He found also, that tiring the muscles did nothing towards relieving the mind ; nor was there sufficient excitement in the employment, or motive in the end to be accomplished, to induce its continuance until perspiration ensued. Finding therefore, that there would soon be an absolute necessity for his either relinquishing the profession he had adopted, or of seeking some more exciting and athletic exercise, he returned to his boyish practices, and partook himself to woodcock and partridge shooting, as the most convenient, and at the same time, as that kind of recreation from which there was the greatest hope of relief. In this he has not been disappointed, but has been able to perform much more mental labor than when he spent the whole day over his writing desk. Two hours per day, from five to seven, P. M. in the summer season, spent in this manner, with a good pointer, will give all the exercise which middle aged men, of ordinary constitutions, require. During this time, the exhilaration of the mind, and the motions of the muscles, are constant; not a little of the interest arising from the wonderful instinct and sagacity, which a well bred pointer dog exhibits in the field, and which the lover of rural sports, however often he has witnessed it, never sees with indifference. The admirer of nature, who for the first time beholds the phenomena which these animals exhibit, when "beating the field," and "standing at a point," will not only be intensely interested, but often struck with astonishment at what he sees. The dog runs backwards and forwards, a little before his master, with his nose elevated above the grass or bushes, until he scents the bird, (which is always on the ground,) when he walks slowly, and carefully, to within a rod or two of it, and then stands perfectly still, with his nose pointing to the exact spot where the game lies. The sportsman proceeding to the spot, sends the dog forward to "*flush*" the bird, and shoots it as it flies, the dog again standing until the game falls, when he brings, and lays it at his master's feet.

In these dogs the pointing is a natural property, or perhaps an acquired instinct, and may be seen in young animals of good blood, without the least training. The training therefore, does not consist in learning the animal to point, but only to obey the commands of his master, with respect to the moment of flushing the game, of bringing it, and of keeping within a certain distance from him, &c.

And now who can account for the reason why this extraordinary property was conferred on this animal, unless it was intended by the Giver to be employed by man in the manner we have described; for in no other respect can it be of the least use to the dog or his master. We cannot but believe therefore, that there was design in this peculiar endowment, and that it was intended to be made useful to man.

It is true that there are objections to this kind of sport. To those situated in large towns, it would perhaps be nearly impracticable as a daily exercise; and besides, there is, at least, a semblance of cruelty in it. With respect to the latter however, the conscience may be greatly relieved by adhering to two rules, which true sportsmen never violate. The first is, never to shoot at any bird which is not fit for the table; and the second, never to shoot at any bird that *is* fit for the table, unless it be on the wing. By adopting these rules, the beginner will have to account chiefly for motives, and intentions, since he will seldom be troubled by seeing his bird fall. Still, however, the excitement does not entirely fail from want of success; and if the tyro will persevere for a few days, or until he has "*bagged*" a few "brace" of birds, he will then find his conscience perfectly at rest on the subject of field sports, both with regard to intentions, and overt acts. Sir Walter Scott was enabled to continue his great mental efforts by the use of this kind of exercise.

ANGLING.

Those who do not require the violent exercise inseparable from sporting with the dog and gun, may perhaps find as interesting a recreation in angling; which ever since the days of that father of "brook sports," *Izaak Walton*, has never wanted most honorable patrons. And it must be confessed, that on several accounts this is hardly excelled by any other recreative employment. Indeed, we have the pleasure of knowing many a Trout-fisher, whose present enjoyments are greatly heightened by this exercise, and whose useful lives will undoubtedly be prolonged by its continuance.

One of these, a gentleman who has retired from an active employment, often expresses his thankfulness that he is attached to this recreation, considering it, independently of the pleasure it confers, as one of the most efficient causes of the fine state of health which he enjoys.

To those who have no *feeling* on this subject, angling might be supposed to want that kind of excitement, which we have described as necessary to healthful exercise. But if such an one will only just touch on the subject, in presence of a "lover of the rod," he will find his mistake; for there is certainly not a more enthusiastic body of men on the subject of sportive recreations, or rather *recreation*, than the anglers; and to these therefore it presents a source of all the mental exhilaration, both as a conservative, and curative means, which could be desired.

But the uninitiated, and the ignorant, are ready to inquire, "From what source can this interest, this excitement, arise?" To which inquiry we will reply, for we have more than once been witness to the intense feeling which men of gravity, and of sound minds, exhibit on such occasions.

In the first place then, an early breakfast, and a ride of several miles on a May morning, with the expectation of a fine day, (that is, a little cloudy,) and fine luck, are preliminaries by no means wanting in interest.

When arrived at the trout-brook, there is the preparation of inserting the joints of the poles, of fixing the lines, and seeing to the bait, during which nothing else can be thought of. But now the chief source of mental excitement begins.

The hook all baited, and ready, is thrown into the water, and perhaps a bite is instantly felt; or as is sometimes the case, possibly the Trout may jump out of the water and seize it; and who could avoid feeling at such a beginning? What cold heart could remain unmoved with such a crown of success? But if no fish jumps up to welcome the bait; if no bite, not even a nibble is felt, still the excitement does not fail, for what is not realized, is every instant expected, and therefore from the very nature of the case, the mind is constantly occupied, the brain continually excited, and nothing but the expected bite can be thought of.

And then, after an early breakfast, a ride and a walk along the limpid, gurgling stream, with the mind intensely fixed on an object,—then comes on an animal sensation, which after a while predominates over the mental feelings of the keenest,—the most ardent sportsman, and the cold dinner is taken with a keenness of appetite, and a degree of enjoyment, known only to those whose gastric organs have been prepared by such means.

After the day's sport is over, still the interest does not cease, for the parties recount to each other, on the way home, the pleasures, and circumstances of the day. And finally after such a day of exercise, both of mind and body, there follows such a night of repose, as the stayer-at-home cannot appreciate,—and such a breakfast in the morning as princes seldom enjoy.

RIDING.

"Of all exercises," says Dr. Ticknor, "riding is most conducive to health, and to vigor of the constitution, but as a good thing may be improperly, or imprudently used, so riding sometimes produces an effect contrary to what is intended. Those who are not accustomed to riding are most apt to suffer—the pleasure, and exhilaration being so great, that fatigue or exhaustion are induced when they are least expected. In cold weather, people unused to carriage exercise are apt to think the same quantity of clothing necessary in walking, will be an adequate protection when riding. Often, a person will not experience a sensation of cold, he will not be aware that his body is becoming chilled, till he alights from his carriage, or till he approaches the fire, when he becomes fully sensible that his ride has been too protracted. Those who are in good health do not often experience any more than a temporary inconvenience from this cause, but in the delicate it is sufficient to be followed by a serious illness. In summer a drive towards nightfall is truly delicious, and is believed to be conducive to health—and so, indeed, it is, with due precaution—but at such times females are generally thinly clad, and a thin dress affords little protection from the damp, and chilly air of an evening."

"There seems, in the present age, a wonderful propensity to be hurried through the world; not only is it convenient for the man of business to be transported by steam at the rate of from fifteen to fifty miles an hour; but there is no pleasure in driving ones' 'own hired' horse at a pace of less than ten miles in the same space of time. Being thus hurried away, Pegasus-like, a just equivalent to sitting in the open air when the wind blows, in sailor's phrase, a 'stiff breeze,' and to do this at sunset would be thought the very extreme of imprudence. There can be no objection to any man's riding with all the speed his horse can make; but it were wisdom to shield himself against a breeze of his own raising."

"Equitation, or riding on horse back, is a different exercise from the preceding; and fast riding is not only active exercise, but severe labor. This is one of the most noble, and manly, and healthful exercises that can be imagined; and as it formed a part of the education of the Spanish youth, so ought it to be made a part of the education of the young of both sexes, in our country. Riding on horseback, exercises every muscle, and every organ in the body; and causes the blood to circulate so freely that in cold weather this is one of the most comfortable ways in which a person can travel, provided he can bear the exercise without fatigue. This may seem paradoxical to those who never have made the experiment; but the evidence of those who have tested it for several successive years, in all weathers, and at all seasons, has established the fact to my own satisfaction, that at the pace of seven or eight miles an hour, no person would feel cold in unusually severe winter weather."—*Philosophy of Living, by Caleb Ticknor, A. M., M. D. Harper's Family Library, No.* 77, *p.* 202.

We will add to the foregoing judicious remarks of Dr. Ticknor, that riding on horseback, with agreeable company, and on a spirited, well trained animal, does afford exercise, at once agreeable, exhilarating, and manly. It also has the advantage of bringing all the principal muscles into play, and of shaking the viscera in such a manner as to give a vigorous action to the *pipes*, and *strainers* throughout the system, and perhaps to detach any little adhesions that might be taking place among them.

A journey on horseback, for a nervous invalid, is undoubtedly one of the best means of restoration, not however, merely on account of the muscular exercise, or the wholesome air, but because there is a constant succession of new and exciting objects, which as constantly exercises the mind, and without requiring so much attention as to at any time create mental fatigue. Such a degree of mental excitement, with the muscular exercise, and pure atmosphere of the country, undoubtedly conspire to form a train of invigorating means hardly to be expected from any which can be employed at home.

It is entirely in consequence of the action of the brain thus excited, or the employment of the mind, by the succession of new objects, that a journey produces such different results on the health of the invalid, from that to be obtained by the employment of the same amount of the same kind of exercise at one place. The fact itself, is well known, otherwise why do physicians order their patients to take journeys far from home, when with respect to the comforts and habits of life, they could be much better provided for there, than abroad. Why not then, ride thirty or forty miles a day, one way, or another, and sleep at home, to which every invalid is attached, and to most of whom the leaving of their beds, rooms, and families, is such a trial as is often not easily to be overcome. From all we have said of the connection which exists between the brain and muscles, the reason is obvious why little or no improvement may be expected from such exercise. The patient expects nothing new—he has already seen over and again all that he expects to see during his ride: he therefore begins his daily task without excitement, and going through it without interest, arrives at the place whence he started, fatigued in body and mind, and discouraged, not only because he finds no improvement, but because he dreads the *very idea* of having to perform the same task on the morrow.

On the contrary, during a journey, there is a constant change of scenery, or of objects, or of persons, which is just sufficient to keep the mind in gentle and salubrious excitement, and which acting through the brain, supplies the muscular system with the requisite degree of nervous power, and thus the two systems, (the muscular and nervous,) are kept in a state of pleasant and healthy equilibrium, which conspires gradually to bring both into a condition of firmness and health. The patient, after such a day's journey, feels far less fatigue than when his exercise is without excitement, and he becomes satisfied that the means he is employing answers the purpose intended, and therefore, instead of being discouraged, he is filled with the hope of a final, and speedy recovery.

A highly intelligent female invalid, whose circumstances allowed her to select the best means of improving her health; employed for a considerable time, daily exercise, either on horseback, or in an open carriage, in the form of little excursions from her residence. From this method however, and for the reasons above stated, she obtained little else than fatigue, listlessness, and discouragement. Having relinquished it, therefore, for a journey through a fine country, at a good season of the year, she returned so much improved, as to astonish her friends, as well as herself, that such a change could have been effected in so short a period: and nearly every reader will no doubt remember similar cases, which have come within his own knowledge.

Exciting exercise absolutely necessary to the studious.— And now, in closing this part of our subject, we cannot but desire to impress it upon the minds of those into whose hands this volume may fall, and who are destined to spend their lives in literary pursuits, or in clerical labors, that an uninterrupted, and long continued course of study, or of ministerial duties, without exciting relaxation, is from the very organization of our systems, in most cases, absolutely impossible. The kind of exercise must of course depend on the choice, or taste, or muscular powers of the individual, only to answer any good purpose, as a restorative means, it must be exciting to the brain, and if possible, be repeated every day, or at least every two or three days, until the equilibrium of the system is restored, and when this is done, must be continued habitually in order to insure a permanency of good health.

The above considerations and remarks, with respect to exercise in adults, although they do not apply immediately to youth, for whose instruction this work is chiefly intended, still it is hoped will not be deemed entirely out of place, since it is highly important that the rising generation should possess proper conceptions with respect to the arduous duties of the clerical office, and also that our young men, who are destined to follow the pursuits of science, or literature, should at the commencement, know the importance of habitually using so much corporeal exercise, as to prevent their falling into that nervous and debilitated condition, under which but too many of their brethren are now laboring.

Sir Walter Scott.—Sir Walter Scott, who produced, in the course of little more than twenty-five years, *seventy-four* volumes of original romances, besides histories, poems, biographies, critiques and dissertations so numerous, that so far as we know, their number has not been computed, and who at the same period employed many hours every day in other mental labors, still found time to take a great deal of amusing muscular exercise. Besides his dogs and gun, of which, being a capital shot, he was exceedingly fond, and with which he exercised himself with all the keenness and ardor of a first rate sportsman, he also, nearly every day in the season, did something in the practice of cultivation, never taking a walk about his grounds without a weeding, or pruning hook in his hand, thus always, even when most at leisure, placing before himself some object of amusement, or motive of action.

It is well known, that for a long time there was a mystery with respect to the author of the Waverly Novels, and it now appears that the apparently constant occupation of Scott, as clerk of the Sessions, and in other employments, was considered as a sufficient reason, why it was not possible that he could have been the author. "In order to thicken this mystification" says one of his biographers," Scott, instead of being always at his writing desk, as might have have been expected in so voluminous an author, seemed through the whole day and evening, to have his time perfectly at command, for the routine either of business or amusement." "Three hours *per diem*," as he often observed, "are quite enough for literary labor, if only one's attention is kept so long undistracted ; and the best time for this, is in the morning when other people are asleep."

In conformity to this practice, Sir Walter Scott used to produce twenty-four pages of quarto manuscript between the time of rising, and ten o'clock in the morning, when the court opened, and at which time his office required his presence. This was closely written, in a small hand, and ready for the press. It is probable, however, that no authorities were consulted during this time, and that he previously had the matter all ready in his mind, otherwise such performances, if continued for any length of time, must be considered as little less than miraculous.

We have cited Scott, to show the necessity, and the practice of active amusements in a man of letters, because his writings are generally known, and because it might be supposed by some, that the great number of his productions, and the rapidity with which they followed each other, precluded the possibility of his spending any considerable portion of time in bodily exercise, whereas we see, that this was, at least for a time, the very means by which he was enabled to perform such extraordinary mental efforts. Nor was Scott an exception in this respect to the practice of other British authors, and especially those of Scotland, who, whatever their ages, or offices may be, are in the habit of making play a part of their daily duties.

But notwithstanding Scott understood so well the principles which ought to govern students with respect to muscular exercise, and for a long time reduced them to practice, still his pecuniary embarrassments forced him to such unparalleled mental exertions, as finally to affect the cerebral and nervous functions in such a manner as to induce a morbid condition of the whole system, from which he never recovered. So that the noble part by which he distinguished the age in which he lived, finally became the instrument by which he was destined to perish.—A striking commentary on the principle, that the equilibrium of the nervous, and muscular systems cannot be deranged with impunity.

It has been, not unaptly observed, by more than one of our Trans-Atlantic brethren, on visiting this country, and noticing our manners and habits, that "the Americans are very complete masters of the art of *working*, but that they do not yet understand the art of *playing*." This is undoubtedly true, the newness of our country, originally, and some parts of it at the present time, making it necessary for all classes to labor more or less with their hands, and to this circumstance the present prosperity and vast enterprize of our nation is in a great measure owing. It is from the same cause also, that as a nation, we have acquired the almost universal sentiment, that a man ought to labor constantly, and with little, or no relaxation, so long as he is able, let his occupation be what it may; and this opinion is followed by a practice nearly as universal. Now so far as muscular labor is concerned, this practice is not incompatible with the prospect of a long life and robust health, and therefore, whether followed from necessity, or for profit, or pleasure, seldom so deranges the balance between the muscular and nervous systems as to induce premature evil to either. But if, instead of depending upon foreign authors for our literature and science—if we are to look to the pens of our own sons, and daughters, for books of instruction for the rising generation, and for even but a small portion of the mental food which this vast republic requires, then it is certain that so far as this class is concerned, the sentiment requiring perpetual labor must be changed, for as we have abundantly shown, the Creator did not form man for incessant mental labor.

PHYSICAL AND MENTAL EDUCATION OF YOUTH.

The proper use of the muscles consists in their alternate contraction and relaxation, and this is one of the most imperious laws of the animal economy. If the muscles are allowed to remain in a state of relaxation for any considerable time, they become incapable of vigorous contraction, as we have already stated. The cases of prisoners long confined in cells, or in chains, so that they could not use their limbs, have often presented lamentable illustrations of this principle. Such persons, without any positive disease, become unable to walk, or even to stand from mere debility of the muscular system. The deplorable case of poor Caspar Hauser who was confined from his infancy in a small dungeon, and whose story is every where known, presented a still more striking, and miserable example of the same principle.

On the contrary, if relaxation gradually destroys the strength of the muscles, so are their powers most rapidly exhausted by continued contraction. This indeed appears to be impossible for any considerable length of time. To hold the arm in a horizontal position for ten minutes, even without any weight in the hand, is what no one can do without pain. To stand perfectly still on both feet, is also a most fatiguing position, because in this posture the muscles of the limbs are under continual tension. Hence it is, that soldiers, who are capable of enduring great exertions in marching, soon become impatient and tired, if kept beyond a certain length of time in the line, on parade; and hence also, the necessity that the drill officer, who would have his men appear well on parade, should often employ the word "*rest*" in its military sense, it being impossible for them to keep the line in the attitude of soldiers, more than a few minutes at a time.

If then men, and soldiers too, are incapable from their organization of avoiding the relaxation of their muscles, how much more difficult it must be, for children and youth, whose limbs are instinctively in perpetual motion, to restrain themselves from this natural propensity. Rest, to these young creatures, after a time, undoubtedly becomes much more painful than any degree of hunger, or thirst they have ever felt; for these wants, it would be considered the highest cruelty not to supply. But the child, often, as every parent may have observed, after coming out of school, prefers the exercise of his muscles, for a while, to the gratification of his hunger.

Consequences of the confined position of Females at School.—"The Principles of Physiology, applied to the Preservation of Health," by Dr. Combe, of Edinburgh, contains some capital remarks, on the subject of muscular action in youth, and which are undoubtedly applicable, though it is hoped, only in a limited degree to our own country.

"Although contraction and relaxation, says the author, or in other words, exercise of the muscles, which support the trunk of the body, are the only means, which according to the Creator's laws, are conducive to muscular development, and by which the bodily strength, and vigor can be secured. Instead of promoting such exercise however, the prevailing system of female education, places the muscles of the trunk, in particular, under the worst possible circumstances, and renders their exercise nearly impossible. Left to its own weight, the body would fall to the ground, in obedience to the ordinary law of gravitation; in sitting and standing, therefore, as well as in walking, the position is preserved only by active muscular exertion."

"But if we confine ourselves to one attitude, such as that of sitting erect on a chair—or what is still worse, on benches, without backs, as is the common practice in schools—it is obvious that we place the muscles which support the spine and trunk, in the very disadvantageous position of permanent, instead of alternate contraction; which we have seen is in reality more fatiguing, and debilitating to them than severe labor."

"Girls thus restrained daily, for many successive hours, invariably suffer:—being deprived of the sports, and exercise after school hours, which strengthen the muscles of boys, and enable them to withstand the oppression. The muscles being thus enfeebled, they either lean over insensibly to one side, and thus contract curvature of the spine; or, their weakness being perceived, they are forthwith cased in stiffer, and stronger stays—that support being sought for, in steel and whalebone, which Nature intended they should obtain from the bones and muscles of their own bodies."

"The patient, finding the maintainance of an erect carriage, (the grand object for which all the suffering is inflicted,) thus rendered more easy, at first welcomes the stays, and like her teacher, fancies them highly useful. Speedily, however, their effects show them to be the reverse of beneficial. The same want of varied motion, which was the prime cause of the muscular weakness, is still further aggravated by the tight pressure of the stays interrupting the play of the muscles, and rendering them in a few months more powerless than ever."

"In spite, however, of the weariness and mischief which result from it, the same system is persevered in; and, except during the short time allotted to that nominal exercise, the formal walk, the body is left almost as motionless as before, the lower limbs only being called into activity. The natural consequences of this treatment are debility of the body, curvature of the spine, impaired digestion, and from the diminished tone of all the animal and vital functions, general ill health:—and yet, while we thus set Nature and her laws at defiance, we presume to express surprise at the prevalence of female deformity and disease."

In the "Cyclopedia of Practical Medicine," the same subject occupies the attention of several writers, and sufficient proof is there adduced that Dr. Combe has not been mistaken in his apprehensions with respect to the consequences of the course of physical education above described.

Dr. Forbes, one of the writers above referred to, says that he "*lately visited a boarding school in a large town, containing forty girls; and that he learned on close and accurate inquiry, that there was not one of these girls who had been at the school two years,* (*and the majority had been there as long,*) *that were not more or less* CROOKED!"

"Our patient," he continues, "was in this predicament; and we could perceive, (what all may perceive who meet that most melancholy of all processions—a boarding school of young ladies in their walk,) that all her companions were pallid, sallow, and listless. We can assert, on the same authority of personal observation, and on an extensive scale, that scarcely a single girl, (more especially of the middle classes,) that has been at a boarding school for two or three years, returns home with unimpaired health; and for the truth of this assertion, we may appeal to every candid *father*, whose daughters have been placed in this situation."

In the same work, it is stated by Dr. Barlow, that at least in some boarding schools, it is the practice to allow the young ladies only *one* hour of exercise, consisting of a slow walk arm in arm on the high road, and that even this, only when the weather is fine,—*while their tasks in school are continued nine hours ; besides which, they are occupied three and a half hours per day, in optional studies, or in works.*

Dr. Barlow further remarks, that the superintendents of these schools are generally extremely anxious about the welfare and health of their pupils ; and that it is through *ignorance* of the consequences, that such a course is pursued.

How far these strictures are deserved by the superintendents of boarding schools in this country, the author does not pretend to judge. It is however well known, and acknowledged, that the subject of popular education in this country, is better understood than it is in Great Britain, or perhaps in any part of Europe ; and we may therefore perhaps justly infer, without reference to the facts, that at least some of the pernicious usages still retained in their schools, no longer exist here.

It is however believed that a reference to the facts will show, that at least in New England, the boarding schools to a considerable extent, are in a measure free from deserving censure on account of confining their pupils too closely ; though we have no doubt that less study and more exercise, taken regularly, would be highly advantageous to the mental progress, and certainly to the constitutional firmness of the pupils.

Instead of so many successive hours being devoted to study and to books, the employments of the young ought to be varied, and interrupted by proper intervals of cheerful and exhilarating exercise ; such as is derived from games of dexterity, which require the co-operation, and society of their companions. This is infinitely preferable to the solemn processions which are so often substituted for recreation, and which are rather hurtful than otherwise, inasmuch as they delude parents and teachers into the notion that this is really exercise ; whereas the slow, measured step, and the locked arms, and the solemn silence, shows that there is not a single element of wholesome recreation in such a procession.

It has already been shown, that mental cultivation cannot be carried on without a proper, and due proportion of corporeal activity, even in adults; and it is well known that youth require much more action than their parents, in order that the several functions of the animal fabric may be properly developed, and ultimately gain their most perfect condition. And who had not much rather see his child return home from school with a little less algebra, and a good stock of health, than to know that she had outdone her class mates, and obtained the highest prizes, while the pallid cheek, and the crooked, emaciated frame, shows that this has been done at the expense of her health?

Boys may run through the streets, play ball, skate, snow-ball, fish and hunt, while the fate of the poor girls is fixed, and bound down to the sedate, and measured walk, and this only for a short distance, and at stated times. And still the girls require full as much exercise as their brothers. It is true, as will be seen in another place, that the dress of females is far more pernicious in its consequences, than that of the males; and hence in a degree, undoubtedly, we may account for the greater number of deaths by consumption in the former, than among the latter. But is it not to be feared that in many instances, a predisposition to consumption is acquired in females in early youth, in consequence of the want of those wholesome sports which the boys enjoy? And is it not the duty of parents and teachers to look to this subject especially, and see whether there is not a prevailing error in this respect?

Remarks of the Rev. Dr. Dick.—The Rev. Dr. Dick, in his excellent work on Mental Illumination, has some good remarks on the subject of school exercises for the body.

"Pupils of every description," says he, "should be daily employed in *bodily* exercises, for invigorating their health and bodily powers. Every school should have a play ground for this purpose, as extensive as possible, and furnished with gymnastic apparatus for exercising the muscular activities of the young of both sexes.—Swings, poles, hoops, see-saws, pulleys, balls, and similar articles, should be furnished for enabling them to engage with spirit and vigor in their amusements. In walking, skipping, running, leaping in height, length, or depth, swinging, lifting, carrying, jumping with a hoop or pole, they will not only find sources of enjoyment—when these exercises are properly regulated, to prevent danger and contention—but these enjoyments will also strengthen, and develope their corporeal powers. All imitations, however, of war and military manœuvres, should be generally prohibited; as it is now more than time that a martial spirit should be counteracted, and checked in the bud,—and those who encourage it in the young, need not wonder if they shall ere long, behold many of them rising up to be curses, instead of benefactors to mankind. They might likewise be occasionally employed in making excursions, in company with their teacher, either along the sea shore, the banks of rivers, or to the top of a hill, for the purpose of surveying the works of nature and art, and searching for minerals, plants, flowers or insects, to augment the school museum, and to serve as subjects for instruction."

"If every school had a piece of ground attached to it for a garden, and for the cultivation of fruit trees, potatos, cabbages, and other culinary vegetables, children of both sexes, at certain hours, might be set to dig, to hoe, to prune, to plant, to sow, to arrange the beds of flowers, and to keep every portion of the plot in neatness and order."

"Such exercises would not only be healthful and exhilarating, but might be of great utility to them in after life, when they come to have the sole management of their own domestic affairs. They might also be encouraged to employ some of their leisure hours, in constructing such *mechanical* contrivances and devices, as are most congenial to their taste."

"If instead of *six* or *seven* hours confinement in school, only *five* hours at *most* were devoted to books, and the remaining hours to such exercises as above mentioned, their progress in practical knowledge, so far from being impeded, might be promoted to a much greater extent."

"Such exercises might be turned, not only to their physical and intellectual advantage, but to their *moral* improvement. When young people are engaged in their diversions, or in excursions along with their teachers, their peculiar tastes, tempers, and conduct towards each other, are openly developed; they act without restraint; they appear in their true colors; and a teacher has the best opportunity of marking the dispositions they display. He can therefore apply at the moment those encouragements, and admonitions, and those Christian rules and maxims, by which their characters, and conduct, may be moulded into the image of Him, 'who hath set us an example, that we should walk in his steps.'"

"The incidents, and the atmospherical phenomena which may occur on such occasions, will also supply materials for rational observations, and reflections, and for directing the train of their affections, and the exercise of their moral powers; and no opportunity of this kind, for producing useful impressions upon the young, should be lost by the pious and intelligent instructor."

Every reflecting teacher and parent, who reads the above remarks, will see in them all that humanity, discretion, and judgment which every where distinguish the pen of Dr. Dick, and especially when he speaks of the physical and moral education of youth. But although several of the exercises he has mentioned, are fit for young ladies, they are meant to apply chiefly to boys, for whose use there seems to be little difficulty in the selection. But with respect to the girls, it is obvious that a distinction must be made, for although they perhaps, require as much action as the boys, it ought generally to be less athletic in its kind, and such as especially to give motion to the arms and muscles of the chest. As a reason for selecting exercise of this sort, for females, we will only recur to the well known fact, already mentioned, that they are more liable to the consumption of the lungs than males, let the cause be what it may. Such recreations therefore, as give motion to the pectoral muscles,—as open and expand the lungs and chest, and give strength to the organs of respiration generally, are peculiarly proper for females.

CALLISTHENICS.

The regular and somewhat scientific gymnastics, formerly introduced into schools, under the title of *Callisthenic exercises*, have, we believe, had their day, and gone into general disuse. Possibly the novelty of this method was its chief recommendation, though it is said that some were injured by it, either from the unnatural positions into which the limbs were thrown, or by the violence of the motions.

The great objection to this mode of exercise, however, we conceive arises, not from these causes, for the positions, as well as the violence of the motions could easily be regulated according to the condition, or strength of the pupil, which certainly ought to be the case in every exercise. The objection is founded on other grounds, and the reason why this method does not prevail, is, that it does not answer the purposes intended; nor will any other exercise, which has no motive connected with it, and therefore does not interest the feelings, and excite the brain.

Mere positions, or mere muscular contractions, as we have abundantly shown, are of very little use, especially to the young. During inclement weather, when the pupils cannot employ the more exciting means of health in the open air, throwing the hoop, or playing at battledoor, may very properly be used as substitutes, and in which some take considerable interest. But throwing the limbs backwards and forwards, or up, and down, or the use of the dumb bell, or any such sort of action, without an object in view, other than that of employing the muscles, ought never to be depended upon as a means of preserving the health of students. (*See more on this subject at the end of the volume.*)

ARCHERY.

One of the most proper, convenient, modest, graceful, and healthful athletic recreations for females is, ARCHERY. Every female school establishment should therefore have a piece of ground marked off, together with targets, and bows and arrows, prepared for this pleasant and invigorating diversion.

This exercise is peculiarly advantageous, and proper for females, on account of the reason already given why they ought to employ every means for invigorating the chest in early life, and were these recreations generally adopted, we have no doubt, but many a slender one, who would otherwise occupy an untimely grave, might long be preserved to herself and society.

Nor is this exercise at all deficient, when properly carried on, in that excitement which gives vigor to the muscles, and buoyancy to the mind. But for this purpose there must be preparations, and circumstances attending it, which it is necessary to describe.

It is well known that the bow and arrow was anciently the most efficient means of defence among civilized men, and that before, and even after the invention of gun-powder, it was the chief weapon employed in the wars of Europe.

In England, in the time of Henry VIII. every man in the kingdom was obliged by law to have in his house a good bow, and three arrows. Charles II. was an archer himself, and once knighted a man for having beat Sir Wm. Wood, a famous bow-man, in a game of shooting. Such was the love of this sport in England, that particular spots of ground were appropriated to the archers, by the law of the land, but these being gradually encroached upon, by tenements and gardens, the people assembled, and without authority, cleared and levelled the grounds without reference to trees, ditches, or other obstacles, until they opened the space of the archery-fields agreeably to the ancient landmarks. Such importance did the people attach to this sport; and at that period, on account of their athletic exercises, men were much stronger in all their limbs than we are at the present day.

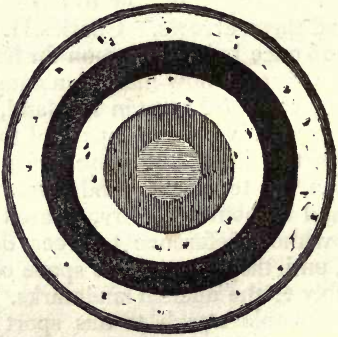
This fine exercise afterwards gradually declined, and for a long time was little practiced except by boys; but has recently been revived, particularly in England, where every year meetings of archers, of both sexes, frequently occur. These meetings are attended by many of the female nobility, and are said often to compose the most brilliant, and attractive rural fetes, which are enjoyed in that country.

Ladies may shoot at a distance of twenty or thirty yards, and the attitude of an accomplished female archer—of one who has studied and practised the art in a proper manner, at the moment of bending the bow, is particularly graceful—all the actions and positions tend at once to produce an appearance of vigor in the frame, and to impart a general elegance to the deportment.

The excitement of feeling, which a competition among the fair archers produces, together with the muscular exertions which such occasions call forth, make this among one of the most healthful and agreeable pastimes in which propriety permits young ladies to indulge.

The face of the target has a gilded centre, around which are four circles, of which the inner one is red; the second white; the third black; and the outer one white, with a narrow border of green. The propor-

Fig. 124.



tions may be as in the adjoining fig. 124. The diameter may be from one to two feet, according to the distance, and expertness of the shooters.

The mode of ascertaining the value of the hits, which is increased in proportion as they strike near the centre, is as follows. The hits in the centre are multiplied by nine; in the red, by three; in the inner white circle by two; by adding a fourth to those in the black, and counting without alteration those in the outer white.

Suppose then that Miss A. has 1 shot in the centre; 4 in the red; 5 in the white; 8 in the black; and 6 in the outer white; then the value of the first is 9; the second 12; the third 10; the fourth 10, and the fifth 6=47; the value of Miss A's shots. Suppose Miss B. has 2 in the centre; 1 in the red; 3 in the white; 8 in the black, and 6 in the outer white, then the value of her shots will be, in the first 18; in the second 3; in the third 6; in the fourth 10, and in the last 6=43, the value of Miss B's shots.

Selection of Bows and Arrows.—Bows should be from four, to five and a half feet in length, according to the height and strength of the individuals who are to use them.

The shaft of the arrow should taper gradually from the head, or *pile* as it is termed, to the *nock* or notch,

Fig. 125.

Fig. 125. The length of the arrow should be from two to three feet, and made of light wood, with a head of some harder material, as lignum vitæ, or horn.

In *stringing* the bow, which the lady should learn to do herself, the bend should not be greater than to bring the string, in a bow of five feet long, to a greater distance than five or six inches from the centre. If the bow be bent to nearly a half circle, as is sometimes done, it destroys a great proportion of its elasticity, and at the same time prevents giving the arrow its full force, by requiring the right hand to be drawn too far back in the act of shooting.

To pull the string back for the discharge of the arrow, good shooters do not employ the thumb, but two, or three fingers, the arrow being held between the fore and second. These fingers are protected by a glove of three fingers, made of stout leather, so that these delicate parts should not be exposed to injury.

The bow being strung, it is grasped, when about to be used, by the left hand, at a little distance from the centre; well made instruments having a place, or handle, for this purpose.

The arrow is then to be taken in the right hand by the middle, and carried under the string to the left of the bow, until its head reaches the left hand, the fore finger of which receives it, and the right hand is removed from the middle to the nock: the arrow is next to be drawn down the bow, and the string placed in the nock, with the red feather uppermost; the fore finger is then withdrawn from the arrow, and placed round the bow in its original place. The body now stands in the position of Fig. 126, with the weapon as there represented.

Fig. 126.

"The attitude of shooting, (says the Ladies' Book,) is a matter of much importance: the heels should be a few inches apart, the neck slightly curved, so as to bring the head a little downward; the face, but not the front of the body, is to be turned towards the mark. The left arm must be held out quite straight to the wrist, which should be bent inwards; the bow is to be held easy in the hand, and the arrow when drawn should be brought, not towards the eye, but the ear."

127.

"The right hand should begin to draw the string, as the left raises the bow: when the arrow is three parts drawn, the aim is to be taken; in doing this, the pile should appear at the right of the mark; the arrow is then drawn to its head, and immediately let go." The arrow passes along the root of the thumb and fore finger. Fig. 127 represents a female archer, at the instant of shooting.

A person at the target is furnished with a card, marked off as follows, for the convenience of inserting the names

Name.	Gold.	Red.	I. White.	Black.	O. White.	Total.	Value.
A	1	4	5	8	6	24	47
B	2	1	3	8	6	20	43

of the shooters, and recording their hits. This will be understood by a reference to Fig. 124, together with the rules for estimating the value of the hits in the different circles, already given. The account is kept on the card, by making a pin hole through the compartments, corresponding to the circles on the target, for each hit.

We have been thus particular in describing this sport, because we consider it one of the most healthful and appropriate in which young ladies can indulge; and cannot therefore but hope that it will be introduced into boarding schools generally, as a recreation.

APPENDIX.

CONTAINING A DESCRIPTION OF THE ATTITUDES OF STANDING, WALKING, SITTING, AND LEANING; TOGETHER WITH REMARKS AND OBSERVATIONS ON SPINAL DISTORTIONS, AND THE USE OF STAYS.

The attitudes which the human frame is capable of assuming, are exceedingly various, but physiologists have reduced them to two kinds, or classes; the *active*, and the *passive*. The former includes all such as require the action of the muscles, as standing, or walking; the latter, such as require no muscular exertion, as when the body lies prostrate.

STANDING.

When we stand on both feet, considerable muscular effort is required to preserve the upright position; and still more when we stand on only one foot. In either case, the centre of gravity, which is between the hips, must be kept over the base.

In the first attitude, the base of support is the space between the feet, including the breadth of the feet themselves in one direction, and their length in the other; and hence when the toes are turned outwards in standing, or walking, the base is enlarged. In the last, the base is the single foot only. During this position of the body, nearly all the muscles of the lower extremities, as well as those of the back, are in a state of continual action; and this is the reason why we become sooner fatigued when standing still, than when walking, in which the muscles are alternately contracted and relaxed.

When we stand erect, the vertebral column transmits the weight of the head, as well as of all the other parts of the body above the hips, down through the lower limbs to the feet; and hence the necessity that this column should have great strength and firmness, as formerly shown.

In standing, if the spine is bent backwards so as to throw the line of the centre of gravity behind the base, the position soon becomes painful; since the muscles of the back must be in a continued state of unnatural tension, in order to maintain this position, and also because the muscles of the lower limbs are unduly straightened, for the purpose of preventing the body from declining backwards, and thus losing its balance. This uncomfortable position is represented by Fig. 128.

The most natural posture in standing, is that which

Fig. 128.

Fig. 129.

can be supported longest with the least fatigue, and this appears to be when the spinal column is kept in a position similar to that shown by Fig. 63; the muscles of the back being kept in only just sufficient action to maintain the spine erect; the chest and arms, at the same time, being thrown forward, so as to bring the centre of gravity somewhat forward, rather than behind the base, as shown by Fig. 129. In this posture, all the muscles will be found to be in as complete a state of relaxation, as is consistent with the erect position of the body.

If the pupil will imitate a few times the different postures here represented, she will soon find by experience, that one can be maintained much longer than the other.

The Foot.—In describing the parts concerned in standing and walking, we will begin with the base, or foundation.

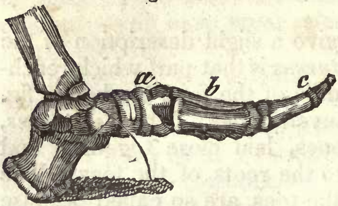
We will however only give a slight description of the bones of this part. The *tarsus* is that part which reaches from the heel to the middle of the foot, marked *a*, fig. 130. It is composed of seven bones. The *metatarsus*, *b*, consists of five long bones, laid close together, and reaching from the tarsus to the roots of the toes. The *phalanges*, *c*, or bones of the toes, are so called because each row forms a *phalanx*. Of these there are fourteen in the whole. Thus the bones of the foot are 26 in number. These are covered with cartilages, and supplied with tendons; the first binding them together in the strongest manner, and the second giving them motion in all directions. There is indeed no part of the human frame which is put together with so much care, and so strongly guarded against accidents, as the foot. It is obvious that were this not the case, so small a part would not withstand the violent concussions to which it is subjected, in sustaining the whole weight of the body, in leaping and other exercises.

The two bones of the lower limb, the *tibia*, or shin bone, and *fibula*, which is placed on its outside, form by their lower extremities, the inner and outer *ankle* bones. These are articulated with the great bone of the foot, called the *astragatus;* by which a hinge joint is formed, having also some lateral motion.

Now when we walk, this joint allows the foot to roll easily upon the ends of these bones, so that the toes may be directed according to the inequalities of the surface over which we pass. But when the foot is fixed on the ground, the muscles instantly act in such a manner as to give the joint a firm support, so that the whole body rests upon it, while the other foot is carried forward.

In walking, the heel first touches the ground, at which instant the bones of the leg and foot are in the positions with respect to each other, represented by Fig. 130. If the legs were situated perpendicularly over the part which first comes to the ground, we should come down with a dead blow, or jolt, as one does who has a wooden leg. Whereas, by this arrangement, the foot acts as a lever; and by the action of the muscles, lets the weight of the body come down gradually to the ground.

Fig. 130.



But notwithstanding these easy motions of the foot, the whole becomes exceedingly firm, and fixed, when the weight of the body bears directly upon it; so that the bones of the leg will be fractured, before those of the foot will be displaced, or will yield in the least.

With respect to the action of the muscles connected with the foot, which are concerned in supporting the body in the upright position, Sir Charles Bell speaks as follows:

"The posture of a soldier under arms, when his heels are close together, and his knees straight, is a condition of painful restraint. Observe then the change in his body and limbs, when he is ordered to "stand at ease;" the gun falls against his relaxed arms, the right knee is thrown out, and the tension of the ankle joint of the same leg is relieved; whilst he looses an inch and a half of his height, and sinks down upon the left hip. This command to "stand at ease," has a higher authority than the general order. It is a natural relaxation of the muscles, which are consequently relieved from a painful state of exertion: and the weight of the body then bears so upon the lower extremities, as to support the joints independently of muscular effort. The advantage of this will be understood, when we consider that all the muscular effort is made at the expense of a living power, which, if excessive, will exhaust the man; whilst the position of rest we are describing, is without effort, and therefore gives perfect relief. And it is this which makes boys and girls, who are out of health and languid, lounge too much in the position of relief, from whence comes permanent distortion."

The standing position is as firm as possible, when the two feet, directed forwards on two parallel lines, are separated by a space equal to one of them. If the base of support is enlarged in a lateral direction, by separating the feet, the standing becomes more firm in this direction; but is less so from behind, and before. When one foot is placed in a line before the other, the backward and forward support becomes firm, in proportion as the base is extended in these directions; while the right and left foundation is diminished to the breadth of the foot.

The importance of the toes in standing, will be seen, when it is considered that their loss will deprive the base of about one fourth of its length in that direction. In walking, the loss of these parts is a still greater misfortune; the elasticity of the step being thereby so diminished, as to give the gait the appearance, rather of one who walks on wooden legs, than on sound limbs.

Standing on one Foot.—With respect to *standing on one foot*, it is only necessary to say, that the base of support is reduced to the surface which the foot covers, and therefore that the muscles of the whole limb must be in strong action, in order to keep the body from falling in such a position, which consequently can only be supported for a few minutes.

WALKING.

In walking, the position of the body should be erect, the head being always kept over the centre of gravity. The step should be firm, with the toes turned out, so that the foot at each step, will make an angle of about 33 degrees on each side of a right line projected forwards on the ground through the centre of gravity. If the feet form parallel lines with each other in stepping, the gait is vulgar, and tottering from right to left, the base not being sufficient to give a firm support to the centre of gravity. If the toes be turned outwards too much, although the lateral sides of the base are thereby extended, yet the movement is awkward, and unseemly, especially in ladies, and the step will want that elasticity from the action of the toes, which gives lightness and grace to the gait. The foot should be carried forward with the toes raised sufficiently to avoid impediments, but no higher, for no position of the foot in walking, is more graceless and vulgar, than that of placing the heel, with the toes so elevated, as to give them an apparent dread of the ground, as though they were covered with *corns*. Such a lifting up of the toes, together with their parrot-like crossing of each other in walking, form a gait, which no well bred person will practice, unless compelled to do so by deformity, for with common attention it may be avoided.

Pedestrianism. With respect to the style of walking which gives the greatest velocity, with the least muscular expenditure, pedestrians have learned by experience to adopt a manner peculiar to themselves. Capt. Barclay, who performed the extraordinary feat of walking 1000 miles, in 1000 successive hours, inclined his body so as to throw the centre of gravity a little forward of the centre of the base, thus making its weight rest chiefly on the front of the knee joints. His step was short, and he raised his feet only a few inches from the ground. Any person, it is said, who will try this plan, will find his pace quickened thereby ; at the same time his walking will be more easy to himself, and he will be better able to endure the fatigue of a long journey, than by taking the erect posture, which throws too much of the weight of the body, it is said, on the ankle joints. Capt. Barclay always used thick-soled shoes, and lambs-wool stockings. The former he found indispensable, and had them so large as to avoid unnecessary pressure. Every sportsman of the least experience understands this, never venturing on an excursion, however dry the walking may be, with thin-soled boots.

SITTING.

The postures which we take in sitting, are exceedingly various, and, on some accounts, of the highest importance, especially to youth. Thus we may sit on the ground with the limbs extended forward ; or upon a low, or high seat, with, or without a back, and with the feet touching, or not touching the floor, &c.

The sitting posture, even without the support of the back, can be maintained much longer than that of standing, because the centre of gravity is thrown nearer the base ; and because the weight is diminished, and consequently the muscular power required to support the erect posture, is lessened. But this position, without the support of the back, after a time, becomes too painful to be endured with patience.

The sad consequences of long confinement in the sitting posture, without any support for the back, have already been described at some length, under another head, but the more we have thought upon, and examined this subject, the more important it appears, and we cannot therefore, in duty to the youth of our country, dismiss it, without some further considerations and remarks.

Causes of Spinal Curvatures.—It is proposed here to trace the effects of the causes to which we have already referred with respect to curvatures of the spine, and to show why certain positions will make this deformity permanent.

The spine itself, detached from all other parts, is figured and described at p. 84, Fig. 63, where the light colored transverse lines between each two vertebrae, show the cartilages of the spine. These cartilages are in the young subject, about the fourth of an inch in thickness, and are compressible, and elastic like pieces of India rubber. Were it not so, the spine would be rigid, and, unyielding as though it was formed of one continued piece of bone. Its motions therefore are in consequence of the elasticity of these cartilages, so that when the spine is bent, one of their sides, or edges, are compressed more than the other.

In the night, when we take the recumbent posture, and there is no pressure on the spinal column, these elastic plates swell and become thickened, but their thickness is again reduced by the weight of the body during the day, and especially in laborers who carry weights on their heads. The diurnal difference in the thickness of each cartilage, from these causes, it is true, is very slight, but their number is such, as to make an appreciable difference in the length of the column at different times. In young persons, the elasticity is much greater than in the aged, these parts gradually hardening with the years a person lives, until the spine finally looses a great proportion of its flexibility, and in these circumstances, there is very little diurnal difference in the length of the column. But in youthful persons, the difference in the length, especially if they are tall, between morning and evening, may be from half, to a quarter of an inch, and may be found by the common mode of measuring. Thus do we grow taller during the night, and shorter during the day.

Now these cartilages, being thus compressible and elastic, in young persons, but gradually hardening with age, it is plain, that if one edge, or side, in such a one be pressed more than the other, and this pressure be continued for any considerable length of time, they will not grow of a uniform thickness, the part thus pressed becoming thinner, and the opposite part thicker than natural. Without reference to growth, the same effect would be produced by the pressure of, and the gradual hardening of these parts. Therefore, if the spinal column be bent into any unnatural shape, and the same posture be continued day after day, and month after month, as is too often the case with young ladies at school, the cartilagious plates will finally become wedge shaped, having a thick and a thin edge, and as they harden with age, they will continue to operate as wedges in retaining the spine in that crooked state by which they were forced into this form: and thus the person will probably become deformed for the remainder of her life, in spite of all the frames, pullies, and weights, or other Procrustean apparatus, which may be applied to remedy the evil.

This effect would be produced in such persons as had not arrived at the age, when the cartilages become hard. But in those who are quite young, as from infancy to 12, or 14 years, even the bones of the spinal column being still comparatively soft, would conform more or less, to the curvature given it, thus making a deformity from which there is not the slightest hope of relief, since the great beam of the whole fabric has thus become permanently misshapen.

Sitting postures described.—It might perhaps be considered unnecessary to give any instructions on the most comfortable manner of sitting, it being a natural supposition that every one would consult their own experience in this respect. And yet, it may be the case, that a few observations and experiments on this subject will be the means of diminishing the pain of those who are for any considerable time confined to this position, and thus avoid some of the evils which might otherwise arise from it.

The sitting posture, it will be found, soon becomes painful, and is maintained with difficulty when the inferior portion of the spinal column is bent inwards, and the arms are thrown back, with an erect position of the neck and head. Even when the spine is supported by a back, as in a chair, this posture becomes uneasy, because the dorsal muscles, and those of respiration also, are kept in an unnecessary state of action. This position will be understood by Fig. 131.

Fig. 131.

Fig. 132.

The most comfortable posture in sitting, is that which at once relaxes the muscles of the back and those of respiration—the inferior portion of the spine being gently curved but not made crooked ; while the upper part is nearly straight, with the neck a little inclined, so as to relax the muscles supporting the head. This position is represented by Fig. 132.

A little experience, with these suggestions in view, will teach the pupil, it is hoped, to preserve a healthful and becoming position at school, without assuming the leaning posture, the consequences of which are so pernicious.

LEANING POSTURE.

One posture which school girls are exceedingly apt to take, is that of leaning forward, and placing the elbow on the desk for support; and this they often do, even when their seats are provided with backs. This posture, if continued so as to form a habit, will often show its effects on all occasions, the young lady having such a disposition to lean as to indulge it when any support happens to be near where she sits, let the place, or company be what it may. Such a one will lean, with the hand supporting the head, when at home, on a table, or window stool, or any other convenient lolling place, for hours together.

Where the spine is weak, in a growing girl, and there is predisposition to curvature, there is no posture that she can take, which is so unfortunate, and will produce such a complication of deformities as this; for if it is continued in one direction, which is commonly the case, the consequences will be *a curvature of the lower part of the spine, together with one high, and one low hip; one high, and one low shoulder; and a crooked neck.*

The general deformity, thus induced, is however, often most apparent in the shoulder blades, one of which is sometimes thrown so far out of place, as to give it the appearance of absolute dislocation, and which indeed, is the case, when compared with its mate. Fig. 133.

The other deformities which we have mentioned as arising from the same cause, may in some degree be concealed, or qualified by means of stays, extra padding, *coussinets*, and other efforts of the milliner's skill, with which we profess no acquaintance. But the dislocated shoulder blades, *especially when they are uncovered,* seem to defy all the arts of the most profound dress-maker, for neither stays, nor buckram, nor foundation mus-

Fig. 133.

lin, nor padding, can hide, but seem rather to magnify this deformity; at least humanity would hope so, when the eye beholds how great it still remains, under the apparent use of all these remedies.

Far be it from us to speak with unkindness, or levity on a subject which but too often calls for commiseration, and gravity. But when we see those, who might, peradventure, have passed, as specimens of symmetrical form among the fairest, and most charming of the Creator's works, unveiling deformities, (no matter what might have been their origin,) merely for the sake of rivalry in the extent of the fashion, we cannot but lament in such, the want of *common discretion*, *common prudence*, or *common modesty*—for did these unfortunates but know how such revelations sometimes affect the minds, and perhaps even the *hearts* of those whose kindness and good esteem they cannot but value, they certainly would have sacrificed less to fashion, and more to decency and discretion.

It is not pretended that curved spines, and deformed shoulders, are caused only, by the leaning posture above described, or that every one who even habitually takes that posture, will eventually become crooked. But in slender, delicately formed females, from the ages of from 12 to 14, who are confined eight or ten hours per day in the school room, with no other exercise, than a walk along the street, with their teachers, such a posture habitually indulged in, will most surely produce deformities to a greater, or less extent. The Hindoo devotees who hold their arms above their heads as a penance, are often compelled to carry them so during the remainder of their lives, the parts conforming to this position.

A highly observant, and accomplished teacher, who has spent more than twenty years in the instruction of females, informs the author, that he has long been aware of the distorting consequences of this posture, and that he could remember numerous instances, of crooked spines and dislocated shoulder blades from this cause :—and that although these very pupils were nearly every day warned of the consequences of such a habit, yet, not seeing, or feeling any ill effects from it themselves, they would carelessly indulge in it, until the posture became so natural, as to set all the common means of prevention at naught, and thus distortion followed of course.

Now if the young lady will give no attention to the mandates or remonstrances of her instructor, or parent, there is little hope of preventing her indulgence in this, or any other pernicious habit, and such, therefore, must be left to the reward of their own doings. But in most instances, it cannot but be hoped and believed, that those who are aware of the sad consequences of this habit, both in respect to personal form and health, whether they become so, by reading these observations, or otherwise, will take warning in due time, and thus escape that deformity which is now but too common among our best educated females.

DRESS ANOTHER SOURCE OF DEFORMITY.

There is, or at least has been, another cause of distorted shoulders besides that above described, and the effects of which, are in a great number of instances apparent, and will remain so during the present generation. This is the recent fashion of dressing so wide across the neck as to leave one, or perhaps both the *acromion processes*, or shoulder tips, in a state of entire nudity.

The young lady, it is true, had the power, by muscular action, of hiding a part of one shoulder at a time, but the dress, if in good fashion, could never be made to cover both these processes, except alternately, though it was quite easy to leave both uncovered. The consequence of this fashion was, that, judging from the perpetual motion of these parts, the wearer constantly felt as though her dress was in danger of slipping down, and which she made as constant efforts to prevent, or to ascertain by feeling with the shoulder whether this was the case, or not, until these motions became habitual, and therefore insensible. As the dress was designed to cover only one shoulder at the same time, this partiality, (for which shoulder it was intended, we know not,) was always extended to the same one, because habit made it most natural and comfortable; consequently the pressure on the two sides became unequal, and the wearer to counteract this, or from the unnatural, or uneasy feeling consequent upon confining one side, while its antagonist remained free, constantly, and habitually elevated one shoulder while the other remained stationary, until the former became permanently higher than the latter.

Although this (without using any other epithet,) pernicious fashion, we believe, is chiefly done away, at least among the fashionables, its consequences still remain, as many a monument of its existence can testify; and therefore, we hope it will not be considered impertinent, or improper to record its history and consequences, that mothers may be aware of both, when its turn, in the never ending cycle of costumal changes, shall again come round.

Fashionable Deformity.—The vast number of instances, in which the causes, already mentioned, or those which we shall hereafter notice, have occasioned female deformity, most of which might have been prevented, is a subject of very serious consideration, for besides the personal defects thus induced, these causes, or their consequences, often produce derangement in the functions of the viscera, which in their turn, superinduce either consumptions, or other lingering diseases, which it is exceedingly difficult, or impossible to remedy, and which therefore end in death.

In cities, personal deformity, among the higher classes has become so common, that it seems to form a characteristic of the age in which we live. A few years since, and perhaps even at the present time, such was the prevalence of curved spines among those females who gave tone to the fashions, that it actually became the *ton* to be crooked, and many fashionables, who had escaped any *misfortune in this respect*, contrived to give the upper part of their spinal columns a gentle curve, so as to imitate the *fashionable stoop*, of these female exquisites. And in many instances where there was not the least *intention* of becoming permanently deformed, but only to be in the fashion for the season, this genteel stoop became a habit, and nature not liking such impositions, has taken these poor devotees at their word, and having formed the cartilages of their back bones into wedges, has forever prevented their regaining that noble position which it was intended that man alone, among all created beings, should assume. These are therefore doomed to continue in one, and the same fashion, for the remainder of their lives.

EFFECTS OF PRESSURE ON THE MUSCLES OF THE BACK.

It is well known to physiologists, that if pressure be made, and continued on any part of the system, the part so pressed will be gradually diminished in consequence. Thus if one limb be tightly bandaged, for a length of time, it will become smaller than the other. To understand the reason of this, it is necessary to state, that every part of the system is furnished with two sets, or kinds of vessels, called the *capillaries*, one set being designed to *secrete*, or produce; and the other to absorb, or remove; and that in the living animal, both kinds are constantly performing their opposite functions. The flesh, and all the other parts of the body, are formed by the secretory system, which consists of the fine extremities of the arteries. We have already explained the manner in which the food is converted into chyle by the process of digestion, and now this is conveyed into the circulation, to be converted into blood. Now it is from the blood thus formed, that the secreting vessels produce all the different kinds of substance of which the several parts of the animal system are composed, one division forming flesh, another cartilage, and another bone, &c. All the fluids are also formed by appropriate organs belonging to the same system. Thus one set produce tears, another saliva, and another bile, and so on.

On the contrary, the absorbent system takes up, and conveys from one part to another, the various fluids which are either employed in the process of secretion, or which being secreted in some cavity, or on some internal surface, and having performed its office, is to be conveyed out of the body. Thus, the absorbents suck up the chyle by millions of mouths, and carry it to the thoracic duct, through which it is delivered into the circulation. They also absorb the superabundant moisture which is secreted in every interior part of the body, and consequently, did they cease to act, this watery fluid would accumulate, and a universal dropsy would ensue. This disease, as it occurs, is owing to the deficient action of the absorbents.

It is the office therefore of the secreting system, to produce and deposite the matter composing all the different organs, and fluids of the body; while the absorbents in their turn, take up and carry away, by slow, and insensible degrees, the matter thus deposited.

Such being the appropriate functions of these two great systems of vessels, which are distributed to every part of the animal frame, it is plain that the identical particles of which we are composed, are perpetually changing, and that in this respect we are not the same individuals now that we were formerly, nor will our bodies at a future time, contain a particle of the identical matter which they do at this moment.

In childhood, and youth, when the frame is growing, the secretion is greater than the absorption;—in adults, and the middle-aged, the effects of the two systems are just equal, there being the same quantity of matter absorbed, that there is secreted; but in old age the absorption is greater than the secretion, and hence the weight and dimensions of the body are diminished, and the skin, instead of preserving its tension, as formerly, becomes wrinkled, in consequence of the loss of a part of the bulk which it covers.

Thus, during one portion of our lives, we increase in size and vigor, until having arrived at maturity, we remain for a time stationary in both; and then, lastly, having passed through these two stages, we begin imperceptibly in both, to diminish, the animal functions gradually becoming more and more feeble, until one after another they cease to act entirely, when life gives place to death. These are the immutable laws which govern all created beings, and which therefore no human means can resist. All flesh must return to dust.

APPLICATION OF THESE PRINCIPLES.

In applying these principles to the use of stays, it is almost unnecessary to say, that during the growth of the system, pressure, on any of its parts, though it may be inconsiderable in force, yet if long continued, will prevent their increase; and this, not only for want of room to expand, but also by interfering with the function of the secreting system in that part. A lamentable illustration of the practical use of this principle, is seen in the feet of the Chinese ladies; which being confined in iron shoes from infancy to the age of sixteen, or eighteen, they remain infant's feet ever afterwards, though terminating the extremities of the aged.

But, besides this obvious effect of confinement during the growth of the system, it is well known that in the adult, as well as in the young, pressure will also diminish any part on which it is made, as already stated at the commencement of these observations. Not only the soft, or fleshy portions of the system may be thus absorbed and removed, but even the bones do not resist the power of these minute vessels, portions of their solid parts being sometimes carried away by their action.— Thus the enlargement of the aorta, or great artery, (which passes down the spine,) by a disease called *aneurism,* sometimes, pressing against the interior sides of the ribs, cause the entire destruction and removal of the parts thus pressed. We have seen an instance, where several inches of three, or four of the lower ribs, next to the spine, on the left side, were entirely removed from this cause; leaving a soft chasm, where the pulsation of the aneurism was frightfully apparent, both to the sight and touch. In the anatomical collection of Sir Charles Bell, there is preserved a specimen, showing the destruction of the lateral parts of four spinal vertebræ, from the same cause.

Indolent tumors, caused by diseased action of the part, are often reduced, and sometimes cured by pressure on the part, which in these cases is employed as a curative means. But it is unnecessary to quote more practical examples of the fact, that pressure will both prevent the growth, and diminish the bulk of any part of the living system on which it is made. This fact is indeed so common, that inveterate *snuffers,* who always carry a pinch between the thumb and finger, often acquire a little cavity in the ball of the former, where they keep this baneful luxury.

The pressure of stays around the waist, it is quite clear from the foregoing principles, must in youth, and while the system is growing, prevent the full development of the muscles of the back, by presenting an impediment to their increase of bulk; and if not assumed until the system has nearly, or quite attained its full size, as at the age of sixteen or nineteen, still the consequences may be equally pernicious, since the form, in this case, will probably be supposed to require a degree of tension in the lacing cords, somewhat proportionate to the time they have been delayed. The effect will therefore be to increase the absorption, and diminish the secretion of the parts pressed upon, and thus to reduce the bulk, and consequently, the strength and vigor of the muscles.

Now the spinal column is chiefly supported in the erect position by the strong muscles of the back, called the *dorsal* muscles; and if these, by any means, are diminished in bulk, or vigor, the spine will inevitably become distorted; and as we have shown that tight lacing produces the first effect, so it is equally certain that the last will follow. Thus the very means which a great proportion of the ladies of the present day, take to give themselves little waists, and consequently, as they conceive, inviting forms, become a deception, because it is a wicked interference with the laws of nature; and instead of producing the desired effect, in many instances at least, actually transforms them into crooked, disgusting objects; and in the sequel we shall see other consequences equally unfortunate from the same cause.

A mother who begins to corset her child at the age of ten or twelve years, intending to present to the world a few years hence, the "works of her own hands," modified and moulded according to her skill and taste, often finds that at the age of fourteen, or sixteen, she begins to "eat chalk," look pale, and grow crooked. To remedy the first, she detains her at home, lest she should expose herself by going into the air, especially if the season is cool; but finding that under this treatment, she becomes listless, and paler still, she consults the family physician, who very judiciously prescribes iron, and other tonics, according to art.

The crook of the spine, the mother undertakes to manage by her own skill, not letting the doctor know that any thing is wrong in that respect; but only that the girl is growing tall so fast, that she has hardly strength to keep herself straight—so that the most important part of the case is kept out of sight, and not prescribed for.

The kind parent begins by procuring a more substantial support for the back of her daughter, in the form of new stays, and which are made to order, with directions to insert an extra quantity of whale bone, and steel; and perhaps this instrument of torture is padded at certain points, so as to press with special force on that part of the spine which is most distorted, with the good intention of forcing it to its proper place. The means of cure being thus provided, they are put in their proper place, and the cords drawn with a force, in some degree proportionate to the affection of the mother, and the amount of the deformity which it is intended thus to obviate. But contrary to the anxious expectations of the family, the evil not only continues, but increases; and paleness, emaciation, loss of appetite, and general debility supervene, notwithstanding the stays are tightened, and the tonics are repeated, with a liberal hand. But it is needless to pursue the details of such a picture. It would in many instances lead us down to a premature grave, and we willingly leave the closing scene to those whose duties call them to witness it.

In such cases as we have above described, (and we leave it to any city practitioner in our country, whether such do not often occur,) the use of tight lacing, whether the patient has been habituated to stays, or corsets, from her childhood, or not, is productive of the worst consequences. The muscles of the back have already been so diminished, and debilitated by pressure, as to be unable to support the spine, otherwise there would have been no need of adding stronger stays; and in this condition, a little reflection ought to show that the offending cause should be instantly removed, or at least relaxed so as to allow the muscles free action; and that this, with country air, time, and exercise, would afford the most reasonable hope of cure. But by increasing the pressure, the healthy action of the muscles is entirely superceded, and a condition at least bordering on *palsy* of the part, is induced, and thus the intended remedy increases, and confirms the distortion.

That these are some of the consequences which follow such attempts to produce fine forms, and to cure curved spines, could have been inferred from physiological principles; but without depending on inferences, almost every person of common observation has seen a sufficient number of living witnesses, to convince him that thousands of such cases, or at least cases of female deformity, do exist.

No fashionable dress maker will deny, that one in four or five of her customers, among what are called *first rate* young ladies, do not require padding, or stuffing, on one part or another, in order to conceal some deformity, or make one side equal with the other.

Now we have nothing to do with the mere extravagances, or follies, if they exist, of the female costume of the present day; our design being to speak only of such fashions, or habits of dressing, as produce deformities, and disease: and in this respect, and on this subject, there are facts so common, and so deplorable, that they ought to induce thousands to raise their voices, and their authority, against the practices to which their origin is plainly to be traced.

EFFECTS OF TIGHT LACING UPON THE LUNGS.

It is true, that while the bones of animals are in a soft and pliable state, which is always the case when they are young, their natural forms may be modified, or moulded into almost any shape. Even the head, together with its contents, that noblest of all created organs in a reasoning being, can be changed from its natural form, to a parallelogram, or cube, as the customs of the Flat-headed Indians abundantly prove. Nor are we aware that this change produces any evil, either to the bodily health, or intellectual faculties; and since our design, as already declared, is only to condemn those fashions which by producing deformities, or otherwise, tend to shorten life, or produce disease, we should have nothing to say against the fashion of moulding the cranium into any form which the taste of the age might propose, if indeed no bad effects followed.

But if our female readers will examine the trunk of the human skeleton, represented at fig. 95, and observe in what manner the five lower ribs are attached, and how readily, in the young subject especially, they would so yield to the force of a tight band, as greatly to diminish the cavity they were intended to maintain; and also remember that this cavity contains the vital organs, the heart and lungs, neither of which will endure pressure with impunity—we think that on contrasting this with fig. 137, they can hardly avoid the conclusion, that other sad consequences must follow the use of tight lacing, besides the deformities we have described.

It is shown by fig 96, and its description, that the lungs are always in contact with the diaphragm, and that they completely fill the cavity of the chest on each side of the heart; this cavity cannot therefore be diminished, without exerting a direct pressure on the organs of respiration.

It is further shown, p. 156, that the lungs are composed of a tissue of blood, and air vessels, of such extreme tenuity, that the latter have been computed to amount to nearly two hundred millions in number, forming a surface of many hundred feet in extent; and that the blood vessels are equally numerous, presenting a surface similarly extensive. And, however incredible it may appear, the whole extent of these two surfaces, thus presented to each other, and by means of which a vital process is effected, without which we could not live a moment, is still contained within the narrow spaces occupied by the lungs; each of which do not exceed a foot in one direction, and six or eight inches in the other.

Now who believes, that organs so "wonderfully and fearfully made,"—so frail and delicate in their structure, as to present tissues of circulating vessels scarcely ex ceeding a spider's web in size, will permit such an abuse, as to be compressed into one third, or even one half their natural dimensions, without some punitive infliction on those who have the temerity to offer such violence to nature.

The first effect produced by compressing the lungs, will be a want of due oxygenation of the blood; because many of these minute vessels must thereby be closed against the admission, both of the air, and the circulating fluid.

By a reference to the article "Circulation," p. 134, it may be seen that in the Amphibia, only one half of the blood circulates through the lungs; and that in the Fishes, there is no aorta by which it is carried to the different parts of the system, as in other animals. The quantity of blood in the latter is also exceedingly small, when compared with that of other animals of the same size. In the amphibious animals, therefore, the circulating fluid consists of one half arterial, and the other half venous blood; and on this account, these tribes are cold-blooded, torpid, and almost without feeling. In the fishes, the small quantity of the circulating fluid, the want of an aorta to give it velocity to the different parts of the body, and the minute quantity of air the water contains; all conspire to keep the temperature of these animals down to that of the element in which they live, and to give their flesh a pallid hue, so different from the florid complexion of that of the Mammalia.

It is true that the organization of these animals, is undoubtedly well fitted to their conditions, and the places they were intended to occupy in the scale of creation. But we find, as we rise in this scale, that the organs of animals become more perfect, and that in the Mammalia, and man, the respiratory apparatus is so complete, as to expose the whole mass of blood to the influence of the atmosphere; and that the circulating system is such as to propel the vital fluid with great force and rapidity, to every part of the frame; and hence it is, that these animals differ so materially from those in which the respiratory function is less perfect, and the circulation less rapid and vigorous. In the former we find a temperature of 98° or 100° at all seasons, instead of a death-like coldness; and a high degree of vigor and vivacity, with a red muscular fibre, instead of torpor, insensibility, and white flesh, as in the latter.

Now if these very remarkable differences are in any considerable degree dependent on the quantity of oxygen, which the different races consume by the process of respiration, and which the facts we have detailed would seem to prove beyond all doubt; then is it not as clear, that by compressing the lungs so as to prevent the ordinary supply of oxygen in respiration, that the vigor of the circulation, which depends on that process, must gradually be diminished; and that paleness, torpor, listlessness, and gradual emaciation, from poverty of the blood, and a consequent want of a healthy secretion, must be the consequences?

It is quite certain that all these consequences, in very numerous instances, follow excessive lacing in young females; and from the hurried, and laborious respiration, which those exhibit who are undergoing the process of being moulded into a fashionable form, there cannot be a doubt but the aëration of the blood is defective; and hence the necessity of the quick and unnatural inspirations, in order to maintain the circulation, which would cease the moment the air ceased to act upon it. These devotees, besides betraying their sufferings by a quickened respiration, shew also by the livid color of the lips, that the blood is not sufficiently decarbonized, or is not completely changed from the dark venous, to the light arterial. (See p. 157.)

It cannot be supposed by those who will reflect upon the subject, that the laws of the animal economy can be thus disregarded, for any considerable length of time, without inducing the most disastrous consequences to the general health and constitution. Every one knows that air is the pabulum of life, and that a free, pure atmosphere, is absolutely necessary for vital and muscular energy. Whoever, therefore, interrupts the free ingress of air to the lungs, besides the injury which will follow to the organs themselves, does the same, in effect, as to create a vitiated atmosphere for her own use; since in both cases, a full supply of oxygen is equally wanting, and in both, the consequences are the same.

Those, therefore, who create by stays, corsets, or otherwise, such a continued pressure on the lungs as to interfere with their regular and appropriate functions, may expect sooner or later, to suffer either sudden death by apoplexy, disability by palsy, or at least, a gradual decay of the constitution, attended with fetid breath, affections of the lungs, liver, or other viscera, and which will terminate in the prostration, and final extinction of all the powers of life.

Pulmonary Consumption in consequence of pressure on the Lungs.—It is most probable, that when a degree of pressure is made on the lungs sufficient to bring the fine tissue of vessels, of which they are composed, into such a state of collapse, as to prevent the ingress of air, and the circulation of the vital fluid, that the portions so pressed suffer a slight degree of inflammation, in consequence of which, they adhere into masses, more or less solid, thus closing them entirely, and preventing ever afterwards, though the pressure may be removed, the full and healthful aëration of the blood. From this cause there would arise all the consequences which come from living in a vitiated atmosphere, or from breathing air which contains, perhaps, only one half the usual quantity of oxygen, as above explained. In such cases, it is possible, that no other effect on the lungs themselves may follow ; the subject gradually declining from general debility, and such poverty of the blood as to allow of no healthy secretions, and thus sink down to the grave without the usual symptoms of pulmonary consumption. Such may be said literally, "to die for want of breath;" not however, stopped by "*the destroying*," but the *self*-destroying angel, if indeed angels ever assist on such occasions.

It is perhaps singular, that this state of the lungs often betrays itself by an offensive breath, without ulceration, a designed infliction, perhaps, on those who thus violate nature's laws. But if nature is sometimes slow in resenting, and avenging the insults offered her, and allows some to live on for years who habitually violate her laws, others are brought to speedy account for such temerity ; for it is well known that blood-spitting, hectic fever, and finally all the concomitants of consumption of the lungs, follow excessive lacing, many of which terminate in a short period. Healthy females, who have no family predisposition, and who begin this practice late in life, as from eighteen to twenty, are not so apt to suffer as those who have such a predisposition, and are laced from their childhood.

In the former, however, the most pernicious consequences sometimes follow, as where a fine healthy country girl, who never had been laced, happens to visit her fashionable cousins in town; and who of course, will not be seen in the streets with her, in such a *countrified* shape. The poor girl must therefore be literally *screwed* into the city form, before she is allowed to "see company;" and having perhaps a capacious chest, such as nature formed, and this being composed of a bony framework, it is impossible to bring it within the compass of the fashionable mould, without lapping the ends of the ribs either over or under the breast bone.

This effect follows in numerous instances, attended with a hard projection on one side of the breast bone, and a hollow on the other; or the bone itself in other instances, has one of the edges thrown outward and the other turned inward, consequently because the lungs, as already shown, entirely fill the cavity of the chest, one or both of the lobes, besides the general pressure, must suffer a local injury from the interior protuberance thus formed.

More than one instance of this effect from excessive lacing, has come within the knowledge of the author; and more than one who reads these observations will acknowledge perhaps mentally, the truth of the statements here made, and will be able to bring examples either in themselves or their friends.

Dr. Morton's case, proving the above assertions.—But since many profess to doubt the injurious consequences of tight lacing on the lungs, at least so far as themselves are concerned, we will here offer an abstract of a case for the consideration of such; and which we cannot but hope will be thought worthy of serious notice by our female readers. It is from a work on consumption, by Dr. Morton, of Philadelphia.

"A lady," says he, "aged thirty-two years, of strong constitution, and good frame, but of a nervous temperament, with dark hair, and brunette complexion, had been for some time under the care of Dr. Hodge, for an attack of severe nervous irritation: when in the absence of that gentleman, I was requested to see her on the 6th of May, 1833. On my arrival I found her dying, and she survived but a few hours.

"There was no obvious emaciation, but the thorax was contracted by a depression of the breast bone, so as to reduce the diameter between it and the spine. On removing the pectoral muscles, the five or six superior ribs were observed to be considerably depressed at their extremities, where the cartilages joined them to the sternum, and at which point there was *a remarkable angle which protruded into the thorax.* The left lung adhered at its apex, at which point the pleura, [the membrane covering the interior of the ribs,] was deeply contracted, or puckered. Within was observed a rounded white mass, about an inch in diameter, composed of little grains of a cartilaginous firmness: this was obviously a cicatrized [healed] abscess, and in its centre were two or three crude tubercles, [the commencement of suppurative ulcers.] The remainder of the lung was perfectly healthy.

"The right lung, like the left, adhered at the apex, where the pleura was also deeply sunk, and puckered; beneath one of these plications was the remains of an old, but very small abscess, half filled with granular matter, like that in the other lung, excepting that it was of a darker color; the remainder of the abscess was in a suppurative state, and contained yellow matter. Close by were the evidences of a second cavity, of the size of a filbert, but perfectly filled, and consolidated by white granular matter, precisely like that of the left lung. The other parts were healthy.

"The unexpected morbid appearances of the lungs," says Dr. Morton, "induced me to inquire into the previous history of the patient, when I was informed by a near relative, that in early life *she had habituated herself to excessive* tight lacing; but although she had never experienced any obvious ill effects from this practice, she had of later years discontinued the practice, from a conviction of its injurious tendency."

"It seems probable, therefore," he continues, "all circumstances considered, that the lungs *became tuberculous and cavernous from the irritation of mechanical pressure;* but on the latter being removed the morbid secretion ceased, and the cavities became cicatrized and obliterated in the manner just mentioned. Can there be a doubt that if this lady had persisted in the unnatural confinement of her respiratory organs, the tuberculous disease would have extended, the abscesses enlarged, and the disease become a fatal malady? The predisposition to puthisis [consumption] being slight, it was suspended by the removal of the exciting mechanical cause; showing what important results physical education may produce on the human frame.*"

* Illustrations of Consumption, by Samuel George Morton, M. D., &c. &c. pp. 99. Key & Biddle, Philadelphia, 1834.

Says Dr. Reid, "Very straight lacing, and straining for a fine shape, hath made many a fine girl spit blood, and ruined the lungs by preventing a full and free respiration." On Consumption, p. 99.

Now since the practice of tight lacing, if not universal, is at least exceedingly common, and as the remains of comparatively few who die of diseases of the lungs are submitted to post mortem examination, it is impossible to give any conjecture of the number who destroy themselves in this way. But I have no doubt that the ladies themselves, to a considerable extent, will agree with me in believing, that *hundreds, nay thousands, of females literally kill themselves every year by this fashion in our own country: and if suicide is a crime, how will such escape in the day of final account?*

We have represented by figures 134 and 135 the difference between a natural human skeleton, and one in

Fig. 134.

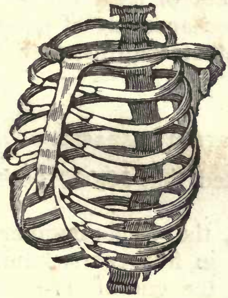
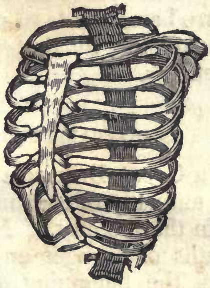


Fig. 135.



which the pressure of stays has pushed the front ends of the ribs inwards, bending the soft cartilages, so as to make them form acute angles outwards. It will be obvious to those who will reflect on this subject, even only for a moment, that the ribs cannot possibly sustain the force often applied to them in the process of forming a slim waist, in a girl of eighteen, without yielding in one direction or another; otherwise, and if the circumference remained the same, no difference would be made in the size of the chest, except that resulting from the compression of the fleshy fibres by which it is covered;

and this certainly is not sufficient to account for the effects actually produced. If we undertake to diminish the circumference of a hoop, we shall find it impossible to do so, without having the ends where the circle is joined shoot by, or lap over each other. The lower ribs, the cartilages of which join the breast bone obliquely, leaving a space between their ends, may be pressed so as to diminish the circumference, by forcing these parts inward upon the lungs, without producing this effect; but the upper ribs, which are continued directly forward to the breast bone, by their cartilages, cannot have their circumferences shortened without doubling these parts upon their ends. The consequence of this will be, that these ends, on one side or the other, must project inward upon the lungs, as shown in the case dissected by Dr. Morton, and stated above.

The diminution of capacity in Fig. 135, when compared with 134, is not nearly so great as we believe actually takes place in many instances of tight lacing, the figure being made to show the displacement of parts in the skeleton, by that process, rather than the extent of its effects.

MORTALITY BY CONSUMPTIVE DISEASES.

In Great Britain it is estimated that 50,000 persons die annually of consumption.

In the the city of New York, the whole number of deaths of all ages and diseases, in five years, namely, from the beginning of 1829 to the end of 1834, was 31,822, making a yearly average of 6364.

Now it is known by the reports of the Inspector, that nearly one in five of the mortality of that city are of consumption, in one form or another, which would give the number of 1272 per year who die of this disease in that city alone. The cities of Philadelphia, Baltimore, and Boston present similar bills of mortality from the same cause; and these bills also show that much the largest proportion of these are females. But there is no reason to believe that females are, from their organization, any more predisposed to consumption than the males. How then shall we account for the difference of mortality from this disease, but by attributing it to a mode of dress, which no one will deny does in many instances, at least, not only create such a predisposition, but actually and obviously brings on the disease; and from which the males, even of the same families, escape, by using a dress which allows the functions of the lungs to be continued agreeably to the laws of the animal economy, and the design of the Creator.

PREVENTION OF SPINAL DISTORTION.

It is no part of the plan of this work to point out the methods of cure proposed, and practiced by surgeons and physicians, for the various deformities and other affections, in young females, consequent upon the causes which have been noticed in the foregoing pages. And yet, we can hardly avoid saying a few words on this subject for the purpose of showing young ladies what terrible remedies are employed for these deformities, and how difficult it is to cure them, even in their incipient stages. This we do as a warning to those who are still in the enjoyment of their natural forms, not to make use of any of the means, or indulge themselves in any of the habits which we have described as the causes of such evils. And also, as a caution to mothers, how they encourage their young daughters in tight lacing for the sake of procuring genteel forms, lest thereby they should thus become the authors of disgusting diseases which art never can remedy, instead of the fine shapes which they expect will be so much admired and coveted.

The attempts heretofore most commonly made to cure curved spines have been by means of various machines, consisting of beams, bars, pullies, ropes, screws, inclined planes, straps and buckles, more or less of which are combined, and applied in different ways, according to the nature of the case, or the skill of the mechanic by whom these machines are employed.

The late Mr. Shaw, a surgeon of reputation in London, who has written a treatise on the cure of curved spines, says that it is the practice of some to keep young girls afflicted with this disease in a horizontal position, for months, and even for years, "*without intermission.*"

Stretching machines are also employed, which, by means of straps passing under the chin, and around the back of the head, keep the spine in a continued state of tension. Nearly the whole weight of the body is suspended by the straps, and thus are often used, until the chin becomes ulcerated, and the countenance permanently deformed, in consequence of their pressure on these parts.

Another invention for the same purpose consists of complicated machinery fitted to the back, and which the miserable sufferer is doomed constantly to wear. With respect to one of these, Mr. Shaw says, "I could not have believed (had I not seen the fact) that with the most determined resolution to endure pain, any person would have submitted to the punishment of carrying such a machine on the back for twelve months."

Of the *stretching chair*, another apparatus for straightening young spines, Mr. Shaw says, "the windlass by which the crane is elevated, and to which the patient's head is proposed to be attached, is so powerful that it might almost tear the head from the body."

For the same purpose the rope and pulley is not only used, so as to raise the patients from the ground by the chin, but to keep them thus suspended for some time. "Until," says Mr. Shaw, "I saw several patients undergo this experiment, I could not believe that it was ever put into practice; for it is quite obvious that while a child is suspended by the chin, the ligaments of the neck must be stretched to a dangerous degree." On examining girls who had been daily swung up for months, in this manner, the same writer found, that the muscles passing from the head to the neck, were so increased in size, as to make a new species of deformity.

It ought, however to be understood, that these are the methods employed by quacks and irregular practitioners for the cure of distorted spines, and that most of them are condemned by well educated physicians. In this country similar machines are made use of for the same purpose, and with what success the patients and their friends are the best judges. It is certain, however, that the patient, as well as her friends, are often deceived by an apparent cure, when the disease and distortion are only confirmed and increased by this kind of treatment. The spine it is true may be stretched into shape, by screws and pullies, but if the muscles of the back are pressed, or their action superseded by the machinery, the cure will be found to last no longer than the machine is employed, and when this is removed the curvature will gradually return, and probably become worse than before, because the muscles by inaction are still less able to support it in the erect position than when such treatment commenced.

A variety of other machines besides those above mentioned, have been invented and are employed for the same purpose, both in Europe and in our own country. One of these is constructed for the express purpose of forcing the vertebræ into their places, under the mistaken notion that in certain cases of distorted spines these bones are dislocated. There is no doubt but many a sufferer from spinal distortion, through the ignorance of herself, her family, and of the practitioner, have fallen disabled victims to the use of these machines. But perhaps enough has been said on this subject.

It is not pretended that want of exercise, improper postures in sitting, and the use of excessive lacing are the sole causes of spinal distortions. On the contrary, these affections are sometimes the consequences of diseases which probably no prudence or foresight on the part of the sufferer or her friends could have avoided. But that the greatest proportion of these cases are owing to the causes assigned, those who will examine the subject will have not the least doubt.

Girls, from their organization, are no more obnoxious to these affections than boys, but with the exception of rickets, to which both sexes are liable, we may look almost in vain for a case of spinal distortion among the latter. And besides, if we go into the country, where fashion allows nature, and not art, to mould the female form, and where the children of both sexes take nearly the same amount of the same kinds of exercise, in the open air, there will be found but little difference in the number of spinal distortions in the two sexes, instances of either being comparatively rare.

If, then, parents and school teachers would avoid the evils in question, they must remember that the first and grand rule in Physical Education is, or ought to be, *never to interfere with, or disregard the laws of the animal economy, in the treatment of their children, or pupils.*

We do not mean by this, that children and scholars are not to be placed under restraint, or that a proper and wholesome degree of discipline is unnecessary or improper. On the contrary, full liberty of person and action during the buoyancy and inexperience of youth, would lead to opposite consequences, more to be dreaded than the strictest discipline to which children have ever been subjected. But in no event should the discipline of children be such as to interfere with, or counteract the physiological functions of any portion of their growing systems. And we need not repeat here what we have already spent so many pages in showing, that young animals have a natural propensity to muscular action, and without which, it is impossible they should make well formed and healthy adults.

Now the muscles of the spine, in common with those of the other parts of the system, require almost constant exercise in the young, during their waking hours; and not only so, their inaction, or unnatural contractions, as we have abundantly shown, are peculiarly liable to be attended with the most unfortunate consequences. The peculiar structure of this part, being composed of alternate pieces of bone and cartilage, renders it peculiarly liable to grow out of shape in youth, for the reasons already assigned, and when once a distortion of this column commences it is exceedingly difficult to prevent its ruining the symmetry of the form, and still more so to bring it back to its original position. Distortions of this part, indeed, are often so insiduous and gradual, that not a friend, nor even the subject herself is aware of it, until it has made such progress as to be apparent to a common observer. And it will perhaps astonish some of our readers to know, that in our cities probably one in six are thus deformed.

To prevent distortions of the spine and shoulders in young females, it may be inferred from the physiological principles we have explained, and the facts we have stated, that it is necessary, first, to avoid tight lacing; second, to avoid improper positions at school, and certain modes of dress; third, that the seats in the school room should be provided with backs; fourth, that the time usually occupied in study at school should be diminished; and fifth, that the students should be allowed to take abundance of exhilarating exercise, such as nature requires, in the open air.

Every seat should be furnished with a back, not however with a narrow strip elevated so as to come across the shoulder blades; but a continuous support from the bench, to the height of about two feet, and not standing perpendicularly, but curved a little backwards. By such a back the spinal column is properly supported.

School rooms ought to be furnished with desks at which the pupils can write in the standing posture. These need not exceed one half, or perhaps one third the number of pupils, and may be used in rotation.

Four or five hours per day, spent in close study and recitations, is perhaps as much time as can be employed, to the mental and corporeal advantage of pupils from twelve to sixteen years of age. And young children ought not to be kept in their places more than an hour at a time, after which some little pleasant relaxation should be allowed, and in which the teachers should participate.

Every school house for young children should, if possible, have a play ground, furnished with implements for amusement, adapted to their ages. And seminaries for young ladies should be provided with a *romping* yard, with a high fence, and a shed on one side, for exercise in bad weather. This should be furnished with bows and arrows, and such other instruments of exciting amusement as may be found most agreeable to the ages of the pupils; and here they should be allowed to enjoy an hour, or half an hour, at proper intervals, several times during the day.

If these suggestion are carried into general practice, we cannot but believe that the number of deformed shoulders, crooked spines, pale faces, and consumptive diseases, would be greatly diminished among our females.

Effects of stays on the size, vigor, and health of our species.—Besides the consequences ascribed to the uses of stays, in the foregoing pages, there is another effect to be noticed, which so far as we know has been entirely overlooked, or at least unnoticed, by writers on the subject of Physical Education; but which the patriot and philanthropist cannot but consider as highly important. We mean the effects of tight lacing on our species in a national point of view.

It has been shown in the preceding pages, that when any portion of the animal system, and especially the soft parts, are pressed, nature sets herself to work, and because she cannot remove the offending cause, avenges herself of the insult, by removing through the absorbent system, the parts pressed upon, and thus relieves herself of the injury.

Now the glands, or organs which secrete the fluids peculiar to the several parts of the system, are particularly sensible to injuries of this kind; and when they occur, nature evinces her resentment by a speedy reduction, or sometimes by the entire removal of the offended organ. In case the gland happens to be one which nature intended should be prominent, the continuance of the pressure will either prevent its full development, or if already developed, will reduce it to the common level of the surface where it is situated. These are well known physiological facts, of which the physician in his practice, and the common observer in his observations, has undoubtedly seen numerous instances.

The class of animals, called Mammalia, as already explained, receives its name from the presence of certain glands, called the *lactescent*, which are common to all the species, and which are designed to secrete sustenance, for the continuance of the races to which they severally give existence; and without such an organization, no tribe of animals can claim a place in the Natural History arrangement of this most important division of the Animal Kingdom.

When this class was formed, the order called *Bimana*, or two handed, of which order Man is the only species, there was no want of those peculiar qualifications in our race, which constitute membership in it; but at the present time, this order, at least in many parts of our country, has lost, in a lamentable degree, and in some specimens entirely, those marks by which its individuals once claimed a *prominent* rank among Mammiferous animals. And if the use of stays, corsets, steel busks, and their adjuvants, continue to inflict their marks on future generations, as they do on the present, the order Bimana will undoubtedly deserve to lose its place in the Mammalia class: since there will ensue an entire extinction of those natural organs, which form the chief characteristic of this class, and from which its name is derived.

The loss of membership among the Mammalia, it is true, is of little importance, except to the naturalist; but to the patriot, and moralist, the extinction of those prominent traits which once distinguished the gender of our species, cannot but create feelings of commisseration, and regret, since such a deformity not only involves a violation of the laws of nature and morality; the first by suppressing the growth of important parts of the animal system, and the second by the hazard of health and life as a consequence; but it also inevitably leads to a deterioration of the species, with respect to statue, form and constitution.

It is true that stays are no recent invention, having been known to the nations of Europe before our fathers and mothers came to these shores; and therefore it perhaps may be objected that the consequences we have attributed to them, may with the same probability have happened formerly as now. But the construction of this article of dress, though called by the same name, is materially different from what it formerly was, as any one may convince herself by hunting up, and examining those worn by her grandmother. These will be found so constructed, as not in the least to interfere with the expansion of the upper half of the bust; while those of the present day, it may be presumed from the forms moulded into them, are so made as either to present a barrier of whale bone, and steel, to any unequal expansion of the parts which they encompass; or if any such provision is allowed, it must be rather in the region of the shoulder blades, than in that of the anterior portion of the bust.

The fact, that the female form has undergone a very material change within the last 20 years, and that this change has been caused by the pressure of stays on parts of the system which are of the utmost importance to the nutrition, and consequent growth, and health of our species, cannot, and will not, be denied by any competent witness. And that we shall become a stinted, puny, and short lived race, in consequence, it requires no more inspiration to predict, than it does to foretell that starvation will produce dwarfs in infancy, and emaciation in adults.

The effects, indeed, are already visible in the number of pale, dwarfish, and crooked children, which may be seen in the schools and streets of all our cities, and many of our smaller towns and villages. And whoever, having been interested in the welfare of the rising generation, will contrast, so far as she can recollect, the aspect of a school composed of both sexes, at the present day, with the appearance of the same number and ages, 15 or 20 years ago, cannot, we think, but be convinced, that there has been a great deterioration in our youth, both in respect to form, size, and healthy looks.

And who, we enquire, would not expect to see such a

Fig. 136.

Venus de Medicis.

Fig. 137.

A Modern Lady.

change in our race, when they behold such a metamorphosis in the better half of our species, as to have produced from a stock like that represented by Fig. 136, a progeny like that shown by Fig. 137. In the first, the parts which are essential to the nutrition and growth of incipient respiratory beings, are so developed as to insure a full supply of lactescent secretion; while in the second, the corresponding parts present a mere pretense, a nullity, a *source of starvation*, rather than one of sustenance, to the nascent beings, who are so unfortunate as to be thrown upon such cotton wool resources of existence.

But what possible motive could have induced the females of the present age, and especially those of these United States, (where ultraism in respect to this deformity is carried to a much greater extent than in any other country,) what, we ask, could have moved those among us, who have the first care of the species, and who ought to be our examples in moral rectitude and conservative discretion, to have thus deprived themselves of the power of fulfilling one of the very first of nature's laws?

Can it be for the purpose of making themselves more agreeable, and more acceptable to the lords of creation? Then certainly their motives ought to meet with the law of kindness, and the tortures through which they are willing to pass in order to arrive at perfection—the sympathy and commiseration of those for whom such perils are encountered. But whatever motives might have led to a deformity so unnatural, it is certain that the Creator intended, that the "noblest work of his hands," should possess the most perfect forms; and therefore, except to a depraved and vitiated taste, such forms will ever be most admired, and most acceptable to those for whom they were designed.

It is true, that there are parts of our country where the practice of excessive lacing, and therefore its degenerating consequences, do not exist; and from whence we are happy to know that many of the daughters of unsophisticated nature, are transplanted into our cities, there to become the fostering angels of a renovated species. And were it not that such resources still remain, the consequences of fashion in all our cities, would have been by far more degenerating than they are at present. Indeed we cannot but believe, that were our large towns walled, and their inhabitants under the necessity of depending on each other for the continuance of our species, that under the dominion of the present code of fashions, the human race within their walls would finally, not only become perfect Lilliputians in size and mind, but that they would be known to future ages only as a fossil race, the types of which would no where be found on our earth in the recent state. But we must at present leave this subject, we hope, to resume it again in a treatise more particularly directed to Mothers ; and containing a detail of facts and circumstances, calculated to enlighten the minds, and touch the feelings of those who have the welfare of their country and their species at heart.