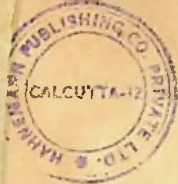


THE ROMANCE OF  
THE HUMAN BODY

Re. 1/8 - only.

Dr. Kartick Ch. Bose, M.P.



# ROMANCE OF THE HUMAN BODY

## CHAPTER I.

*he most wonderful self-regulating engine that ever existed—the acme of divine creation.*

Have you ever been to Agra to see the beautiful Tajmahal or did you ever feel an inclination to see it? If you have not seen, you may possibly have read in the books that it is a most wonderful work of art and a perpetual glory to human craftsmanship. You would never miss an opportunity, if it ever comes, to behold such a magnificent thing. If you had heard the stories of Europe, you must have known the splendour of the Vatican or of the St. Paul's Cathedral in Rome. You have learnt in your books about the *seven wonders of the world*. You would like me to tell you of many other wonderful things that I know. But do you ever think that you are constantly surrounded by the most graceful and wonderful things that were ever created? Can you guess what these are? These are you yourself, your mother, your brothers, sisters, your father and every other human being you see around you. You will tell me that they are not the least wonderful things. But I shall tell you what a wonderfully complicated machine the human body is and still how graceful the machine looks.

Most of you, I suppose, have seen an engine. Some of you who live in towns, will, perhaps, know a good deal about machines; others have seen the engines that draw the railway train. There is a great similarity between yourself and an engine.

- (1) You require food, the engine also requires food in the shape of fuel which may be coal or oil, and water.
- (2) You give out waste materials through perspiration, urine, stools etc., and the engine also gives out extra steam and burnt ashes.
- (3) You are to live cleanly and avoid dirt and dust otherwise you become ill. The engine too has to be kept clean and well-oiled, otherwise it will go wrong and will make awful noise and ultimately it will stop working.

The engine requires that some one must, always, be in attendance to shovel in the coal, to let out the steam, and to draw out the burnt ashes. But your body does all its works automatically. Whenever you feel hungry, you eat something. The waste materials of your body are separated out in the kidneys and pass out as urine and all these are done without anybody's help or any seeming effort on your part.

A watch, what a delicate thing it is, you know. Once you wind it, it will tick and tick for days and will indicate the hour, the minute, and the second. But think of the genius of man, and the various sorts of work he is able to do. He can write, he can read,

he can deliver a speech, he can think and what not. It is his thought which regulates his work. You have heard the names of great scientists like Newton who from the fall of the apple, laid down the laws of gravitation, like Harvey who cut into the human body and found out that there is a system of pipes which carry a moving liquid called blood which circulates within. Don't you think that man is more ingenious than the watch ?

Man is verily the perfection of creation. Do you understand anything from it ? Of all the creatures, the fish, the frog, the lizard, the bird, the dog, man is the most intelligent. He is made to the image of God. So man is utilising everything of the world to his own advantage. He is using the horses and the cattle as porters and carriers. He has bound down the greatest force of nature namely electricity which is seen in lightning, to serve his own purpose, as in telephone, telegraph, electric tram-cars etc. It is, therefore, that you and I and every other human being are ranked in the highest stratum of creation. This high rank in the universe is due to your brain which is located in your head. Now I may presume, you will agree with me that you, your father and every other human being are the most graceful and wonderful of all things ever created.

Dear readers, don't you feel an inclination now to know about this wonderful machine of the human body, how it is constructed, how it works, how it grows and gets strong and how it gets rid of its wastes, and many other things concerning it ? I think you

have grown eager and inquisitive by this time. I shall try to satisfy your inquisitiveness as fully but concisely as I can.

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## CHAPTER II.

### *We are living and growing things.*

The engine, you know, cannot grow larger and larger in size. It consumes the fuel and the water, as we consume food but the difference between an engine and the human machine is that the latter gets bigger and stouter day by day, shortly, that it *grows*. Every one of us was at one time a small baby with tiny little hands and weak legs, measuring 1 foot or so in height ; but twenty years later, here it is the strong man of about 6 feet with broad shoulders and mighty hands or the tall woman with her cheerful, active ways and kind, helpful thoughts.

“How he or she has grown!”—has been said of all of you by some of your friends who has not seen you for a long time. By that, is meant that, you have become bigger, stouter or stronger. When we are quite grown up, the body still goes on growing though apparently we do not grow bigger. All the growing power is then engaged in repairing the body itself.

The engine when it goes wrong, is to be repaired by engine makers who may build a new part and replace it for the old worn-out one. But the human machine can mend or repair any part of itself though it cannot

replace any fresh part for an impaired one. This as I told you in the previous chapter is the peculiarity of the human machine. But there is a limit up to which the body can make good its own wastes. You know that a machine, requires a skilled man and careful manipulation to work it. Human machine, how delicate it is, still can bear rough usage up to a point, and if this is exceeded, the machine will go wrong and your body is then diseased. In this case, it tries to rectify the wrong itself as much as possible; the doctor comes with his medicines only to aid Nature in her process of repair. It is, therefore necessary that you should know the construction and workings of your valuable machinery, so that you may not transgress the ordinary laws of health and fall an easy prey to disease and if anything is wrong with your body, you can easily find out where the rub is, how it has been caused and in what way to do away with it, and you can also thus be a master of your own physique and have not always to call for the doctor who lives really upon our ignorance on these matters. One thing which must be borne in mind is that "It is never too late to mend." Though you may be diseased, you may, still, mend matters right if you strictly follow Nature and regard the golden rules of health.

We grow—this is a characteristic of all living things. The rock also grows *i.e.*, increases in size. Therefore, is it a living thing? No, certainly not. There is a difference between the growth of the rock and the growth of our body. Then, what do we understand

by growing? "Growing is the *assimilation* of certain portions of the environment by the *animal* or *plant* that grows."

Just now, two sorts of growth were mentioned—the growth from small to large and the growth of repair or mending and by assimilating. In order to make it easier to understand, we shall consider the growth from small to large. If an inorganic thing is to get bigger, something must be added to it. You have a piece of mutton, you want it to be bigger; you ask the butcher to add another piece of meat to it.

Take the instance of the rock. It was of a certain size five years ago. It has grown bigger now by the addition of the earth, sands and gravels thrown upon it by the wind, or ashes, lava and stones from the neighbouring volcano.

We imagined the meat made bigger by the addition of more meat. This was only by adding together.

We imagined the rock to become larger by the addition of earth and stones which were not only added but there was a certain amount of intermingling of the earth coming from the volcano with that of the rock. The earth which was its environment at one time is now a part and parcel of the rock which has grown larger thereby. But the human body has to do more than the mere act of adding and mixing them. It has to assimilate or work upon its food, until some of it is taken up and transformed into its own materials and absorbed in the system for building up the body, whilst the rest is thrown out as waste materials.

It is in this power of assimilation that the growing man differs from the so called *growing* rock.

A living thing must die, *i.e.*, cease to exist. Death may occur from individual causes *e.g.*, various diseases or from accident. But how may we explain the death of old people who have not suffered from any disease? Some consider that in them, effect of small injuries of the past years imperceptibly accumulate and ultimately bring about death. Others think that death is the natural end of organic growth. As age advances some of the organs become useless or atrophied and at the time of death, this natural atrophy overcomes the whole body and we say he or she is *dead*. Now the question arises "Is death a necessity?" Yes, it is a necessity for developed organisms. Higher animals, after they live for a certain period, become unfit to sustain themselves by absorption or assimilation or add to the species by normal process of reproduction. So, if they were awarded an eternal lease of life, they would remain as burdens to the species and hence their existence was to have been injurious to the welfare of that species and therefore absolutely unnecessary.

What has been said above concerning death is from the biologist's point of view. In what light should men in general look on death? Though it is the inevitable end of every human being, still it is a thing which everyone should try to delay as much as possible. If you live carefully and abstemiously and obey the natural laws of health, it is possible for you to prolong

your life to a considerably advanced old age. The *rishis* of the *Vedic* times are said to have been alive for 1000 years or more. Only a few years ago died the venerable Trailangya Swamy at the age of 360 years as they say. Even now we hear of old grandmas and grandpas who have lived for more than a century, and why then is it not possible for every human being to live up to a good old age ?

Bulgaria is said to be a land of centenarians. A country with a population of nearly three times that of Calcutta though it is, still, it can boast of 10 men who have passed the age of 125 years. There are 88 men whose age is between 120 to 125 years and 234 men whose age is over 110 years. Few years ago a man died at the age of 139 years. The longevity of the Bulgars, as most people believe, is due to the regular consumption of curdled milk or *Dadhi* which is one of their principal articles of diet. But whatever be the cause of their longevity, why should we not try to prolong our lives to the best of our ability by obeying the simple rules of health ?

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## CHAPTER III.

*The Constitution of the Body in General—the Cells.*

Will you believe me, if I say that your body more or less looks like a bee-hive or a sponge? It is an absurd and most revolting idea to you. But the scientist will say that it is really so. If you take a portion of our brain or of the sheep's brain and cut a very thin slice of it with a sharp knife and look into it by the aid of the microscope, you will actually find a network or small pentagonal or polygonal or oval masses lying side by side and united with each other. Does this not suggest the idea of the bee-hive? The comparison I made before, is, therefore, not as ridiculous as you thought it to be at first. What are these small units called? These are the *Cells*. The cells consist of the living material called *Protoplasm* which resembles very much the white of an egg. The dimension of the cell varies from the  $\frac{1}{1250}$ th part of an inch—which is the size of the ovum or egg from which the whole human body is developed—to the  $\frac{1}{60000}$ th even  $\frac{1}{100000}$ th part of an inch. All cells are, therefore, too minute to be seen with the naked eye and can only be detected under the lens of a microscope. Embedded in the protoplasm of the cell is a more solid body in the form of a nodular core, called the *Nucleus*. The nucleus takes an important part in the division of cell. First of all a cell will grow for a certain time to a certain extent and then it will get a waist (fig. 2), then the nucleus

of the cell divides into two and the living protoplasm gradually surrounds the two portions of the nucleus and the waist is torn asunder; in this way one cell divides into two and thus cells, keep on procreating amongst themselves.

### Various Kinds of Cells :--

When the constitution of the body is closely scrutinised, we find not only cubical and columnar cells as in

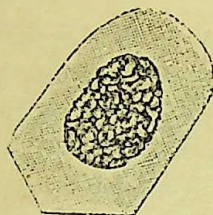


Fig 1.—A MORE OR LESS PENTAGONAL CELL SHOWING AN OVAL NUCLEUS IN THE MIDDLE.

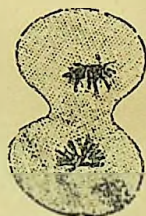


Fig 2.—THE SAME IS SEEN TO DIVIDE INTO TWO CELLS. THE NUCLEUS HAS DIVIDED AND THE PROTOPLASM HAS NOT YET BEEN COMPLETELY DIVIDED.

the digestive tube, flat and polygonal cell as in the mouth or in the eye but also like fibres, these elongated fibrous cells being found in the muscles or flesh of body, in the ligaments connecting one bone to the other and thus forming joints and also in the nerves which represent the telegraph wires of the body conveying messages to and from the brain.

Some cells, when, they divide from each other and lead separate existence are termed as *unicellular organisms*; while others divide without separating and keeping at least tangible connection with each other and producing a great variety of cells and are called *multicellular organisms*.

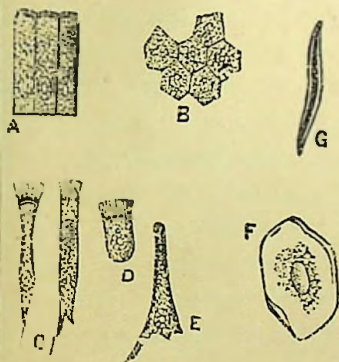


Fig 3.—Various kinds of cells.

A—FROM THE DIGESTIVE TUBE.

B—FROM THE EYE.

C, D.—FROM THE WIND-PIPE.

E.—FROM THE BRAIN

F.—FROM THE MOUTH.

G.—A CELL PROLONGED INTO A MUSCLE FIBRE.

Are these something different from the cells? No, these are developed by the elongation of the same original cells. The human body, to begin with, is represented by an ovum or egg—one single cell. This ovum divides and divides in the mother's womb and from the one microscopic cell is developed this complex human body—a tremendous colony of billions of living cells. It bewilders the mind of ordinary man to think of such a thing actually happening day after day. But it is a fact; from that one ovum is to be developed the muscles, the bones, the skin, nerve, brain, the digestive tube; and hence we may rightly conclude that

any and every structure we meet with, is developed from one cell and consequently the cell is the typical unit or proto-type of the whole human body.

### Work of the Cell :—

All the work that is done by the body is through the efforts and for the comforts of cells. The man takes his food and that food after digestion goes to each one of the innumerable cells of the body carried by the blood. Here it supplies nourishment to the cell. We take in oxygen, this oxygen is taken down to the cells, the oxygen combines with the protoplasm of the cell, and changes go on; carbon dioxide is given off as wastage by the cell, which ultimately comes out with the expiration. The saliva in our mouth is worked up by the cell of the salivary glands. The same remark applies to different kinds of juices secreted in our stomach and the intestines.

Then the most extraordinary thing about the cells, is their power of reproduction, respiration, assimilation and also of movement. The molecules of the living cell, are continually breaking down and built up again and have the power of repairing their own substance and of sustaining with and building up new molecules out of what are known as food-substances absorbed in our system.

### How is Exercise beneficial :—

After a certain period of energetic work, the cell becomes worn out and ultimately dies, and in its

place grow new cells with increased vitality. Exercise destroys all but worn-out cells. The dead cell is burnt up by the oxygen which we breathe in and the waste is excreted through the skin as perspiration and through the kidney as urine. Exercise not only destroys the old debilitated and defunct cells ill-suited to perform the function of the body, but it also gives an impetus so that new cells are produced with newer, fresher and better material. If exercise merely resulted in replacing matter in the body with equivalent matter there would be little or no benefit in exercise. It is through the improved quality and increased quantity of cell matter supplied that exercise works its wonder. Even the muscles and bones of a full-grown adult may improve, though slowly through exercise.

### Body's Chemical Composition :—

In the human body fourteen elements are found, all of them largely distributed all over the world. The more important of them are the following :—Oxygen, Nitrogen (both found in air) Carbon, Hydrogen (found in water), Sulphur, Phosphorus, Calcium, (found in lime) Potassium (found in vegetables) Sodium and Magnesium. These elements form various combinations or compounds some of which such as water, common salt, phosphate of lime, chalk etc., are also common to the world around us, but other compounds such as protoplasm or living matter, fat, sugar, starch etc. are found only in the living beings *viz.*, plants and animals.

The body of a man of proportionate size taking it at is composed of

Water . . . . .	70.70	Per cent
Nitrogenous matter	18.18	„ „
Fat . . . . .	6.10	„ „
Sugar . . . . .	0.1	„ „
Mineral matters .	5.5	„ „

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## CHAPTER IV.

### *Various Tissues of the Body.*

A collection of a large number of cells forms a tissue. There are five kinds of tissues in the body *viz.*—

- (1) Epithelial or covering tissue.
- (2) Connective tissue or binding tissue.
- (3) Muscular tissue which is in common language called *flesh*.
- (4) Nervous tissue or the message carrying tissue.
- (5) Blood and Blood vessels ( These are included connective tissues ).

### Epithelial Tissue or Covering Tissue :—

Epithelial tissue is formed of one or more layers of flat or cubical or columnar cells placed in close apposition. It is found in the outermost coating of the skin, in the living membrane inside the wind-pipe, gullet, stomach, and whole length of the intestine.

( large and small ) *i. e.* the coiled pipes inside our abdomen. This tissue affords protection to tissues lying underneath it and always bears the brunt of the fight with outer nature. Friction over or scratching on the skin shreds the uppermost ( almost dead ) cells whose place is taken by cells lying just underneath.

The epithelial tissue also lines the ducts of glands. *Glands*, we may mention here, are very minute knot or sponge like reddish organs which secrete, that is to say, produce certain substances necessary for carrying on the work of the body. Glands have different names according to their different locations and to different secretions they produce. Saliva secreting glands are called salivary glands, glands secreting juices in the stomach are called gastric glands, glands secreting mucus—a shining substance, are called mucous glands, and so on. The water running from the nose in acute catarrh or cold is nothing but mucus. Examples of glands are also found in the liver—the largest gland of the body and the sweet bread which secretes a juice in the tubes inside the abdomen. Most of the glands possess a duct or a pipe through which the secretions of the gland flow. These ducts are lined by epithelial tissues.

#### Connective Tissue or Binding Tissue :—

This includes the tissue lying underneath the skin, between it and the muscles. Bone and gristle or cartilage are also classed as connective tissue. The fat of the body is made of nothing but connective tissues, the

cells of which are distended with fat. This fatty tissue has an important function to perform. It acts in the same way as a coat of wool. It preserves the body-heat and similarly prevents cold from reaching the interior of the body. A fat man, therefore, does not suffer so much from the cold blast as the lean man; though sometimes exceptions are seen to this general rule. Besides this the fatty tissue acts as a bed in which delicate organs are placed such as the eye. The fat contained in the fatty tissue also serves as a food material for the body during starvation. Hence it is that a fat man can be starved for a longer time without injury than a lean man with very little amount of fat in his body.

The other tissues of the body will be dealt with later on, as we begin to study muscles, nerves and blood vessels.

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## CHAPTER V.

### *The Skeleton,*

Look at the Picture of the skeleton (*Front page*). It is made of several pieces of bones bound together in such a manner that the utmost advantage may be derived from it. In the adult human body there are 206 pieces of bones. These bones are connected together by strong fibrous bands called *ligaments*. Bones united with each other by ligaments constitute what are called joints. Had there been no joints

he body we would not have been able to make various movements of our body that we do daily in our different daily activities.

What is the skeleton for?—The skeleton is the strongest part of the body and, as such, it is the skeleton which *gives the shape to the body*. Imagine the skeleton removed and you see an odd looking lump of flesh rolling on the ground. The bones of the skull besides giving the shape to the head, serve to protect the most vital structure of the whole body *viz.*, the brain. The bones of the chest-wall called the *ribs*, also protect an important organ *viz.*, the heart. Hence the secondary purpose which the bones serve is one of *protection of the vital parts*. You have seen the astounding feats of an acrobat. All those wonderful movements of his body would have been impossible if he were boneless. And here we come to the third use of the skeleton. The bones of the skeleton afford attachment to the muscles and in this way act as fixed points for the action and regulation of muscles whereby the *various movements of the body* are produced.

Now we come to consider the bones themselves but before we do this, you must learn something about bone itself and what it is. Bone is chiefly composed of

I. Animal matter (organic) called 'collagen' which gives the bone additional tenacity.

II. Mineral matter (earthy); consisting mostly of carbonate of lime and phosphate of lime.

To every one part of the animal matter there are

two parts of mineral matters. Both substances are well mixed together and forms a homogeneous mass.

The proportion of animal matter and mineral matter varies with age. In young children the animal matter is in abundance, whereas in the old the earthy matters are in much greater amount than in the young.

One day while I was walking along a public street in Calcutta, I saw an old man come out of his house carrying a tiny bonnie lass. He had not gone far when his foot slipped on a piece of mango-peel. The man fell flat, the baby thrown out of his arms and rolling a few yards off. I rushed to pick up the baby, as one naturally does in like cases, and though she was crying at the top of her voice, her bones were intact and there was no great injury except some minor abrasions and bruises on the skin. Her bones containing greater amount of collagen, were too soft to break like the twig of a new plant. But the poor old man had one of the bones of his fore-arm broken and had to be removed to the hospital. Age had added more mineral matters to his bones and hence his bones had become so much brittle.

All bones are made up of two kinds of tissues :

- (a) Compact or dense :
- (b) Cancellous or Spongy

The compact tissue is dense, ivorylike and forms the outer 'coat of all bones. The spongy tissue is found only in the interior of the bones. The presence of the spongy tissue inside the bones makes them lighter without materially damaging their strength.

Bones are divided into three classes according to their shape and size :—

- (1) Long bones.
- (2) Flat bones.
- (3) Irregular bones.

**Long bones**—are hollow inside ; the cavity is filled up with bone-marrow. The bone-marrow consists of blood vessels and cells full of fat. It is the seat of production of the red blood corpuscles (or minute red-looking oval bodies floating in and lending red coloration to the blood). Long bones are found in the arm, forearm, hand, the thigh, the leg and the foot.

**Flat bones**—are present only in those portions of the body where extensive protection is necessary for the vital parts lying underneath the bones ; they are stretched like the wings of birds when protecting their young ones under them. The skull and the chest wall therefore are the places where we must look for flat bones.

**Irregular bones**—are found in the vertebral column or spine, in the wrist and in the ankle. They are generally found in a large number, differently shaped and therefore produce a limited amount of movement, at the same time keeping the integrity of the parts.

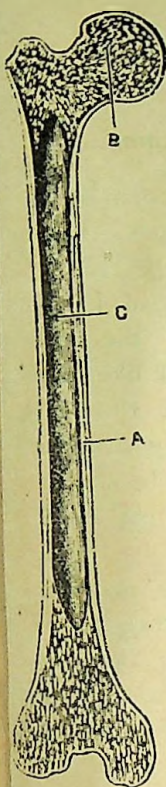


Fig 4—Section  
of a long bone—  
The Femur  
of the thigh

A.—COMPACT  
TISSUE.  
B.—SPONGY  
TISSUE.  
C.—THE CAVITY  
FOR BONE  
MARROW.

## CHAPTER VI.

*The Back-bone—The Vertebral Column.*

The back-bone is a column (or pliable stick) of bones which run centrally along the back of the body. Look into the picture of the back-bone given on page 22.

The best idea of the back-bone can be had if you take 24 reels of cotton and add to each of the reels three wooden flaps so that these may look like three wings sticking out of a reel. Now place the reels one above the other and thread them tightly and you have a stick made up of reels which can be made to move to and fro. This is the best (though not exact model of a vertebral column.

The back-bone or the vertebral column is made up of a number of bones each standing on the other as we imagined the reels doing. Each of these bones is called a *vertebra*. Though the bones of the vertebral column differ slightly in size and shape, according to location, yet the general structure of all is one and the same. The uppermost of the cervical vertebra (neck bone) is called the Atlas on which the upper portion of our head rests.

The part marked S in the picture is the body of the vertebra; the part marked M is the *Foramen* or channel through which the spinal cord passes just as we imagined the string going through the cotton reels. The parts marked A, W, E, are the three wings or *processes*

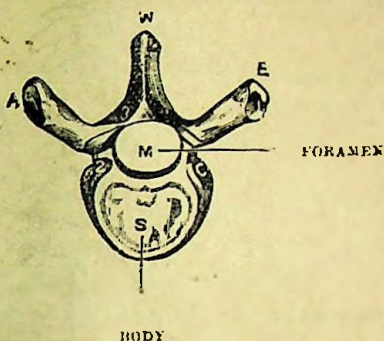


Fig 5.—Diagram of a Typical Vertebra.

of the vertebra. The central one (W) of the three processes projects directly backwards and can be felt from outside along the furrow midway on the back of the body. But the smooth round body projects forwards and lies inside. The spinal or vertebral column is gifted with almost incredible strength and the most important of all bony structures of our body, since it dominates all functions of the body, helps to keep the upper portion of our body straight and it is the seat of the nervous system of which we shall speak later. The back-bone is often the seat of disease and persons affected with disease of the spine feel much pain in walking about or cannot stand erect.

Look at the picture of the vertebral column and count the number of the vertebræ.

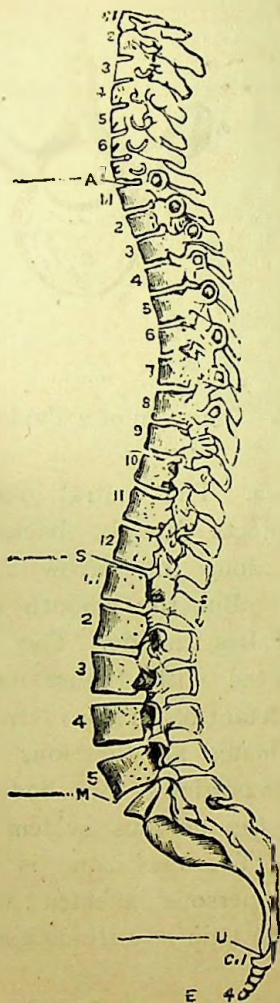
7. NECK BONES  
(*Cervical vertebra*).

12. BACK BONES  
(*Dorsal vertebra*).

5. LOIN BONES  
(*Lumbar vertebra*).

BONE AT THE BACK OF THE  
PELVIS (*Sacrum*).

TAIL BONES  
(*Coccyx*).



Fig—6. A side view of the back bone (vertebral column).

There are—

7 up to the first line marked A—these belong to the neck.

12 up to the second line marked S—these belong to the back.

5 up to the third line marked M—these belong to the loin.

The 5 up to the line U are really jointed together and so fused into one after boyhood and may be counted as one, and then, there are

4 little ones at one extremity marked E and these form the beginning of the tail in lower animals.

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33 in all.

The five vertebra below the loin or lumbar vertebra unite in the adult to form a single bone called the *Sacrum or sacred bone*. It is a three-sided wedge-shaped affair wedged between the hip-bones forming the key-stone to the pelvis and gives some support to the whole spinal column.

The four little ones below it also fuse in the adult to form a single bone called the os coccygeus or coccyx. Therefore in the adult there are 7 in the neck or 7 cervical vertebræ, 12 in the back or 12 dorsal vertebræ, 5 in the loins or 5 lumbar vertebræ and 1 sacrum and 1 os coccygeus or the tailbone, *i. e.*, we have got altogether 26 pieces of bone. The different classes of vertebræ have special features of their own which will be too difficult to learn. But one point which you can yourself verify from the picture is that the vertebra becomes more

massive as you approach its lower end up to the sacrum after which it decreases in size up to the coccyx.

The vertebral column is not straight but bent forwards and backwards and of undulating shape, as shown in the above figure. It gives attachment by its processes and adjoining portions to the strong muscles of the back which bend or straighten the column. The pieces of bones do not lie over each other directly, but pads or cushions of cartilage (soft bones, as we have got in the ear) intervene between one bone and the next and serve to act as the buffers of the railway carriage and give the needed elasticity to the spine. The pieces of bones though freely movable are restricted in their movement by strong bands or *ligaments* stretching between the bones. Take for instance, when the head moves forward or backward, it moves on the axis, but the ligaments prevent it from moving too far—completely hanging on either side. This restriction in the movement of the vertebral column is necessary, otherwise the spinal cord contained within its canal would be crushed or smashed and in that case there would be immediate paralysis and loss of sensation throughout the system causing ultimate death.

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## CHAPTER VII.

*The breast bone (the sternum and ribs).*

Every one of you has a little hole or depression in front of your throat and if you press here with one finger you feel some difficulty in breathing. Pass your finger downward a little vertically from this depression and you feel a flat bone—which is the **breast bone** or the **sternum**. At the lower end of the sternum the finger dips down into a depression in the region of the *diaphragm*, which is called the pit of the stomach. This bone is shaped almost like a butcher's knife and has a very important function to perform, viz., to support the ribs in the front of the body. The sternum is tough and elastic at the same time. It is rarely fractured by a blow in the breast, as it is tough and elastic at the same time and have great resistant power. It is in this place that there is a plate of cartilage called the **ensiform process**. Cartilage is popularly called gristle. It is softer and more elastic than bone. It can be cut into by a knife. Gristle is also present at the end of long bones up to 21 years of life after which it is turned into bone. The long ribs are united to the sternum and to each other by bits of cartilage which remain as such up to adult life.

The ribs are like hoops going round a barrel.

There are twentyfour ribs in every human body, twelve on one side and twelve on the other. So we

have twelve pairs of ribs, each pair starting from the opposite sides of the vertebral column (Dorsal Vertebrae). They curve round the sides of the body and come to the front where most of them, but not all, are

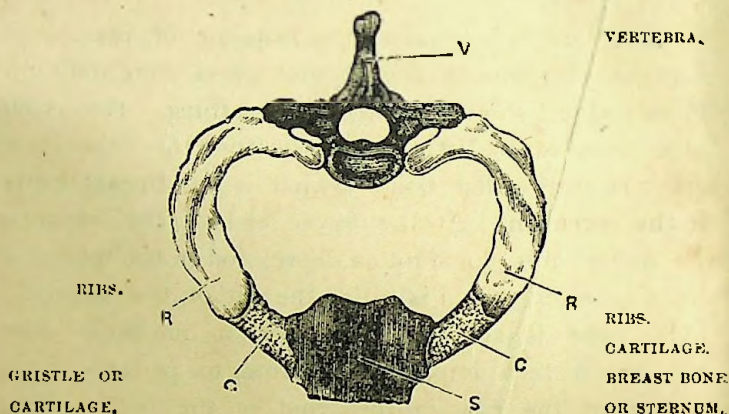


Fig 7.—The hoop of bone protecting Important Organs.

united to the breast bone by pieces of gristle which took like so many isthmuses. Of these there are 7 pairs as you can count in the picture given on page 27. They are called 'true ribs' since they all connect directly on both sides of the body with the sternum. Of the remaining 5 pairs the upper three pairs called the 'false ribs,' unite with each other before joining the gristle of the 7th rib. The lower two pairs (*i.e.*) 11th, and 12th, are called 'floating ribs' because their forward ends are not in any way associated with the sternum and are free to a great extent,

The ribs are capable of moving up and down by

means of imperfect joints at their connection with the dorsal vertebræ. The spaces between succeeding ribs are occupied by strong muscles termed as the *Intercostal muscles*—one set raises the ribs, the other set depresses them. Stand erect with your right hand placed over the breast bone. Now take in a deep breath, the breast bone is elevated and thrown forwards and then force

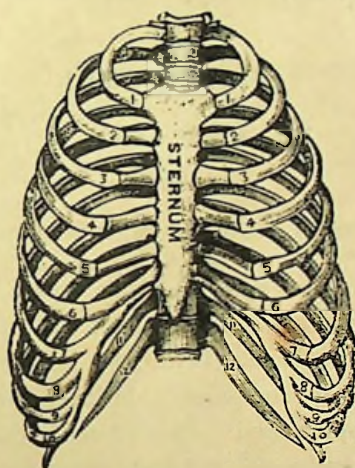


Fig 8.—The Ribs and the Sternum.

out the air taken in, the reverse things happen. When the ribs are raised the breast bone is thrown forwards and thus the cavity of the chest is enlarged and the lungs (which are situated in the chest) expand and take in a deep draught of air. The ribs are then depressed by the intercostal muscles, and this movement diminishes the cavity of the chest, so that the lungs being pressed

down are compelled to send forth some of the air through the mouth and the nostrils. Thus we can understand how the action of intercostal muscles is necessary for the normal breathing in and breathing out of air.

Tight lacing and wearing of corsets deform the chest cavity and interfere with the normal movements of the ribs and also activities of the stomach.

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## CHAPTER VIII.

### *Upper Limb.*

#### LESSON I.

#### Bones and Joints of Upper Limb

Man has two upper and two lower limbs. Each upper limb consists of three parts, the upper arm, the forearm and the hand. With the bones of the upper extremity, it is customary to include the two shoulder blades or scapula and two collar bones or clavicles, of which we will speak at length presently.

Each upper limb therefore contains the following bones :—

Shoulder	}	Scapula.
&		Clavicle.
Upper arm	}	Humerus.
		Radius
Fore-arm	}	&
		Ulna.

Hand { 8 Carpal (wrist) bones.  
 5 Metacarpal (palm) bones.  
 14 Phalanges or finger bones.

The shoulder blade (*scapula*) is a triangular flat piece of bone. It joins with the collar bone by a thick process of bone which can be felt under the skin just above the shoulder. It forms the either side of the upper portion of our back. The scapula practically hangs from the one extremity of the clavicle and to a great extent held in place by muscles, ligaments and cartilages that bind it in its place. The outer angle of the triangle is thick and presents a cup-shaped depression called the Glenoid cavity which comes in contact with the head of the arm bone or the Humerus.

The collar bone (*clavicle*) is a piece of slender but thick bone shaped like the italics letter "f." By one end it joins with the breast bone and by the other with the scapula which is suspended from the collar bone. The collar bone is very liable to be broken by falls from horse back or any other high place.

### The upper arm bone (Humerus)

It is a long bone and at the same time a strong one. It has a long and cylindrical body and two ends. The upper end is round and is called the head. The head of the humerus fits into the cup of the scapula (glenoid cavity) to form—

### The Shoulder Joint.

This is a ball-and-socket joint. The ball is formed by the globular head of the humerus (the bone or the

arm) and the socket by the Glenoid cavity referred to above. The advantage of the ball and socket joint is that it enables the arm to be moved almost freely in any direction. Try, and you will see that you can move that limb up and down, backwards and forwards, and you can twist it round and rotate it.

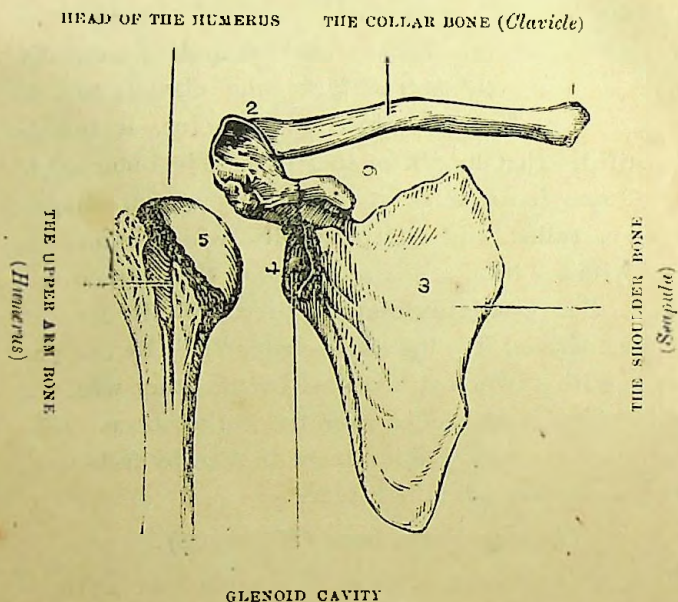
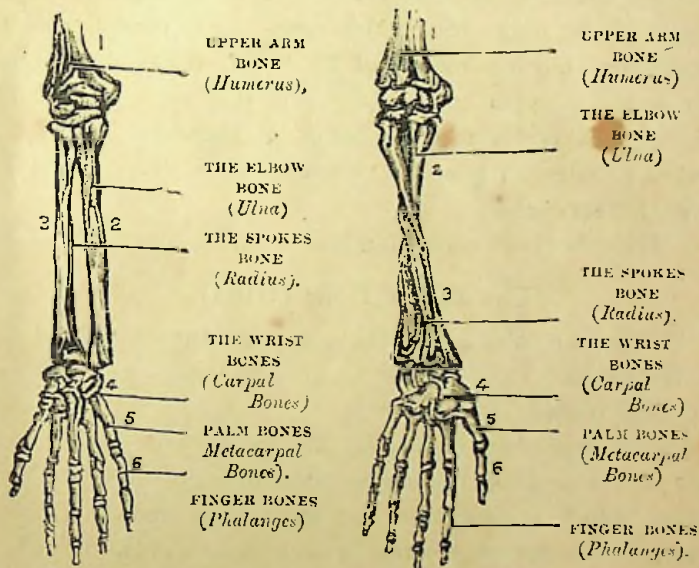


Fig. 9.—The collar bone (*CLAVICLE*), the shoulder bone (*SCAPULA*) and head of the upper arm bone (*HUMERUS*)

1, CLAVICLE ; 2, CORACOID PROCESS ; 3, BLADE OF THE SCAPULA ; 4, GLENOID CAVITY ; 5, HEAD OF THE HUMERUS ; 6, ACROMION PROCESS.

During all these movements the head of the humerus which is proportionally larger than the cup of the scapula does not slip off only on account of strong

membranous bands or ligaments which bind the bones together and the muscles which extend from the trunk to the limb. But by accident the head may slip off its cavity which is known as *dislocation of the shoulder joint*. In such a case the hand must be pulled down in such a manner that it gets below the rim of the cup and then the head of the humerus will slip in again.



THE BONES OF THE RIGHT FOREARM.

Fig. 10—with palm upwards (Supination)

Fig. 11—with palm downwards (Pronation)

1, HUMERUS ; 2, ULNA ; 3, RADIUS ; 4, CARPAL BONES ; 5, METACARPAL BONES ; 6, PHALANGES.

The upper arm bone has two extremities. The upper one, we have already said, forms the shoulder joint. The lower end which is elongated fits on to two bones and forms the elbow joint. The shorter of these two on the same side of the arm as thumb, is called

### **The Spokes Bone ( Radius ).**

It is so called because it resembles one of the spokes of a wheel; It is also called radius because it is articulated with the wrist-bones and permits the radiation (turning round) of the wrist. It has also two ends. The upper end is a small shallow cup. Its lower end is fastened to bones of the wrist. It lies on the outer side of the forearm when the palm is directed forwards.

The other bone of the forearm is called

### **The Elbow Bone (Ulna)**

When the palm is directed forwards the elbow bone—larger one of the forearms, lies on the inner side of the forearm.

The elbow bone or ulna by its upper end fits into the lower end of the upper arm bone by a kind of hinge which is just like the hinge of a door. The forearm cannot therefore be bent backwards. The elbow bone, the spokes bone and the upper arm bone enter into the formation of—

### **The Elbow Joint.**

The elbow joint is a hinge joint so called from the fact that it allows forward and backward movements

as those of the door. Unlike the previous joint, viz., the shoulder joint, the elbow joint possesses a very limited amount of movement. The main movement of this joint is one of bending or flexion and of extending or extension. There are two other kinds of movements which is peculiar to this joint in man. These are Supination and Pronation. When the forearm is rotated so that the palm of the hand points forwards, the movement is called *Supination* (Fig. 10). When the palm points backwards and the back of the hand is exposed, the movement is called *Pronation* (Fig 11). During these movements the elbow bone remains stationary, but the lower end of the spoke bone turns round and rolls over its neighbour as shown in the picture on page 31.

### The Wrist Bones (Carpal bones)

are very small and eight in number. They are bound down to each other by strong connecting bands or ligaments but still there remains much flexibility and the division of the wrist bones in two rows renders the wrist less liable to fracture or pain. For any blow or any shock coming to any part of it, is at once distributed to all the bones and thus its violence is to a great degree decreased. Succeeding the wrist bones we get

### The palm bones (Metacarpals).

These look like the beginnings of the fingers but they are not so. They form the bony structure of the palm

and can be felt in their entire length from the wrist bones to the

### Finger Bones or Phalanges.

Of the finger bones there are 14; 3 in each of the four fingers, this making 12 and the remaining 2 in the thumb. The greatest freedom of the phalanges is directed to various forms of grasping, although other movements of the fingers are employed in the use of the hand.

## LESSON II.

### A Talk on Muscles.

We have already mentioned about muscular tissue while dealing with the various tissues of the body. This muscular tissue, which in common parlance is called *flesh*, covers all the bony framework of our bodies.

The chief use of the muscles is to cause movement in the body. All the various gestures and postures, walking, talking, chewing, lifting, hammering etc., call into play the action of various groups of muscles. The arms and the legs being constantly engaged in various sorts of laborious works show the most well-developed muscles. Look at the arms of the blacksmith who is hammering on the anvil day after day. Look at the calf of the mail-runner; how strong and well developed muscles these are! And by and by, you will learn that the more work we give to our muscles, the better they

like it, and larger and stronger do they develop. The firmer and larger the muscles are, the greater the strain that they will be able to endure. The more the muscles are trained, the greater will be the varieties of motion possible.

Let us see how all this movement is brought about. Suppose you take two long pieces of wood and hinge one of them on to the other. If you now fasten a strong piece of elastic thing like India rubber by its ends to the bars of wood, I think, I can make you somewhat understand how a muscle acts. The bars of wood stand for two bones joined by a sort of hinge. If you stretch them out and then remove your hand, the elastic thing will at once recoil and pull the bars together. This, though not an exact comparison, is the best one you can have, because muscles cause the movements of the body simply by contracting or shortening themselves. Muscles are like a piece of elastic India rubber for three reasons :—

- I. Muscles can become longer, or can expand.
- II. Muscles can become shorter, or can contract.
- III. Muscles can remain as they are, or remain stationary.

Now I will talk to you on the structure of a muscle. If you take a well boiled piece of meat and examine it, you will notice that it is composed of a number of coarse strings or a bundle of great many fibers. You can separate from each string a number of finer strings and these finer strings can again with the help of a needle be divided into many finest threads.

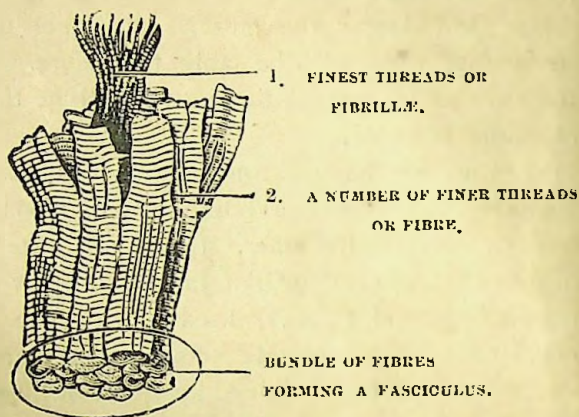


Fig 12—Picture of a piece of muscle as seen through a strong Microscope.

1. These finest threads are called fibrillæ, which are nothing but a combination of elongated tissues.
2. A number of these finest threads lying together is a fibre.
3. A bundle of fibres form a fasciculus.
4. A number of these fasciculi bundled up make a muscle.

Now, we should learn here another thing that almost all the muscles of our body is *striated* or striped (some what like the spiral spring), that the striated appearance is to be seen even in the fibrillæ, and that there is a very thin—thinner than the fabulously thin Dacca Muslin,—transparent sheath

called *Sarcolemma*, which encases individually each of the fibrillæ, fibres and fasciculi.

The learned men divide the muscles into two great groups :—

1. The willing (voluntary) muscles which obey our will.
2. The wilful (involuntary) muscles which act without our knowledge or control.

The wilful or involuntary muscles, although they do not obey our will, yet frequently respond to our feelings. They do not obey our orders but, nevertheless, they sympathise with us, so to speak. The finest samples of these muscles are to be found in the heart, lungs, stomach, liver and kidneys which carry on their respective works in spite of all as long as our life lasts. The willing or voluntary muscles are all attached to bones frequently by tendons, and are long, red and striated. But the wilful or involuntary muscles are not attached to bones. They have no fixed support nor striated appearance, as the willing muscles have. They occur either as circular bundles of fibres just like the coils of a rope or as longitudinal smooth band-shaped bundles of fibres. Involuntary muscles are often seen to be composed of a series of needle shaped cells that form flat textures like sheets of paper. The wilful muscles just under the skin will contract when a man is frightened and by their contraction will cause the hairs of the body stand on end. The lady reads the news of her father's death, she staggers and looks pale; her face turns white. She turned white

because the muscles of the blood-vessel, though they are involuntary muscles, reply to the feelings and contract. The blood cannot pass quickly through, so the veins become almost empty and the complexion loses its natural reddish glow.

### LESTON III.

#### Muscles and Nerves of the Upper Limb.

In the previous lesson, I have told you about voluntary or willing muscles. The muscles we are now going to learn about are all voluntary muscles. They already do exactly as we tell them, sometimes they do things without our knowing that we have told them; but this is only because that we have made them carry out our orders repeatedly so often that they have got used to acting without fresh commands.

We have already shown in the previous chapter that we cannot move nor exist without muscular system; without our muscular tissues, we could not imagine ourselves as *ourselves* and the functions of our various internal organs and vital processes of life could not proceed for an instant. It is self-evident that the more perfectly trained and cultivated the muscles are, the more efficient will they become in themselves, and the more capable the individual will be whose will they obey.

So, if you want to be a strong man you must have strong and well-developed muscles. Muscles become developed and strong, only if you use them, and engage

them in proper work. The various forms of exercise that have been invented are only intended for giving the muscles the right kind of work. The development, however, of a strong will and whole hearted concentration ought to be kept in view by every physical culturist who wishes to strengthen his muscles ; but, unfortunately, it is a matter which many of us neglect most and this accounts for the failure among tyro physical culturists. The willing or voluntary muscles, as pointed out before, are directly under the control of our will. Now if you say "Let my muscles contract more easily and develop more strongly", then it cannot but act up to it. Thus by repeated exercise of your will you can perform your feats much more to the advantage of your body. But on the other hand if you have no mind in the exercise you are performing, the muscles will contract as feebly as they have done before, there will be no strength, no energy in their contraction and so you are deprived of any benefit whatsoever, which you expected.

A glance at the-accompanying diagrams ( Figs. 13 & 14 ) will show the position and arrangement of some of the important muscles of the upper limb.

The *deltoid* is the muscle which forms the outer side of our shoulder and gives it a rounded outline. It is a strong and thick muscle. It covers the shoulder joint ; when it contracts it raises the arm directly from the side so as to bring it at right angles with the trunk.

That boy has a well-formed chest. What is that due to ? It is due to the *Pectoralis major* muscle

which are well-developed in his case. The muscle arises from the breast bone and the rib cartilages. As its branches gradually approach the arm they unite into a flat tendon which becomes attached to the upper part of the Humerus. Tendons, I should like to remark in this connection, are associated with muscles where it takes attachment or are inserted into the bone. Their structure is quite different from that of a muscle. They are composed of strong white glistening fibres and look like strong jute ropes.

Bend your elbow and bring up your forearm near the shoulder. Don't you see a prominent swelling in front of your arm? This swelling many of you have noticed with curiosity from your childhood. Now I shall tell you what that is due to. It is produced by the contraction of an important muscle the *Biceps* or the muscle with two heads of origin. The insertion of the Biceps is in a single tendon that is attached to the upper part of Radius, the outer bone of the forearm. Its action is to bend the elbow joint. Perhaps, you will remember in this connection, how the upper ends of the Ulna and Radius so joined together as to effect a hinge-joint with the lower end of the humerus and it will be understood from this how the Biceps contort to bring up the forearm.

As an antagonist of the Biceps you have the *Triceps* or the muscle with three heads of origin which lies just on the back of the arm. It extends the elbow joint and so its action is just the opposite to that of the Biceps.

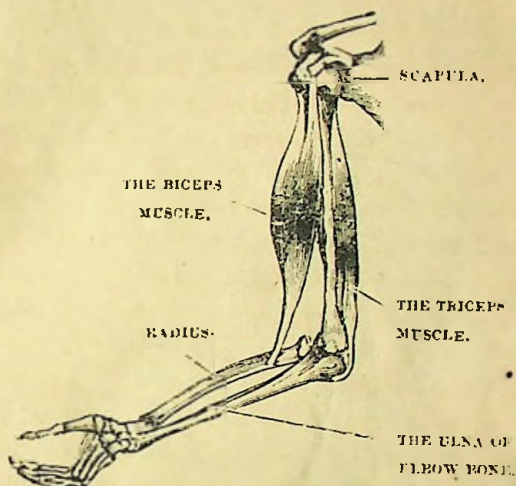


Fig. 13.—Diagram showing the two principal Muscles of the Arm.

Coming to the forearm we meet with two sets of muscles.

1. Bending muscles ( flexors ).
2. Extending muscles ( extensors ).

The bending muscles lie in front of the forearm and pass through the palm and are attached inside the bones of the hand, their principal function being to bring the palm of the hand up toward the forearm ; whereas the extensor muscles are all situated along the outer edge and some on the back of the forearm and pass through the back of the wrist to the back of the palm where they take insertion into the metacarpal bones ; the work of the muscles is to extend the hand.

One of the most important muscles of the forearm is the *Palmaris Longus* which is instrumental in the

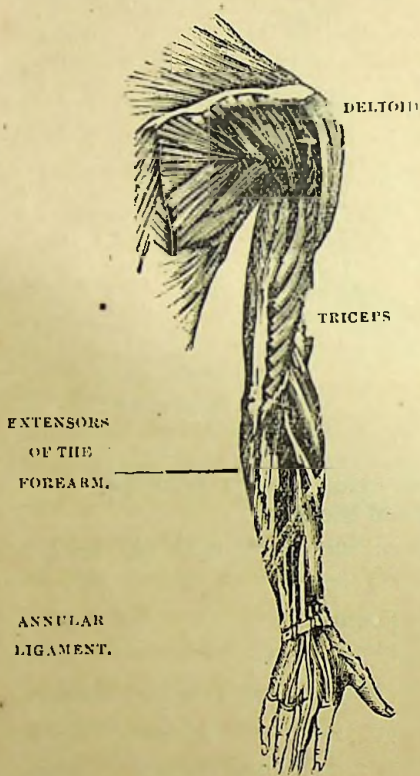


Fig. 14—A back view of the Muscles of the upper limb.

successful work of the palm of the hand. This is a slender and narrow muscle rising in the condyle (extremity) of the Humerus and first seen along the inner side of the forearm; but obliquing gradually inward is found crossing into the palm of the hand at about the centre of the wrist.

At the base of the hand, where it joins the wrist, is a strong tape like ligament tied around, which is called the *Annular ligament*. Now the tendon of the palmaris longus passes under this annular ligament and ends almost entirely in *Palmar fascia*, which is nothing but a very thin common sheath covering the muscles of the palm of the hand, (looking

somewhat like a Japanese toy fan) branching off into five slips each connecting with the base of one of the five fingers.

Besides these muscles there are in the palm two sets of small muscles connected with the thumb and the little finger. It is these muscles which produce the elevations just on the two sides of the central palmar depression.

In close association with the muscles are the nerves and blood vessels. About the blood vessels we shall speak later on. But here I want to tell you something about the nerves.

Nerves are white glistening cord-like or thread-like solid structures which convey impulses either from

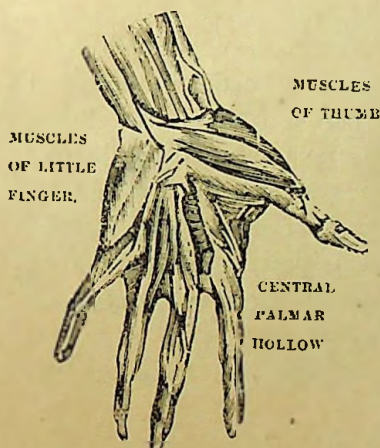


Fig. 15.—The muscles of the Hand.

the brain or spinal cord to the muscles and other organs, or experiences from the organs to the spinal cord or the brain. It has been thought that energy and impulse is generated in the muscles, but in reality they are powerless to act without the dictates from the nerves and these nerves are but the faithful couriers of our brain and spinal region where

every thought is created, transferred into will, every

feeling is perceived and every impulse is born. The brain and the spinal cord may be compared to a central telegraph office from which messages are sent to different stations. The central office also receives messages for disposal from the various stations outside. The nerves represent the network of telegraph wires. Nerves that convey messages from the outside world—*i. e.*, experiences of the five senses, are called *sensory* nerves, while those that carry impulses from the central nervous system to the different muscles and voluntary parts of our body, are called *Motor* nerves.

Nerves generally end in the muscles and the skin. If by any injury the nerve is cut or torn, then neither can we feel anything nor contract the muscles.

The nerves which come down to the upper limb arise in a plexiform manner from that portion of the spinal cord which is situated in the region of the neck. From the intermingling of nerves issue out some distinct nerves which take various courses along the arm and the forearm. The study of different nerves and their relative usefulness, is, though most important and instructive, very complex. We shall speak more elaborately of them in some succeeding chapter.

The most important nerves of the hand are the following :—

The *Median nerve*—It is so called because it passes along the middle of the arm and forearm to the hand. It supplies some muscles of the forearm and the palm and also the skin of the palm.

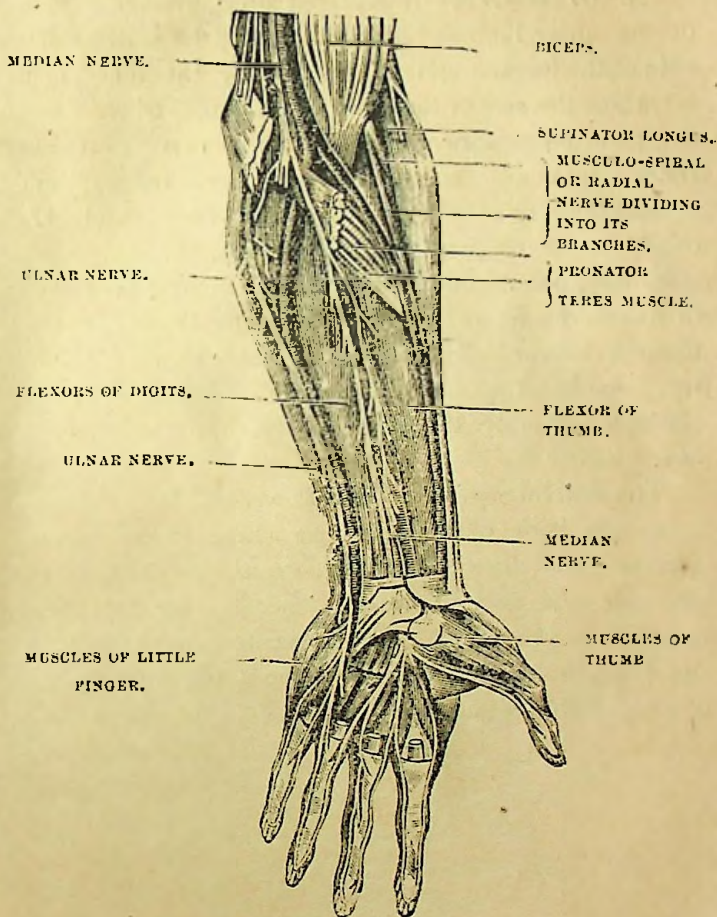


Fig. 16—Nerves and muscles of the forearm and hand. ( Front view. )

The *Ulnar nerve*—It is placed along the inner side of the upper limb and is distributed to the muscles and skin of the forearm and the hand. By the inner side is meant the side of the arm nearest the trunk when the palm faces forwards. The ulnar nerve is sometimes struck near the inner side of the elbow joint against the table or any other hard thing, and this causes us a ringing and unbearable, though very transitory, pain. The median and the ulnar nerves have branched off from the Brachial plexus (by Plexus we mean a *network* or *knot* of nerves) which is situated just amidst the Deltoid muscle. These 2 nerves principally supply the sense of touch to the fingers and hands.

The *Musculo-spiral or radial nerve*.—It is placed along the back of the upper arm where it supplies the Triceps and then bifurcating, sends one branch to the outer side of the forearm where it supplies the muscles at the radial side of the forearm, the other supplying the skin of the back of the forearm and that of some of the fingers.

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## CHAPTER IX.

*Lower Limb.*

## LESSON 1.

## Bones and Joints of the Lower Limb.

The general arrangement and number of the bones of the legs bear a remarkable similarity to those of the arms. Thus the leg (like the arm) consists of the thigh, the lower leg and the foot. There is one bone in the thigh while there are two in the lower leg. Exactly similar arrangement exists in case of the upper extremity. In the foot the tarsal bones correspond with the carpal bones of the hand and metatarsals and phalanges tally with the metacarpals and phalanges of the palm.

The bones of the lower extremity are :—

Thigh	Femur	(thigh bone)
Lower leg	{	Patella (knee-cap)
		Tibia (shin bone)
		Fibula. (buckle bone)
Foot	{	7 Tarsus (ankle bones)
		5 Metatarsus (instep bones)
		14 Phalanges (toe bones)

These make thirty bones in all. So, there are sixty bones altogether in our two legs.

The legs are fastened to the trunk through the intervention of *the body-basin or the Pelvis*. The pelvis is formed by two "*nameless bones*" (os innominata) on two sides and the sacrum and coccyx behind. It

contains many important organs viz, the urinary sac called bladder, the lower portion of the digestive tube (the large intestines), the womb or uterus (in the female) and the organs of generation, besides many locally important blood vessels and nerves.

The nameless bones give the shape of the buttocks and each of them on the outer edge presents a deep cup-shaped cavity in the middle into which fits the head of

### The Thigh Bone or Femur.

The femur is the longest, strongest and heaviest bone of the body. It has a rounded head at its upper end which fits into the cup of the nameless bone to form

### The Hip Joint.

The Hip Joint is a very stable joint and is strengthened by the strongest ligaments (connecting bands) of the body. It is a ball and socket joint and through this joint the weight of the body is transmitted to the legs. Powerful muscles surround this joint.

But the stability of the joint in a certain measure interferes with its free movement. The cup or cavity in the nameless bone is deeper than the cup of the scapula into which fits the head of the humerus and this accounts for the diminished mobility of this joint. Try to move your leg at the hip-joint and you will see that you can swing your leg forward, backward and sideways to a great extent, but you cannot raise it up to your head.

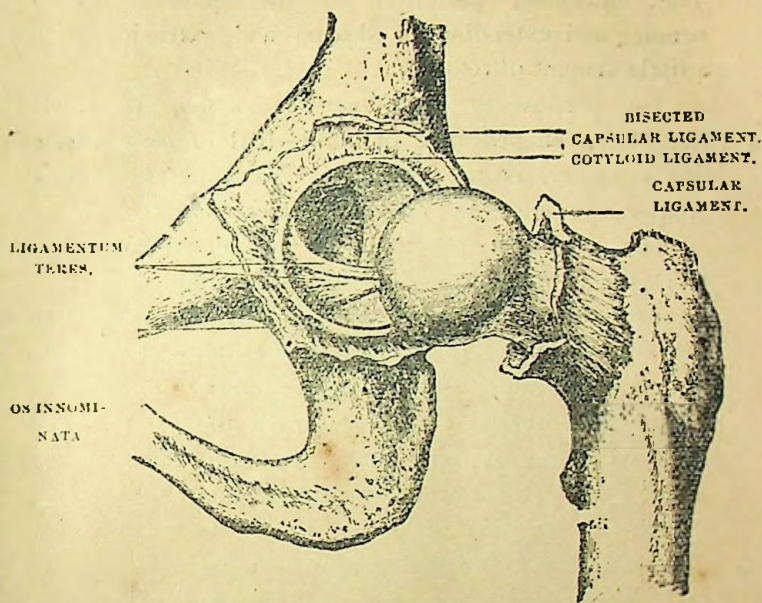


Fig. 17.—The Hip joint.

[ *Capsular ligament has been bisected to expose the ligamentum teres which sprouts forth from a small hole on the head of the Femur, being strongly inserted into the cavity walls* ]

The lower end of the thigh bone presents two rounded swellings called 'condyles' which can be felt at the sides of the knee and which fit with the head of the shin-bone to form

### The Knee Joint.

In front of the lower end of the Femur is the patella or knee cap which glides over a smooth surface.

The movement permitted in this joint is one of bending and extending or flexion and extension with a little amount of rotation.

The purpose of the knee-cap which is small irregularly shaped disc of bone—little hollow inside like a saucer, is to protect the joint and to give a greater leverage to the more important muscles there.

The peculiarity of this joint is the abundance of a lubricating fluid or *synovia* which is contained in thin membranous sacs called *bursae*. *Synovia* resembles the white of an egg in appearance and may be termed as joint-lubricator. By oiling the joints it defeats the friction that otherwise would wear out the joints. The synovial lining is very often the seat of inflammation which causes stiffness and swelling in this joint.

At the junction of bones, there are also often found thin layers of cartilages, which make the joints fast and secure. Sockets have deep ring of cartilage at and round the outer edge for the purpose of making the socket deeper and the head sit tight into it. To hold the bone in place, ligaments pass over the joints connecting the two bones with tough elastic fibers that give the bones reasonable freedom and yet hold them strictly to their position. Ligaments do not break as bones do, but in exceptional cases may be torn or lacerated.

In the leg, you can see from the skeleton, there are two bones—the inner shin-bone or *Tibia* and the outer buckle bone or *Fibula*. It is the *Tibia* which forms what is commonly called the shin of the leg; and it

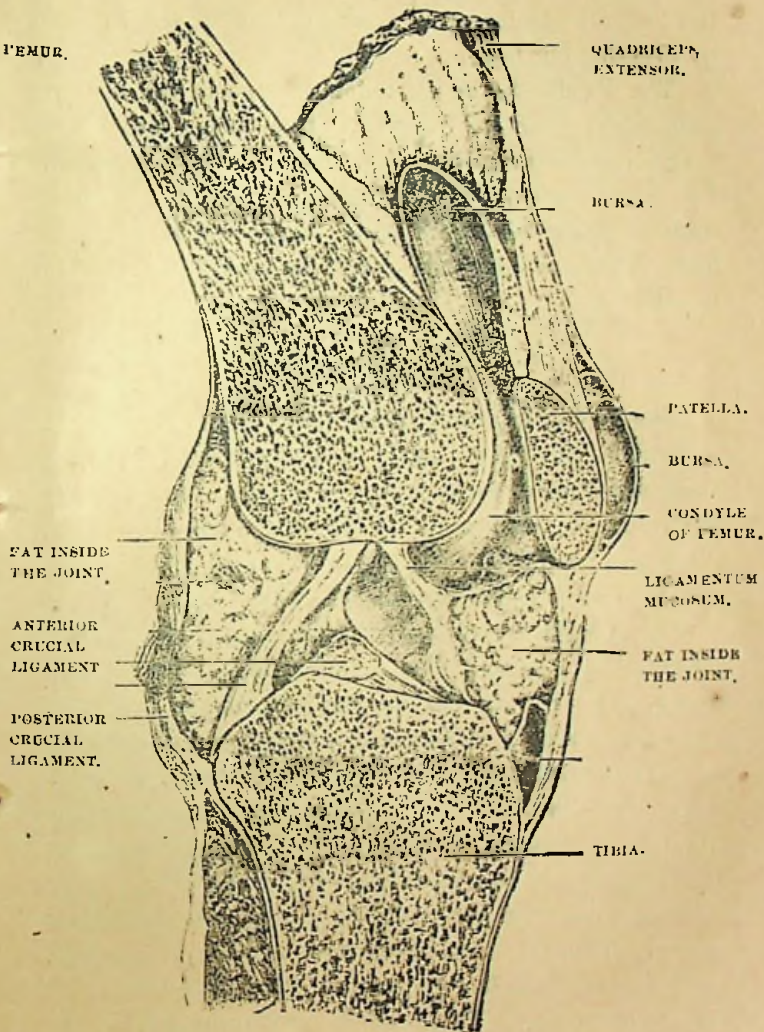


Fig. 18.—Lateral section through the knee joint.

lies mostly under the skin and can be easily felt by pressing our finger.

The Fibula is the most slender bone of the body in comparison with its length. These bones are bound together by strong ligaments both above and below. The lower ends of these bones form prominent projections on either side of the ankle known as *malleoli* or little hammers and join with the bones of the ankle to form

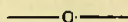
### The Ankle Joint.

The ankle joint is a hinge joint. The bones of the ankle *i. e.*, the tarsal bones and the lower ends of the Tibia and Fibula, enter into the formation of the Ankle joint. It is surrounded by ligaments on all sides. When the ankle is accidentally sprained, either some muscle or some ligament round the joint is injured.

The Tarsal bones make up the ankle ; these bones are seven in number. One of the Tarsal bones is very strong and projects out as the heel bone or *Os calcis*. It is very strongly developed, as the weight of the body is directly transmitted to the ground through this bone. Next to the *Os calcis* is found the *Astragalus*, one of the tarsal bone that articulates with Tibia and to a great degree, bears the weight of the body on the foot.

Succeeding the tarsal bones we get the metatarsals and the phalanges, whose structure as well as arrangement is very similar to that of the palm-bones and the finger-bones. These bones are arranged in arches of which the piers are formed by the *Os calcis* behind

and heads of the metatarsal bones in front. Strong ligaments have, therefore, to exist here to keep the integrity of the arch. The muscle tendons also help in maintaining the arches. Had there been no such ligaments or if these were ill developed, we got a condition known as "*Flat Foot*."



## LESSON II.

### Muscles and Nerves of the Lower Limb.

Muscles lie underneath the skin separated from it by what we call subcutaneous tissue which consists chiefly of fatty and connective tissues.

A large number of muscles help to form fleshy portion of the thigh. Some of the important ones are described below.

The *Sartorius* is the longest muscle in the body ; it is flat, narrow and ribbon-like. Originating from the upper part of the Os innominata, it extends from the outer side of the thigh and crosses obliquely over the upper portion of the Femur to the inner side of the legs. It becomes much prominent in the tailor's position when he sits cross-legged.

The *Quadriceps extensor* is composed of four muscles which cover the front and sides of the thigh and these are united below into a single tendon which end in the patella. This muscle is principally used for straightening the leg. The four muscles composing the quadriceps are the Rectus Femoris, the Vastus

Externus, the Vastus Internus and the Crureus. Each of these muscles has its own head or point of origin. These four branches unite near the knee in a single tendon that is attached flatly to the patella.

The *Adductor muscles* of the thigh consists of three powerful muscles with the triangular appearance of an open fan, which arising from the front portion of the so-called "nameless bone" under the Spermatic cord, are set up one above the other along the inner side of the Thigh bone or Femur. These muscles are brought into action in drawing the two legs together and in bringing either leg inward in line with the spine and even in crossing one knee upon the other. They are principally used in riding in which it is necessary to grasp the flanks of the horse between the two thighs and knees. In cavalry soldiers the greater portion of the adductor muscles transforms into a tendon and the whole of the muscles sometimes becomes hard and bony through constant exercise.

The prominence of the Hip is formed chiefly by the *Gluteal muscles*. They are three in number. These glutei and 5 other are all found on and around the buttocks. They perform a variety of muscular work, the most important of which are adducting and extending the thigh and in conjunction with other back muscles materially holding the body erect.

The *Iliacstring muscles* cover the back of the thigh; they bend the leg upon the thigh and act in opposition to the quadriceps extensor. The most important of

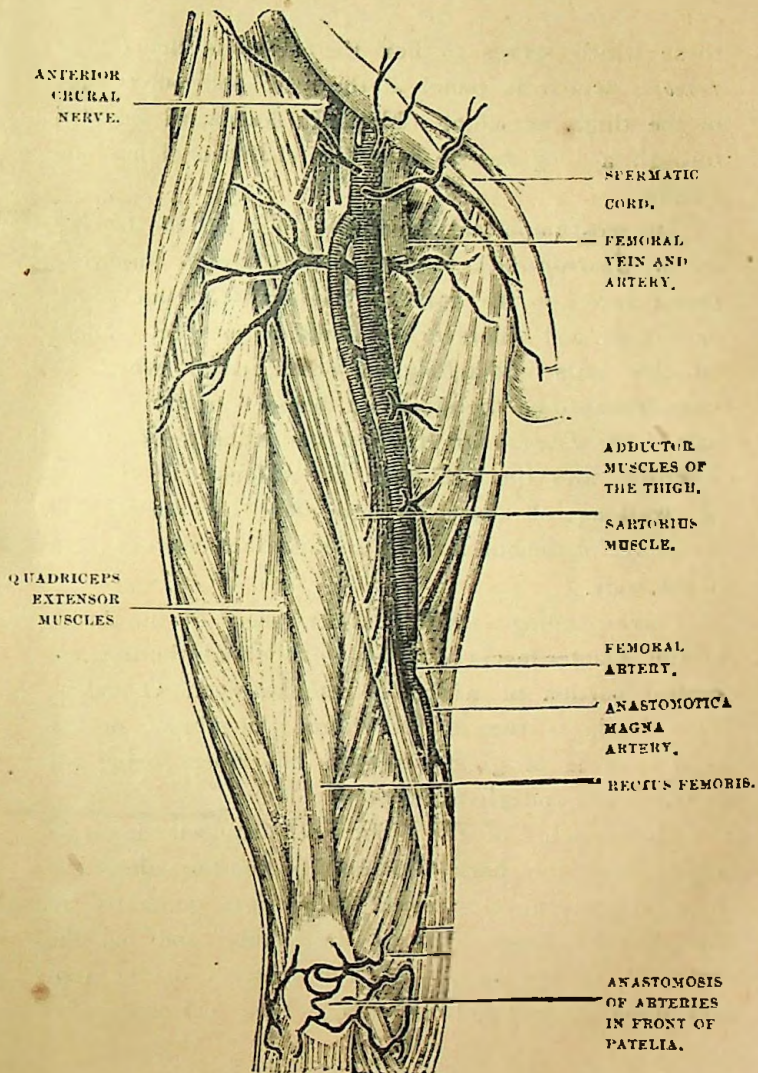


Fig. 19—Muscles, nerves and blood vessels of the thigh ( front view.)

these which serves to flex the knee, is the *Biceps femoris* which is found at the back and outer edge of the thigh extending obliquely downward inserted through a long tendon into the shafts of Tibia and Fibula.

The most important among the muscles of the leg are the *Gastrocnemius* and the *Soleus* which form the prominence of the calf. These muscles are much developed and distinct in montanic people. These muscles unite into a long and broad tendon which is considered to be the strongest tendon in the body—named the *Tendon of Achillis*, and this tendon takes insertion into the heel-bone *Os calcis*. In the act of walking, at every forward step this muscle and its powerful tendon is used to raise the entire weight of the body.

Corresponding with the Palmer fascia of the hand, is the Planter fascia of the sole of the foot, the thickest central portion of which is attached to the *Os calcis*. This fascia is the densest fibrous membrane of the body and is of great strength, the fibers being all pearly white and glistening.

The muscles of the Foot are arranged in two regions—on the back (*dorsum*) and on the sole of the foot. These muscles have their origin generally in the fibrous tissues around the ankle and on the sole of of the foot. All the muscles of the foot act upon the toes and bring about their various movements.

BACK OF THE KNEE.

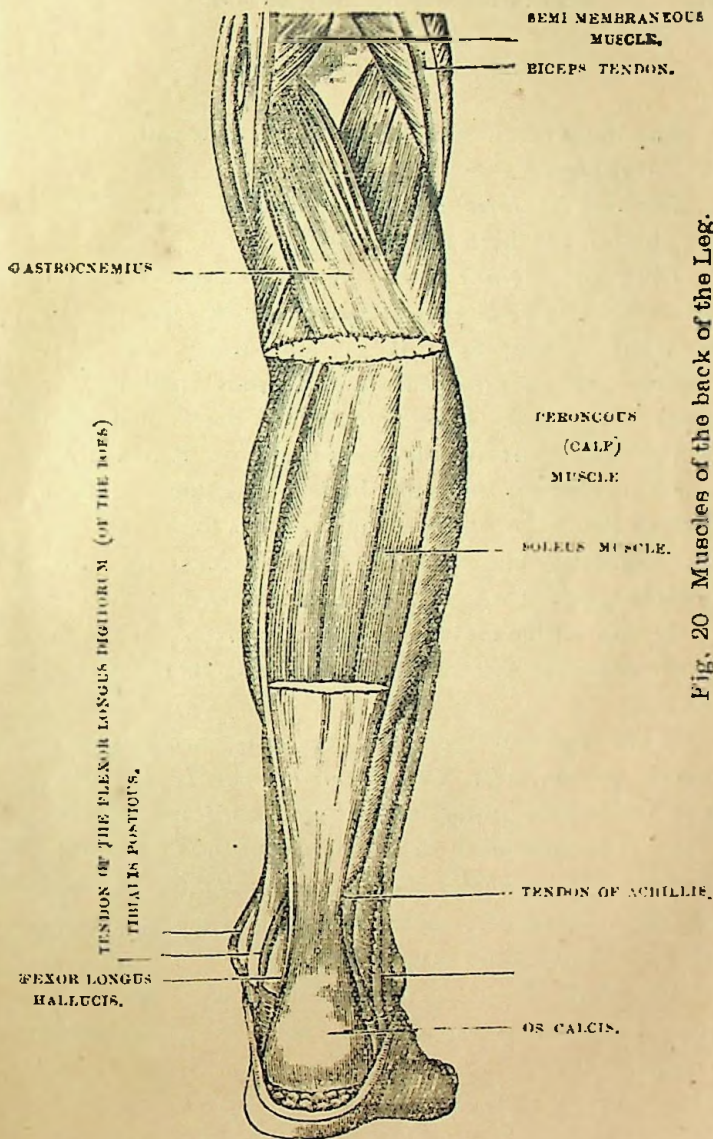


Fig. 20 Muscles of the back of the Leg.

### Nerves of the Lower Limb.

The important nerves of the lower extremities are the following :—

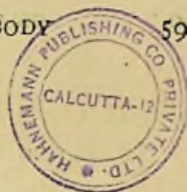
*The small Sciatic nerve*—supplies the skin of the back part of the thigh and the leg.

*The great Sciatic nerve*—is the largest nerve in the body and measures about three quarters of an inch in diameter. It is so strong that you cannot tear it off even by vigorous pulling. It arises from the lower portion of the spinal cord in the back part of the body-basin or Pelvis from which it emerges into the back of the thigh. At the back of the thigh it gives off branches to the skin and the hamstring muscles. It then divides into two branches, one of which goes along the back of the leg to the sole of the foot, where it terminates ; while the other comes in front of the leg and ends on the back of the foot.

In the front of the thigh there is another nerve known as *Anterior Crural or Femoral*. It arises from the lumbar portion of the spinal cord and supplies branches to muscles of the front part of the thigh, to the hip joint and knee joint, and is continued down sending off-shoots along the inner side of the leg and the foot where it supplies the skin only.

We shall dwell on these wonderful nerves in general and its system very soon in a succeeding chapter.

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## CHAPTER X.

*The Value of Food and the Digestive Organs.*

## LESSON I.

## The mouth and the teeth.

Let me once more remind you of the gross similarity that exists between the engine and the human body, of which you were told in the first chapter. The engine requires water, fuel etc., to carry on its propelling work, and so does our body require food and drink in order that it may carefully and faithfully discharge its works in various avenues of life. Though we apparently perform no work during our sleeping hours, still the heart goes on palpitating and the lungs go on with the usual taking in of Oxygen and giving out of Carbon Dioxide. So there is constant waste in the various parts of our body during the twenty-four hours of the day. This waste is to be made good by the food we take. Another important function the food has got to perform is to furnish muscle and other power for the work of the body and generate heat to keep it warm. But in order that the food may be utilised for the needs of the body, it has first to undergo certain changes. The process by which these changes are brought about is known as *digestion* and the organs which are concerned

in this act are collectively known as the *Digestive System*.

The digestive apparatus may roughly be compared to a *long tube* at one end of which is the mouth and at the other end the anus. The tube is not of uniform bore throughout, but widens into pouches or retorts at several places the stomach being the biggest of all, shaped like a bag-pipe.

The first wide portion is the mouth which we are going to deal with in this Lesson. **The Mouth** is an oval shaped cavity in which the food is first received and masticated. It is bounded in front by the lips, on the sides by the cheek, above by the hard and soft palate and below by the tongue. The palate forms the roof of the mouth, the anterior—bony part being known as hard palate, while the posterior—moveable portion called soft palate. Just behind the soft palate, there is a conspicuous elongation hanging down in the shape of a small tongue, called *uvula*, which is known to be of little or no importance to our body.

In the mouth, the **Teeth** form the mill which crushes up the food, while the tongue performs its part of a mill hand by bringing the food under the mill. The tongue is one of the most remarkable of our muscular organs, being endowed with the sense of taste, and power of speech (taken in connection with the larynx and the vocal cords).

The grown up man has thirtytwo teeth. The teeth are set in the jaw bones to which they are fixed by a

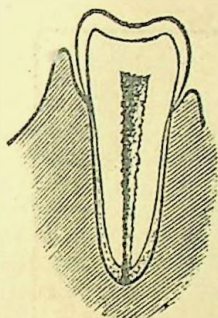


Fig. 21—A tooth set in the gum ; in the middle the Pulp Chamber containing blood vessels and nerves.

*cement* like material. The portion of the tooth which is set inside the jaw-bone is called its *root* and the portion sprouting outside it, is called its *crown*. A tooth is made up of a kind of material little harder than the ordinary cartilage known as *dentine*. The comparatively softer dentine is protected by a very hard but fine ivory like coating called *enamel*. It is this enamel which gives the smooth, polished pearly appearance to the teeth. If this enamel (covering) becomes any how impaired, it does not grow again ; the softer dentine is thus exposed and rendered liable to decay and degeneration by coming in contact with air etc., and we get a *carious* tooth. In such a condition there is no alternative than to seek the help of a dentist who will properly plug the exposed part and thus save the soft dentine from further decay. In the centre of the tooth in a small triangular sheath ( Chamber ) is the *tooth pulp* which is a mass of nerves and blood vessels by which the tooth is nourished.

Good teeth, besides being one of the natural adornments of the body, are most essential to the proper digestion of food. The teeth should therefore be kept well-cleaned by the use of a tooth-brush \* and some

\* The manner of using the brush is to move it in a direction parallel to the long axes of the teeth with a down-ward stroke

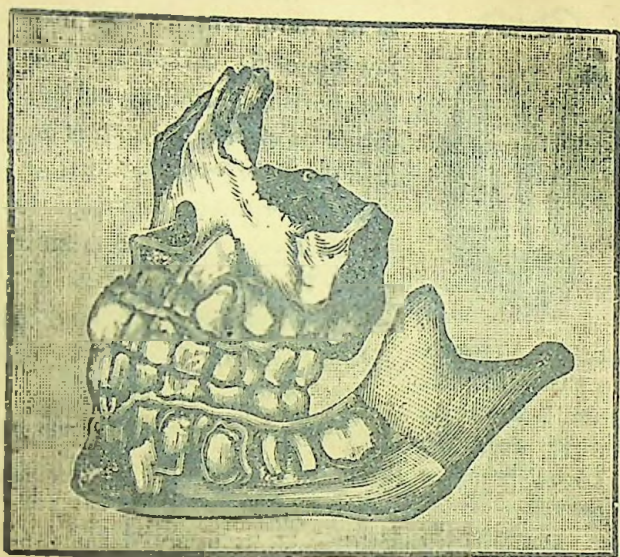


Fig. 22—A side view of the two rows of teeth ; root and crown exposed.

reliable tooth-powder (preferably tooth-paste for those who have already carious teeth) or by the use of a pencil like chip of the twig of such trees as Nimba (*Margosa*), Babla (*Acacia Arabica*), etc. In brushing the

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in the case of upper row and upward stroke in the case of lower one. The teeth should never be brushed *across* their long axes as this action does not clear the interspaces, but tends to pack the food-debris etc., further *into* them, and it also does much harm wearing transverse grooves near the neck of the teeth. The brush must be washed thoroughly after use and preferably disinfected in an antiseptic solution.

teeth the food particles sticking at its root, are to be thoroughly removed, otherwise decomposition will take place which will give rise to a very foul odour in the mouth and may even injure the health of the gums which may become spongy. At the roots of the teeth of aged adults we sometimes come across a sort of hard chalky substance of a varying colour which is known as *Tartar of the teeth*. The tartar is formed by the phosphates from secretions of glands near the gums and entangled food particles. The excessive accumulation of the tartars favours the growth of bacterial infection around the gums, when we get a condition known as *Pyorrhœa alveolaris* which forms pus within the gums, renders them too tender to admit of the touch of cold liquids or acid foods, completely deteriorate the dentines and may cause the formation of *Alveolar abscess* which, sometimes needs the manipulation of a surgeon. If once the enamel is accidentally injured and scraped off by biting at hard substances such as unripe nuts or by carelessly picking the tooth with a pin or scratching with a pen-knife, the softer dentine underneath it decays, and the tooth becomes hollow being eaten into the very pulp chamber, which gives rise to unbearable toothache. So we should not be unmindful of such petty things such as teeth, as you now see that trifling as they seem to be, they are absolutely essential to our existence and the welfare of our body.

Now to the different kinds and duties of teeth.

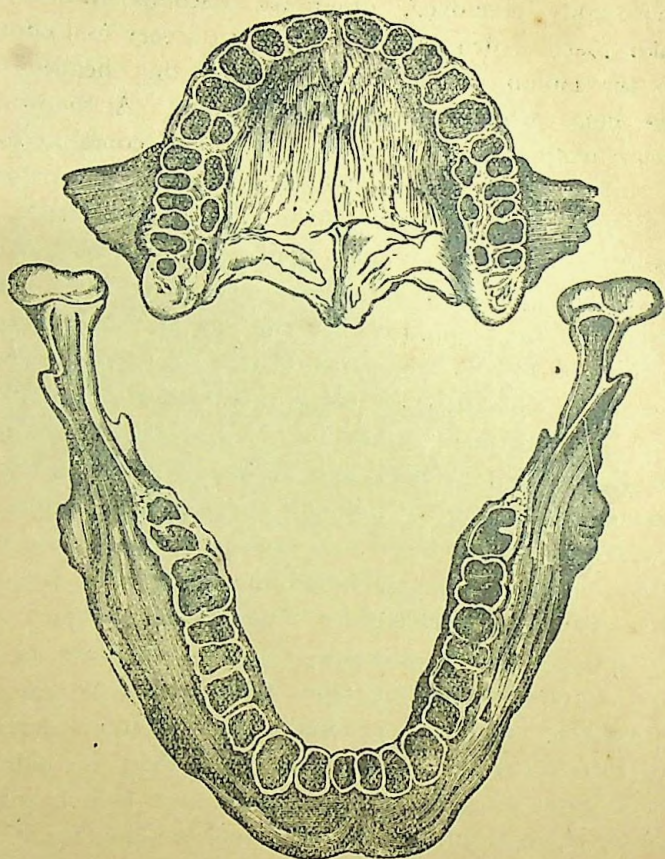


Fig. 22—Upper and lower jaws, showing gum-chambers for 32 permanent teeth

The teeth are classified under four headings according to the various duties they discharge :—

1. The Biters ( <i>Incisors</i> ) of which there are	8
2. The Tearers or Dog Teeth ( <i>Canine</i> ) of which there are	4
3. The Chewers ( <i>Bicuspid</i> ) of which there are	8
4. The Grinders ( <i>Molars</i> ) of which there are	12
	<hr/>
TOTAL	32

The Incisors (8) are arranged side by side in the front of the mouth—four on the upper and four on lower rows. They have each a sharp chisel-shaped edge and specially used for biting and dividing the food. The middle two are *central incisors* and the two by the sides are called *lateral incisors*.

The Canines (4) are singly placed just beside each of the lateral incisors; their fangs are single, larger than the incisors and conical shaped, the crown being pointed like a wedge. They are used for tearing fleshy or elastic substance.

The Bicuspids (8) are arranged four in the upper and four in the lower jaw. They are grooved laterally and the crown is surmounted by two ridges or cusps separated by a groove. They are instrumental in grinding and smashing down any hard food.

The Molars (12) are arranged three in each side of each jaw behind the bicuspids. They are short and broad, having 2 or 3 roots. The upper molars have four and the lower five ridges each separated by a crucial depression, they serve almost

the same purpose as the bicuspid and very suitable for grinding and pounding the food to a paste in conjunction with the saliva of the mouth.

Young people have got only 8 grinders *i. e.*, altogether 28 teeth. But after they pass the age of twenty-one will be added four more to their set of teeth, and these teeth which appear at such an advanced age giving us so much trouble, are called the **Wisdom teeth**.

You should know one thing more about the teeth. There are two sets of teeth which make their appearance at different periods of life. The first set appears in childhood between the age of 6 and 14 months remaining up to 8 or 9 years, and is called **Temporary or milk teeth**; they are twenty in number. But this set is replaced by another during the age of 7—12 years and these teeth which remain up to old age are known as **Permanent teeth**.

Teeth—whether they are permanent or temporary, should always be kept scrupulously clean and we should not forget that they were intended for a purpose and should be rightly used for that purpose, not only for their own welfare but for our general bodily welfare. Mouth is the gateway of our body and teeth are the gate-keepers. Who would fain wish to keep the porters of their house weak, faithless and unclean?

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CHAPTER X. (*Contd.*)

## LESSON II.

## The Saliva and its Work.

That the inner surface of the mouth is always wet—every one of you know. The thing we touch on the inner surface is called the mucous membrane. It is a very fine sort of skin which lines every part of the digestive tube. It is always wet or moist and the fluid which keeps it moist is called the mucus. The mucus is formed from tiny little structures called glands which are widely distributed.

**Glands** are minute organs which have the power of imbibing from the blood certain of its constituents. These constituents of the blood which are taken up by the glands are either worked up into some new substance useful to the body or are rejected out of the body. The glands which prepare substances useful to the body, are called *Secreting* glands and the glands which separate the useless matter of the blood to be thrown out of the body are called *Excreting* glands. The sweat glands, the kidneys are examples of excreting glands.

The mucous membrane of the mouth is always kept wet by what we call the spittle or **saliva**. The saliva is formed by the secretion of tiny glands situated all over the mucous membrane in order to keep the latter wet, and mainly formed by special spittle-making or **salivary glands**. The spittle-making glands are

secreting glands because the spittle which is formed from them is very useful. It keeps the mouth moist and it also aids to digest the food.

There are three pairs of spittle-making glands. The one near the ear which is the largest is called the *Parotid*. The one under the jaw which is next in size is called the *Sub-maxillary* and the third under the tongue is called the *Sub-lingual*. There are two of each of these glands, one on the right side and one on the left side of the mouth. The glands sometimes become inflamed or swollen as in the disease called the "*Mumps*." The swelling is very prominent behind and below the ear. From the diagram given below you can best study the relative positions of the salivary glands.

The secretion of the spittle is controlled by nerves. Fear and shock parches up the mouth by withholding the secretion of the spittle. The sight of dainty and delicious food makes the mouth water by exciting the glands to secrete.

The work of the saliva is to make the food wet in order that it may be easily masticated and swallowed and to turn into sugar the starchy portion of the food. These starchy matters before they are saturated with saliva are insoluble but when converted into sugar—*Dextrine* and *Maltose*, they are quickly dissolved in the stomach and absorbed into the blood. You can easily verify the statement that the saliva changes starch into sugar by the following method. Hold some arrowroot in your mouth for a few minutes. You will find that it gradually loses its sticky nature and becomes thin



state resists to a great extent the action of the saliva, but when cooked it is digested with great facility.

Saliva owes its active influence on starch to the presence of *ptyalin* in it. Though this substance exists in saliva in a very small quantity, it is not practically used up or destroyed in the conversion of starch into dextrine or maltose but can go on converting an indefinite amount provided the converted materials are removed as soon as possible. Its action is most vigorous at moderate temperature ( $38^{\circ}$ — $43^{\circ}$  C.), a higher temperature and the presence of free acid arresting its action.

This shows the necessity of properly masticating or chewing our food. By hurriedly swallowing the food without chewing it properly, the saliva is not allowed to mix with it thoroughly, and consequently a large amount of extra work is thrown on the intestines which may in the long run result in flatulence, indigestion, dyspepsia, pyloric spasm, heart burn, colitis, gastritis, anæmia and many other gastro-intestinal troubles. It is therefore advisable to chew each morsel of our food at best thirty-two times before swallowing it as the famous British minister Gladstone used to do.

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CHAPTER X. (*Contd.*)

## LESSON III.

## Pharynx, Uvula, Tonsils and the Gullet.

The PHARYNX or the throat-chamber is a sac-like cavity into which opens the mouth, the nasal passages, the middle ear and from which begin the passages to the lungs and to the stomach. It may seem curious how the middle ear open into the pharynx. But you may verify the fact very easily. Shut your mouth and nostrils and blow hard and you will feel some pressure over the tympanic membrane of your ear. This test is therefore employed in determining the perforation of the membrane due to any serious ear disease. The food which we take by the mouth has to pass through the pharynx right into the stomach. There must be some contrivance so that the food may not enter the wrong passage which is none other than the windpipe that leads into the lungs.

This contrivance is a very simple one. There is a (thumb-shaped) plate of cartilage called the *Epiglottis* or the small tongue, which you can see in the diagram given in the next page. The epiglottis which is situated *below* the base of the tongue, automatically closes the mouth of windpipe as soon as some food or drink is swallowed, and the food or drink passes over it to the gullet, but cannot enter into the wrong way. During this moment, respiration is held back for

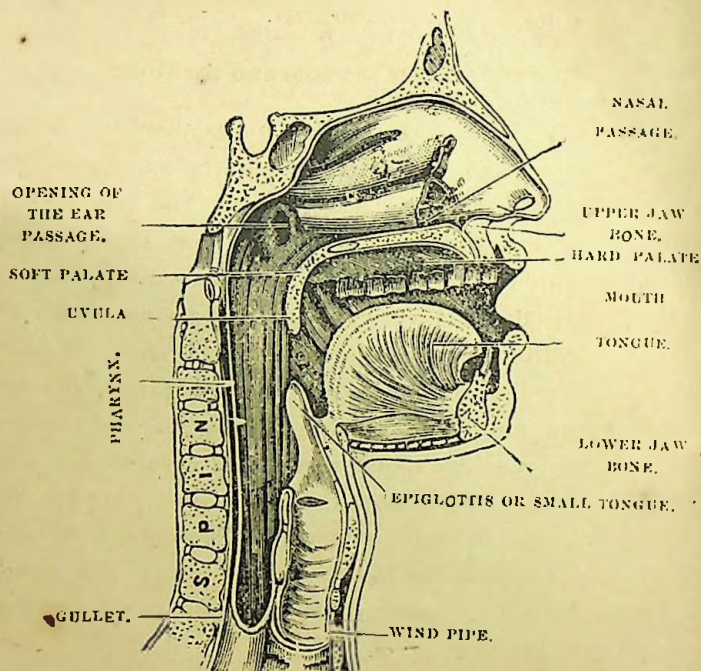


Fig. 25—Diagram showing the pharynx, windpipe and the gullet.

a while. But if you make any effort to speak while you are swallowing the food, it may pass into the wrong way, and you are most likely to get choked up. Then follows the vehement coughing and sneezing and the food particles are thrown out of the gate of

the windpipe, with such force that it may even come out through the nasal passage.

**THE UVULA** ;—If you stand in front of a mirror and open your mouth wide and say "Ah-h-h-h..." you will then see a little strip of flesh seemingly hanging down from within the soft palate of the mouth. It jumps down and up as the sound comes out of your mouth. This bit of flesh which is situated at the back of the soft palate as you can see in the diagram is called the *uvula*. Why it is present there we do not know. This is something peculiar, as in the human body there is rarely anything which is of no use to the body.

Arching down from the base of the uvula are two folds of mucus membranes on each side between which are situated a lobulated structure called the *Tonsil*. In the average healthy man the tonsils should not project out of the arches. But when the tonsils are inflamed ( *Tonsilitis* ) they become very large and project out of the arches.

There is another tonsil situated at the back of the nasal passage at the upper end of the pharynx very close to the spot where the ear passages open into the pharynx. This cannot be seen on opening the mouth. In some children, specially among *mouth breathers*, this tonsil is so much enlarged that it almost blocks up the nasal and ear passages. This condition is spoken of as *Adenoids* and the obvious symptoms of such a condition are mouth-breathing and some sort of defect in the ear. Parents, when they notice any such thing among



their children should at once have the matter rectified, otherwise it will prove detrimental to the health of the young ones.

After passing through the pharynx the food passes into the *gullet* or the passage that leads to the stomach. The gullet or the *Cesophagus* is a narrow tube about 9 inches in

**Fig. 26. A Mouth-Breather.** length. It lies behind the wind pipe and in the chest lies behind the heart. It enters the abdomen by piercing the diaphragm or the muscular partition that stretches between the chest or thorax and the abdomen. The gullet ends by opening into the stomach. The gullet is easily tickled. As soon as it feels the food, it allows it to pass by the peristaltic action of its muscular walls, and then immediately closes up behind it and pushes it down. The food goes on a little way about an inch, and then that inch of the gullet closes up behind it, and so the food has no other alternative than to go down until it reaches the stomach.

The gullet or *Cesophagus* is composed of three coats. The *External muscular* coat—which is composed mainly of wilful or involuntary muscle fibres, consists of an outer layer of longitudinal muscle fibers and inner layer of circular ones. The *Inner* or

*Mucous* coat is formed by a mucous membrane which is thrown into longitudinal folds. The *Intermediate* or *Sub-mucous* coat consists of connective tissue which binds the outer with the inner coat.

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## CHAPTER X. (*Contd.*)

### LESSON IV.

#### The Stomach—the Gastric Juice and Digestion.

The stomach is the most dilated portion of the alimentary canal which begins from the mouth and end in the rectum, and is one of the chief seats of digestion. Its size varies considerably in different persons and with the state of distension. When moderately distended its length is about twelve inches, and its transverse diameter about four. The stomach lies a bit left side below our heart. The food which passes through the gullet enters the stomach through the stomach-door (*Cardiac opening*). After undergoing certain changes in the stomach the food passes out through the stomach gate (*Pyloric opening*) into the long system of coiled tubes known as the Intestines.

Besides having the three coats mentioned in connection with the structure of the gullet, stomach has got a fourth coat which is the outermost one. This coat covers most of the internal organs and goes under different

names in the different parts of the body. In the abdomen it is called the *Peritoneum*, a thin smooth membrane. It secretes a fluid which serves the purpose of a lubricant and prevents any cracking or scratching of the walls of the stomach which would otherwise have happened from friction with other sister-organs.

Inside this coat of peritoneum is the muscular coat composed of involuntary or wilful muscle-fibres arranged in different directions. These muscle fibres contract and relax rhythmically as soon as any food reaches the stomach and thus brings about a sort of churning process which serves to mix the food thoroughly with the gastric juice inside the stomach.

The next coat (Sub-mucous) is made up of connective tissue in and under which there are the nerves and a net work of microscopic blood vessels. This coat binds the muscular coat to the innermost mucous coat. When the stomach is empty, the mucous coat lies in folds, but when the organ is dilated with food, the coat gradually unfolds. On the other hand, when the stomach is empty, the mucous coat is almost colourless, but when foods enter and the stomach begins to distend, blood rushes in at once to the tiny blood vessels and the mucous coat takes up a pink appearance.

Now, in close proximity to the blood-vessels, there are myriads of tiny glands—they are called *Gastric glands*—which at this time are set in action by the added blood into the blood vessels. Then these glands open and tiny drops of certain fluid—commonly called Gastric Juice to aid in the process of digestion.

The sub-mucous coat when viewed by a powerfully magnifying glass shows a honeycomb like appearance. Into the pits of these honeycomb are poured out the secretions of the gastric glands whose diagrams are shown below :—

### Minute Anatomy of Mucous Membrane of Stomach.



Fig. 27—Peptic Gastric glands (*Enlarged*)

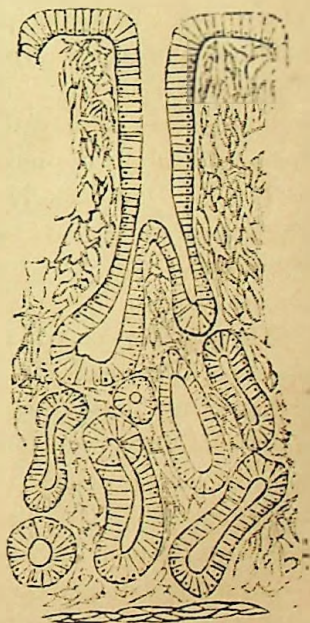


Fig. 28—Pyloric glands of stomach (*Enlarged*)

By the bye it may be mentioned here that when food enters the stomach both ends close of themselves.

### Gastric Juice and its action.

The juice which is secreted from these glands has an acid reaction. The sight of food first induces the secretion of the juice; worries, anxieties arrest the secretion. So if in taking your dinner you constantly fret about and grumble, the result will be that the gastric juice will not be poured out in proper amount and you will suffer from either loss of appetite or indigestion.

The amount of gastric juice secreted in 24 hours comes up to 10 to 12 pints ( $3\frac{1}{2}$  to 4 seers).

The free Hydrochloric acid which is contained in the juice, destroys any bacteria or microbe that may be taken in with the food and is thus a *safe guard against disease*.

The gastric juice is an indispensable factor in our process of digestion, and practically the churning and mixing of the food-bolus with the gastric juice may be termed 'secondary digestion *per se*', the primary digestion having commenced in the mouth. The juice chiefly contains, (1) Pepsin, (2) Hydrochloric acid (free), (3) Rennin, (4) Mucin, (5) Salts and water

Pepsin in the presence of free Hydrochloric acid in the gastric juice, dissolves all the proteid elements of food. All foods containing nitrozen and carbon are proteid, hence they are also called nitrogenous

foods. Nitrogenous foods may be classified under different forms ; such as *Albumin* (in egg), *Casein* (in milk), *Globulin* and *fibrin* (in blood), *Gluten* (in wheat), *Legumin* (in dal and peas), *Myosin* (in muscles) etc., *Albuminoids*, *Chondrin*, *Gelatin* etc. These proteid foods in some forms are absolutely essential to our life. Meats, fish, nuts, eggs, peas and beans are familiar and useful samples of nitrogenous foods. The gastric juice contains about one fifth of Hydrochloric acid, one third of salts. The characteristic action of the gastric juice is its working specially upon albuminous compounds, converting them finally into peptones. The *gluten* of bread is dissolved by the gastric juice and converted like Albumin into peptone, the starchy portion being set free undigested. Milk is quickly coagulated by the *rennin* in the gastric juice and Casein is formed which being redissolved is finally converted like gluten into peptone. Meat, milk, bread, lentils and other pulses and similar other *nitrogenous food* are acted on by the gastric juice in the stomach. Fatty and starchy foods are almost wholly unaffected by the gastric juice.

Cooking renders meat more easily digestive by separating and breaking down the fibers. Fish and half boiled eggs are digested in the stomach in about one hour and a half or two hours. Beef, mutton, peas, pulses, bread etc. are dissolved within three hours, but if mixed with fat (ghee) or oil, it takes five to seven hours with a healthy person. Rice is the most easily digestible, though not *most*

substantial food of all cooked cereals ; it can complete digestion in the stomach from one hour to one hour and a half.

Now you may be inquisitive to know what changes occur in the meat or the lentils after it is acted on by the gastric juice. The changes which occur are very complicated, so that it would be very difficult for you to understand and learn them. This much you should remember that in the ordinary condition the food we take is not diffusible through animal membranes to reach the blood, but when the meat or the lentil or any other nitrogenous food is acted on by the gastric juice and reduced into peptone, by far the greater portion of it is so changed that it can easily pass through the walls of the capillary blood-vessels right into the circulating blood whence it may be carried to the tissues for their nutrition and building up.

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## CHAPTER X.—(Contd).

## LESSON V.

The 12 inch pipe, the Sweetbread and its work.

In the previous lesson, we spoke of the changes produced in our food in the stomach. The food after it had been thoroughly acted on by the gastric juice and completely churned by the peristaltic action of the stomach-walls, is distinctly acid and reduced to the consistency of a paste of greyish colour, which is called the *chyme*. Unless and until the food attains this condition the stomach gate will not open. The stomach gate or the pyloric end of the stomach is surrounded by a ring of circular muscle fibres. This ring is closed so long as the gastric juice is acting on the food. When the food paste is properly formed, the gate opens, and the food paste is allowed to pass out of the stomach.

"I have got such a pain, doctor" said an old man.

"Did you take anything that does not agree with you?" I asked.

"Nothing unusual," said he, "But lately I have lost all my teeth. So I have to swallow. I do not think that's of any consequence."

"Therein lies the cause of your pain. Without chewing, the food bolus is not reduced to the proper consistency of a food paste or chyme. No nostrum of the doctor can remedy the defect. The sole remedy for you is to have a set of artificial teeth."

You young men should learn a lesson from this poor man's ailments. You should realise the importance of keeping your teeth sound and strong. If you do not take care of your teeth, ere long you shall have to suffer the fate of the poor man.

After passing through the gate of the stomach, the portion of food as are still undigested enters a narrow pipe or tunnel called—

### The 12 inch pipe (Duodenum).

This pipe is curved somewhat like a U. Into this pipe open two tubes which are shown in Fig. 29 and 30 (d).

One of these pipes carry the bile, a yellowish green alkaline fluid which is formed in a compartment of the liver and the other pipe pours out the secretion of a gland called the **Sweetbread** or **Pancreas**. The acidity of the chyme is responsible for the secretion of both the fluids mentioned above. In those people in whom there is diminution in the acidity of the gastric juice, there is a corresponding deficiency in the flow of the pancreatic juice.

Both the bile and pancreatic juices are alkaline ; so they neutralise the acidity of the food paste or the *chyme*. The whole mass then becomes alkaline and further digestion commences through the action of the pancreatic juice.

The pancreatic juice carries the action of the saliva and the gastric juice a step further. By the work of the saliva, as we have said before, a certain amount of the starchy portion of the food had been changed

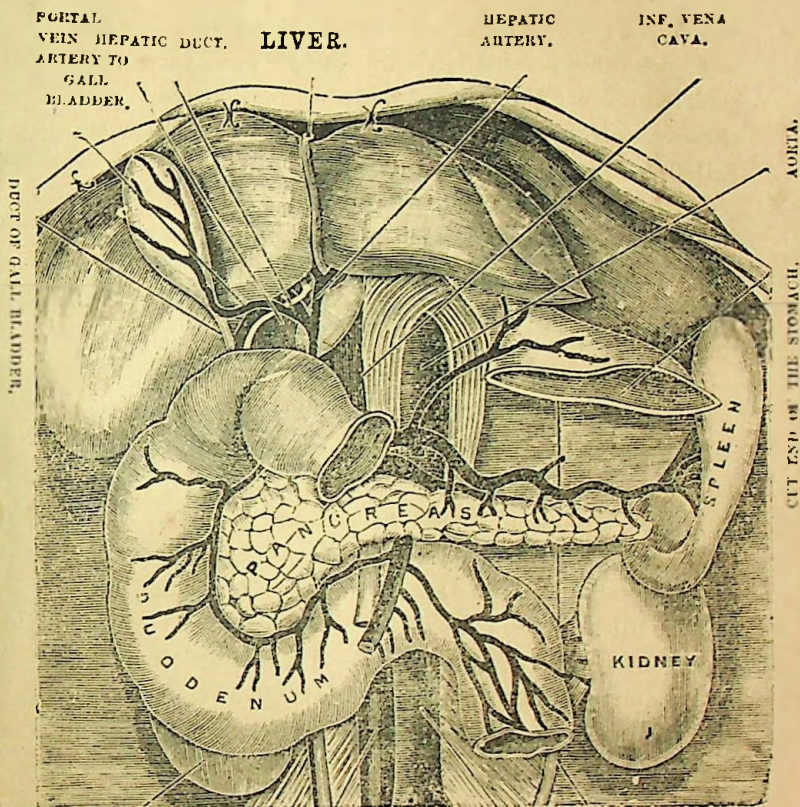


Fig. 29.—Showing the position of the Duodenum in relation to Pancreas and other Organs.

[The Duodenum is shown dissected from the stomach and the intestines.]

into soluble sugars. The pancreatic juice acts on the remaining portion of the starchy constituents and even on unboiled starchy foods which are not acted on by

the saliva. The gastric juice breaks down meat, lentils and such other protied foods into simple substances ; the pancreatic juice through an acid medium cleaves down these simple substances into still simpler substances called *Leucin*, *trypsin* and *urea*.

Milk is also finally digested by the pancreatic juice. It has already been curdled by a curdling substance called *rennin* present in the gastric juice and this curdle now being still more coagulated undergoes digestion by the active agents present in the pancreatic juice.

There is another class of food which has not yet been acted on by any of the juices already met with. To this class belong the fats, oils, butter, ghee etc. These are broken up by the pancreatic juice into fatty acids and glycerine. The fatty acids again combine with the alkaline substances of the pancreatic juice and the bile, to form soap-like substances. When the digestion in the 12 inch pipe is thus completed, the food acquires a yellowish and creamy colour and passes on through the remaining portions of the long coiled tubes, which we are going to consider in the next lesson.

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## CHAPTER X—(Contd.)

## LESSON VI.

The Intestines and the Intestinal Juices,—  
Peristalsis and Defæcation.

The long coiled tube which extends from the stomach to the rectum is known as the Intestines. The upper larger portion of the intestines is of small calibre and is known as the *Small intestine*. The remainder of the tube which is of larger calibre is known as the *Large intestine*.

The *Small intestine* is a convoluted tube about 20 feet in length and three-quarters of an inch in diameter. It is twisted and turned about, and made to content itself with a very small space. In the diagram given in the next page, the tubes have been shown uncoiled.

The small intestine shows the same four coats like the Stomach and the 12 inch pipe (Duodenum).

The outermost coat is the over-all coat formed by peritoneum. It surrounds the intestine completely and forms a fold at the back known as the *mesentry*. The small intestine is suspended from the back of the abdomen by means of that fold of peritoneum. The peritoneum abounds with numerous glands which secrete a sort of lubricating fluid. But for this lubricating fluid, the intestines would not have been able to move constantly with so much ease and safety.

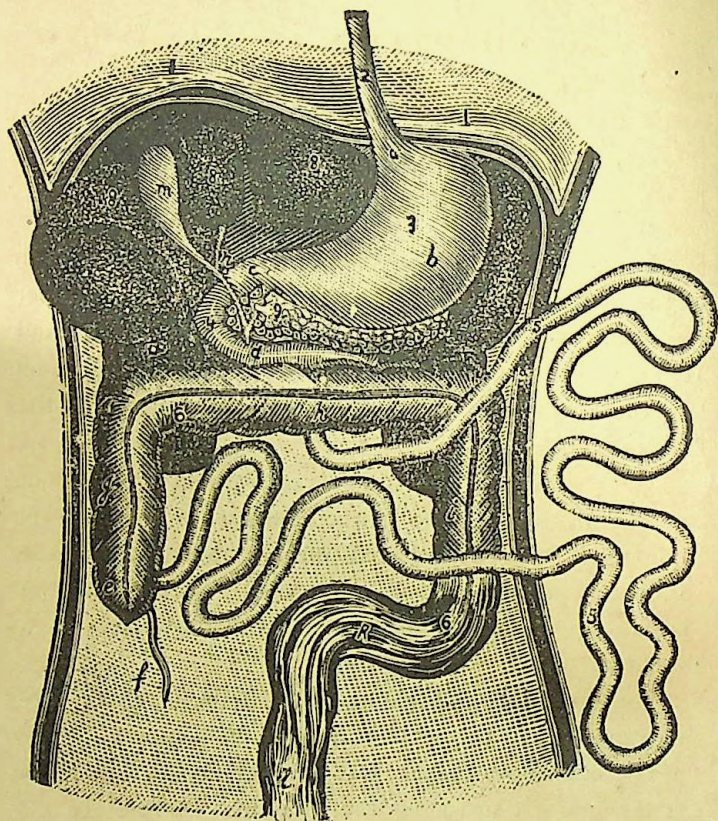


Fig. 30.—Diagram showing the digestive tube.

[THE SMALL INTESTINES HAVE BEEN UNCOILED.]

1. Diaphragm. 2. Gullets. 3. Stomach. 4. Duodenum.  
 (d) Common opening of Bile and Pancreatic ducts. 5. Small intestine. 6. Large intestine, (f) Vermiform appendix.  
 (g) Ascending colon. (h) Transverse colon. (i) Descending colon. (l) Rectum. 8. Liver. (m) Gall Bladder, 9. Pancreas.

Under this coat is the muscular coat arranged in two layers—the outer fibres running lengthwise and the inner fibres circularly. The muscle fibres, it is needless to say, are all involuntary in character.

These muscles are very delicate and susceptible to fluctuation of temperatures. If you suddenly expose your belly to cold draught, you are sure to be troubled with pain. This pain arises from irregular contraction of the muscle fibres of the intestine. It is therefore necessary that every one should try to preserve an uniformity of temperature round about the belly.



Fig. No. 31.—Inner surface of small intestine showing folds of mucous membrane.

The next coat (sub-mucous) is composed of connective tissue in which are ensconced vessels and nerves. The mucous coat forms the innermost lining. The mucous membrane is thrown into numerous folds which unlike those of the stomach, are not obliterated when the intestine is distended. These folds retard the passage of the food along the intestines and afford a large absorption area. Projecting from the mucous membrane

of the small intestines throughout its entire course, are numerous minute pimple like glands covered with epithelial cells which give the surface a cushion like appearance. These glands or *Villi* composed of a net work

of vascular tissue surrounding a central space called the *lacteal*, play an important part in the absorption of fat. The fig below illustrates the villi in magnified form.

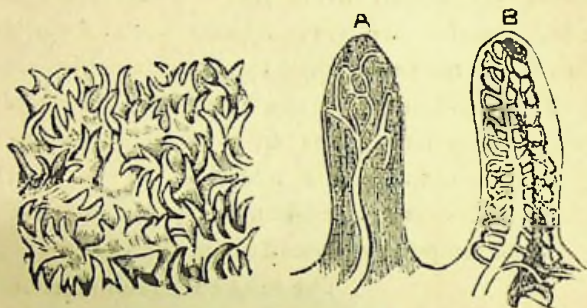


Fig No. 32 — Villi—General appearance; A—B—Sections of villi showing lacteal and blood vessels.

In the lower portion of the small intestine are to be found aggregations of lymphatic tissue called *Peyer's patches*. These get inflamed during typhoid fever. In the mucous coat are also to be found numerous glands which secrete

### The Intestinal Juice.

This intestinal juice has, in fact, the properties of Saliva, Gastric Juice, Bile and Pancreatic Juice, all in one. It is intended to act upon all matters in the intestine still unaffected by the other juices, so that no part of the food may be wasted. At the same time that this last portion of digestion is being completed, the part of the food which is already in a fit state to be taken and used, is being absorbed by the villi

or shaggy hairs of which I have told you in the previous paragraph.

The residue of food which is not taken up by the small intestines and which chiefly consists of cellulose and other insoluble rejectable matters and even of useful substances that could not be absorbed by the small intestine, now passes on to

### The Large Intestine.

The large intestine is about 5 feet in length. It is largest at its commencement and gradually diminishes as far as the rectum where there is a dilatation of considerable size just above the anus. At the junction of the small with the large intestine, there is the *Ileum* or final portion of the small intestine; it is smaller in diameter, finer in texture and paler in color and ends in *Cecum*—the first part of the large intestine, where there is a sentry-box, as it were, called the *Ileo cecal valve* which allows food to pass from the small to the large intestine but prevents the opposite movement *i. e.*, the backward flow of materials from large into small intestine.

Just below this valve, there hangs down a blind worm like process, opening into the large intestine which is known as the *worm-like appendage* or *Veriform appendix*. The tube is inflamed in case of the disease called Appendicitis.

The large intestine consists of the colon and the rectum. The colon extends in an arched manner above the coils of small intestine. It begins as the

*ascending colon* from the right side of the pelvis and comes up to the under surface of the liver where it takes a bend and pursues a transverse course from the right to the left where it meets the spleen. This portion is known as the *transverse colon*. There again it takes a bend and descends down into the pelvis where it ends by joining the rectum. This portion is known the *descending colon*.

The rectum is six to eight inches in length. The rectum opens outside the body into the the anus which is guarded by a circular ring of muscle-fibres called *Sphincter ani*. The rectum is ordinarily filled with fæces or stools. The gliding down process in the large intestine of the effete materials physically and chemically changed by the secretions of the stomach and small intestine, is very slow, and as they are gradually pushed down by the alternate contracting and relaxing of the muscle fibers of the inner walls, the materials begin to harden. The sphincter ani is normally contracted under the influence of a nervous centre in the cord. The act of defæcation consists in an inhibition of the nervous centre controlling the sphincter, the relaxation of which then takes place.

The large intestine has the same four coats as the other portions of the digestive tube. From the residue of food which passes on to the large intestine only water is absorbed and the residual waste materials are rendered acid by fermentative changes, and acquires the odour of fæces.

What is it that is responsible for this propulsion of

the food material along the intestines? It is a natural question that may arise in any one's mind. The whole intestinal tube as we have said before, is constantly surging along in a manner somewhat resembling the motions of a worm and all this time it is squeezing and forcing forwards its contents. This worm like motion of the intestines is technically known as *peristalsis*. In those persons in whom this natural peristalsis is damped, the contents of intestine are not so smoothly pushed forward as in a normally healthy person, and the result is constipation. For normal and natural defæcation proper peristalsis is essential.

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## CHAPTER X.—(Contd.)

### LESSON VII.

#### Absorption of Food and Nutrition.

We have traced the course of the non-essential portions of the food up to rectum from where it is thrown out of the body as the fæces. But we have not yet learnt anything about the destination of the essential portion of our food. Blood is ultimate destination of all food materials. With the blood the nutrient materials are carried all over the body and as the tissues are bathed with the nutrient fluids, they take up what nutriment they naturally require from it, and this fluid which is

deprived of its nourishing power again comes back to eat up fresh food material in order to enrich itself with nutritious elements from the digested foods to nourish the body cells in return. I have already spoken to you of the *villi* or shaggy hairs for the diagram of which I refer you back to the previous lesson. These shaggy hairs are sorts of sucking apparatus. They are found in the mucous membrane of the small intestines. By the time the food matters reach the small intestine, they have been almost completely digested or broken up into simple and subtle substances. These substances can easily permeate through the epithelial skin covering these shaggy hairs. Fats and oils etc., pass through special channels in the villus. These are called the *lacteals* or milk tubes as you have learnt, for the absorbed fatty portion of the food as it passes through them, looks like milky fluid. These milk tubes unite with one another forming larger and larger trunks which ultimately open into a central trunk called the *Thoracic Duct*.

The *Thoracic Duct* pursues a long course in front of the spine from the abdomen to the base of the neck where it pours its contents into the left Subclavian vein, and thus, at last, after a round about course, the fats we have eaten pass into the blood.

The rest of the digested food matters or chyme consists largely of sugar which has been formed from starch by the saliva and the pancreatic juice and also of other simple substances (amino-acids) derived from the digestion of proteid material such as meat, fish

etc. These pass directly into the blood stream. Minute blood vessels from the whole of the digestive tract unite to form a large trunk called the *Portal vein*. The blood in this portal vein is laden with food materials and on its way back to the heart this blood passes through the liver where important changes take place in the quality of the blood of which I am going to tell you in the next chapter.

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## CHAPTER XI.

### *The Liver and its Functions.*

The liver is the largest gland in the body. It weighs from 3 to 4 lbs. and forms about one thirty-sixth part of the body weight of an adult. All the salivary glands put together cannot form a mass equal in size or in weight with the liver.

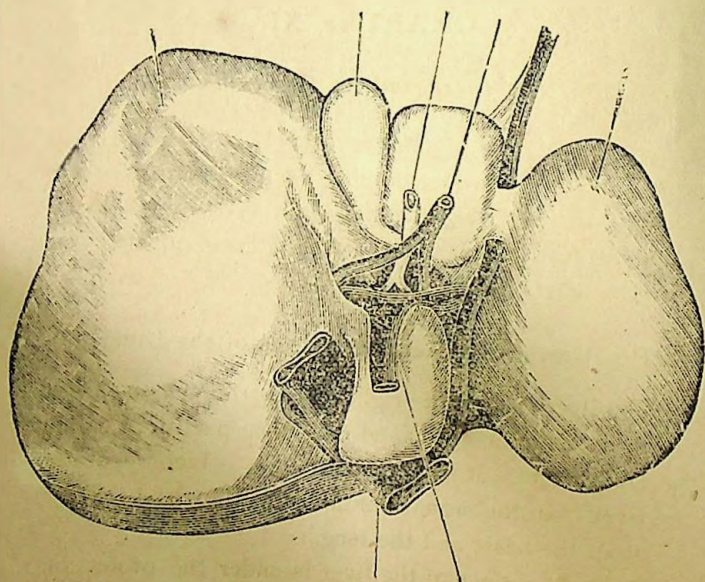
#### **Position and general relations of the Liver.**

The liver lies on the right side of the abdomen just underneath the dome-shaped muscular partition called the Diaphragm. It is the diaphragm which separates the liver from the organs contained in the chest cavity, *i.e.*, from the heart and the lungs.

The front surface of the liver is under the protection of the lower 5 or 6 ribs of the right side. The liver generally projects  $\frac{1}{2}$  inch or so beyond the lower limit

of the ribs. The back part and the upper surface of the liver are in contact with the diaphragm. The liver has two coverings,—the *serous* and the *fibrous* coats. Fig. 33 illustrates the view of the under surface of the liver. It is depressed at some places and elevated at other places in conformity with the shapes of various organs which come to lie against it. The principal among these organs are the stomach on the left side and

RIGHT LOBE, GALL BLADDER, HEPATIC DUCT, HEPATIC ARTERY, LEFT LOBE,



INF. VENA CAVA, PORTAL VEIN,  
IN WHICH THE HEPATIC VEINS OPEN.

Fig 33.—Illustrating the under surface of the Liver.

the upper portion of the kidney, a part of the colon and the first portion of the small intestine on the right side.

We must now study the inns and outs of the organ before we may understand its functions. Look at the diagram given above and you will notice a transverse fissure in the middle and three pipes dipping into this fissure.

### **The Factory of the Liver.**

The *first* is called the Gate Vein or the **Portal vein**. The portal vein does the work of a porter. It has to carry the load of the digested food materials from the whole length of the digestive tube to the factory of the liver. In the factory of the liver there are numerous workshops each of which is represented by a lobule.

A *Lobule*, very minute though it is, measuring only one twentieth part of an inch, is composed of still smaller units called the *Liver cells*. Each liver cell represents a compartment in one of the numerous workshops. Each one of these is contained in itself and performs all the various marvellous works that are carried out in the factory of the liver.

### **Various articles turned out in the factory of the liver.**

What kind of work is done in the factory of the liver? The portal vein, so to say, brings the raw materials out of which various substances will be prepared by the liver cells.

The protein element of our food which is present in a large amount in meat, fish, peas etc., after it is absorbed, is carried to the liver factory by the portal vein. Here a portion of it is taken up and changed into urea. Urea is one of the chief waste products derived from protein food. It is excreted in the urine but it is not formed in the kidney. The liver is the principal seat of its formation.

The next element of the food is the carbohydrate portion which is present in abundance in rice, wheat, potato, sugar etc. All carbohydrate food materials are absorbed as sugar and mainly pass through the portal vein. After a starchy meal the blood in the portal vein becomes very rich in sugar but as the portal vein reaches the liver cells, it is robbed of its excessive richness, and how? The sugar of the blood is, by the help of the liver-cells, changed into an insoluble form of sugar called *Glycogen* or animal starch. This glycogen is stored up in the liver cells. Bodily exertions and muscular movements consume the sugar in the circulating blood and the blood is thereby rendered very poor in sugar. A message is therefore sent by the tissues to the store-house—"We need more sugar, supply us sharp". At once the liver cells start their work. The stored up glycogen is then changed into soluble sugar and sent out to the blood which is thus maintained in its normal composition. Thus we see that *Glycogen is a kind of reserve food material for our system*. When we do not take any food as during fasting or between two meals, we are sustained by these reserve food materials,

and at the expense of the tissues of our body, when these reserved food materials are all used up. We might therefore compare the liver to a banker who receives the cheques and drafts of his customers, and pays out money that is required, in the form of ordinary currency (in this case, soluble sugar) which can be used to pay the customer's workmen (in this case, the tissues of the body).

A proof of the liver's manner of dealing with sugar is afforded by the disease known as *Diabetes*. In this disease there is an excess of sugar given out from the liver due either to the inability of the tissues to properly consume the sugar or to a certain want of action on the part of the Sweetbread or the Pancreas. The Kidneys cannot but allow some sugar to pass out by the urine in order to keep the blood at the constant concentration. Some attribute that diabetes is due to improper nervous control over the liver, while others affirm that over-eating and want of proper physical exercise are the predisposing factors of diabetes.

This last cause of Diabetes seems to be exactly true for most cases of Diabetes in our country. Just fancy a man taking in rich and delicious dishes every day and doing nothing but reading a newspaper and going for a drive in the evening as most of our rich people do. How are these men going to burn up all the materials that they are ingesting. The consequence is that glycogen is being stored up continually but there is a limit up to which the liver manufactory can handle its raw materials and dispose of its finished products

properly and to the best advantage of its customers, namely, the tissues of the body. Once this limit is exceeded, there is a derangement in the manufactory and everything goes wrong. The liver can no longer control the sugar of the blood and the percentage of sugar in the blood rises, the result being diabetes. In such cases of Diabetes, regulation of diet has been found to be very suitable in decreasing the amount of sugar passed along with the urine. But, whatever, may be the cause of Diabetes, certain it is that there is some derangement of the function of the liver which is responsible for the excessive output of sugar from the liver into the circulation.

### The Bile.

Bile is one of the products manufactured by the liver-cells from the blood carried by the Portal vein. It is a yellowish green opaque liquid of an alkaline reaction. It is composed of pigmentous and albuminous matter which are of no use to the body. The pigments are derived from the destruction of the red blood corpuscles of the body. Therefore, Bile is to be regarded as waste-matter which the liver-cells have separated from the blood. The liver may thus be ranked with the skin, lungs and kidneys, as an organ which tends to deal with a certain portion of the body-waste which is inseparable from the wear and tear of life.

The Bile, as it is formed, is collected by the bile capillaries and is thrown out of the liver by a *second* pipe called the **Hepatic duct** which

comes out of the transverse fissure above referred to. The bile is carried from the hepatic duct to the *Gall bladder* to be stored up pending the necessity for its use. This latter is a small pouch-like reservoir situated at the anterior and under surface of the liver. The coats of the gall bladder and its ducts are very sensitive and as soon as the semi digested food materials pass out of the stomach to the first portion of the intestines, the gall bladder spurts out some bile which is carried by the common bile duct to the small intestine. The bile in the intestine helps in the emulsification and partial digestion of the fats of our food. If by an operation, the bile is not allowed to enter the intestine, it has been found that most of the fat taken is passed out as such with the fæces. It is, therefore, advisable that persons who have got liver complaints should abstain from all fatty foods.

Bile is said to cause the peristaltic or veriform motion of the intestine. Some say that bile has got an antiseptic property and that it prevents the putrefaction of food in the intestine. But the question as regards this property of the bile is still *sub judice*. After having taken part in the digestion of the contents of small intestine a certain quantity of the bile is reabsorbed to aid in the chemical changes produced in the liver tissue. In the disease known as **Jaundice**, there is some defect either in the excretion or reabsorption of bile which is consequently absorbed into the general circulation and gives a yellow colour to the eyes and the skin.

## Synopsis of the articles turned out in the manufactory of the Liver cells.

### RAW MATERIALS.

The blood carried by the Portal vein which contains, besides other things, the products of digestion of carbohydrate and nitrogenous foods and also the blood carried by the Splenic vein which abounds in colouring matter derived from the breaking down of red blood corpuscles in the spleen,

### FINISHED PRODUCTS.

1. From the nitrogenous elements—  
a part of it changed into urea which is sent by the blood current into the kidneys there to be excreted, and the remaining part going to the tissues as such.
2. From the carbohydrate elements—a portion of it is stored up as an insoluble animal starch or *Glycogen* and the rest being soluble goes with the circulating blood for the nourishment of the tissues.
3. From the already destroyed red blood corpuscles—  
The alkaline coloured fluid known as *Bile* is prepared.

The Liver is an indefatigably hard-working and at the same time very exacting boss. In its factory there is no "*eight-hour a day.*" The liver and all his assistants have to labour all day long, only doing a little more work as soon as the stomach receives fresh food, and slackening off a little when its owner is hungry. It never stops still. But it cannot work so hard without being well fed and the food it requires is the blood. It is the *third pipe* called the **Hepatic artery** which brings the food of the liver in the form of fresh blood lately cleaned and enlivened by the oxygen of the air.

After all the work is done, both sorts of blood, namely, the impure blood of the Portal vein and the pure blood of the Hepatic artery want to leave the liver. But there is only one passage by which they can leave the organ. This passage is through the **Hepatic veins** which drain out all the blood entering the liver. The Hepatic veins ultimately open into the largest vein in the body (the *Inferior vena cava*) which finally pours it into the heart.

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## CHAPTER XII.

### *Our Food and Drink.*

In Chapter I, human body was compared to a steam-engine and as a point of similarity it was mentioned that as the steam-engine requires water and

fuel, so our body too needs food and drink. If you do not feed the engine with sufficient coal and water, it will not work long and up to its maximum capacity, and ultimately it will stop altogether. The same remark applies to our body. Suppose the amount of your food and drink be lessened day by day as actually happens in case of famine-stricken people and what do you think will be the possible outcome? You will get thinner and thinner, the fat of your body will be all consumed. And, at last, you will be reduced to a mere skeleton and get so very weak that you will not be able to do any work for earning your bread.

Such instances actually occurred in famine-stricken areas of Bankura and Khulna only a few years ago, and even cases are known where hundreds of people were starved to death.

Now you understand the importance of food. Without food life is impossible. But most of you pay little attention to what you take and how much you take. So I should like to tell you what sort of food you should take and in what amounts.

The human body must eat four sorts of food. They are called—

- Energy-producing food (*Carbonaceous*)
- Body-warming food (*Fatty*)
- Flesh-forming food (*Nitrogenous*)
- Mineral food (*Salts*)

At every movement of our body we are giving out some energy. What is it which produces this energy

of our body? There is something which is burnt up inside our body during the various muscular movements and it is the burning up of this thing that gives off this energy which manifests itself in the external movements of the body. Why only external, the constant beating of the heart, the slow and regular contractions of the intestines—these internal manifestations of energy are also due to the burning up of this same substance. This substance to which we have referred is the carbonaceous portion of our food. In rice, wheat, potato sugar etc., there is an abundance of carbonaceous food and hence these are classed under energy-producing food. The natural inclination of a person, after hard physical exertion, to take some sort of syrupy drink bears out the statement that in bodily labour the energy producing food is used up. To speak in scientific language, the carbohydrates (or compounds of carbon, hydrogen and oxygen) are the chief energy producing food. Hence athletes and people who earn their bread by physical labour require more of this carbohydrate or energy-producing food than ordinary people who lead a sedentary life.

A question, which may naturally arise in your mind, is that we are not taking this energy-producing stuff continually, but still how is it that our body is continually giving out energy. For this I should refer you to the chapter on Liver. You may remember that the carbohydrate element of our food after absorption is stored up in the liver as glycogen. This glycogen is again according to the necessities of the body changed

into sugar and in this way a continual internal feeding process is going on inside our body. In excessive bodily labour and during starvation this reserve food material may be almost absent from the liver and hence there is so much hankering for carbohydrate food after physical exertion.

The following diagram and the note given below will clearly explain how carbohydrate food is used up in a healthy individual.

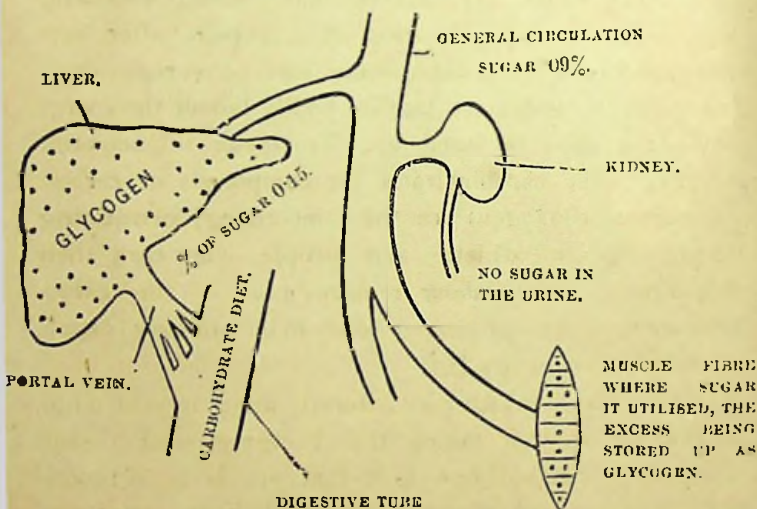


Fig. 34.—Diagram illustrating the fate of sugar in the healthy individual.

[ Dots stand for glycogen ]

The diagram shows how the carbohydrate food namely, rice, potato, sugar etc., which we take after it is digested in the long digestive tube, gets into our blood and what takes place when it is circulating with the blood. All forms of carbohydrate food after it is digested is transformed into sugar. It is the sugar which is absorbed by the portal vein which carries it to the liver. There a portion of the sugar is stored up as insoluble animal starch or glycogen. The black round dots represent glycogen in the diagram. Hence the blood which is carried away from the Liver by the hepatic veins into the general circulation becomes poorer in sugar. The percentage of sugar in the portal blood is 0.15, whereas in the general circulation the percentage is only .09. The blood that goes for general circulation carries the sugar to the muscles where the sugar is burnt off to supply energy for our muscular movements and ultimately carbonic acid gas is left over and this is eliminated in the lungs. The excess of sugar which is not used up by the muscles is again stored up as glycogen in the muscle fibres. This glycogen is again used up when we do some physical exercise.

Then comes the **Body-warming food**. The various kinds of fats, oils, ghee, etc., fall under this group. These articles are necessary for keeping up the body-temperature but the greater proportion of such food are stored up as fat in our body. People who live in colder countries, require these body-warming foods in greater amount than those living in tropical countries.

The Esquimaus of Greenland where the temperature falls below the freezing point of water mainly subsist on whale-fat or blubber. We, people living in the tropics, could not tolerate such a great amount of fatty food but how can they tolerate so much? It is only because they live in very cold countries and they therefore require greater heat to be produced in order that they may keep up the normal body temperature.

In considering the **Flesh-forming food**, I must first of all tell you that this is not an appropriate name for the nitrogenous food because the nitrogenous food not only builds up the flesh or the muscle but also the blood, the marrow, the brain, the bone and in fact every part of our body. To be terse and scientific, the nitrogenous element helps to build up the protoplasm or the living material of our body-cells. It will be wrong to say that all the nitrogenous food that we take, is built up into living tissue; but on the contrary much of the nitrogenous food that is absorbed is changed in the liver into urea and some other substance which on being burnt up may produce energy, and if the nitrogenous food is taken in excess this substance may even be stored up as glycogen (animal starch) and fat. Hence we see that a human being can subsist only on nitrogenous food (or proteid food), for the nitrogenous food can supply almost all the needs of the body, when the other kinds of food-stuffs are absent from our diet. But if we are to subsist solely on nitrogenous food, we shall have to eat such a lot that the kidneys will find great difficulty in disposing of the waste products arising therefrom, namely,

*urea*. It may be mentioned in passing that kidneys have to spend much more energy in excreting a small amount of urea than is required in excreting a large amount of water or any mineral matter. The unnecessary and useless strain which is thrown on the kidneys by habitual meat-eating, consequently renders the meat eaters very susceptible to kidney diseases of a grave type. It has been therefore found suitable to replace the nitrogenous food as much as possible by carbohydrate food. Still we cannot go without nitrogenous food. It is essentially necessary for the actual building up or growing up of the body. Youngsters, therefore, require more of this food than old men. In old men the nitrogenous food is used only in making good tissue waste, while in growing boys and girls the nitrogenous food will be used not only in repairing the waste but also in preparing actually living substance which will make them grow.

As regards the fourth item namely **Mineral food**, it is as much necessary for the body as the other three classes of food, Mineral matter constitutes nearly 5% of the total body weight. Among the mineral food Sodium chloride, Potassium, Calcium and Iron salts and Phosphates are the most important. The blood in every healthy individual should contain a certain fixed amount of sodium chloride and we are excreting every day some sodium chloride with our urine. To make good this loss of sodium chloride from the blood we generally take 15 to 20 grammes of common salt or sodium chloride with our food. Vegetarians show a greater

craving for salt and why they want so much salt? Because the vegetables being rich in Potassium salts replace the sodium salts of the blood and hence, is the necessity for taking more salt.

Salt has the property of attracting water. When there is too much salt in the body due to deficiency in excretion, water accumulates in the tissues and this condition is called œdema or dropsy. Doctors, therefore prescribe a salt free diet in such a condition.

The other salts which are necessary for the body, we habitually take with our food. Green vegetables contain a large amount of Potassium salts and Calcium salts. Calcium salts are essential for the building up of bones and as well as for maintaining the muscles and nerves in a good condition. Children suffer from a disease called *Rickets* when there is deficiency of calcium salts in their food. In *Rickets* the bones cannot grow due to want of calcium salts and the child may even show deformities in his skeleton. Loss of calcium salts from the blood causes it, so to say, to drink more fluid. Hence it takes a long time for the blood to clot or curdle. Calcium salts make the blood clot rapidly or to put in scientific terms increases the coagulability of blood and hence the doctors prescribe calcium salts in cases of hæmorrhage from the internal organs. This you will learn in detail later on when we talk on blood.

Iron salts are necessary for building up the hæmoglobin or the red colouring matter of our blood. The yolk of the egg contains a large amount of Iron

salts, hence persons suffering from anæmia in which there is loss of hæmoglobin, should be advised to add egg yolk to their ordinary dietary.

Phosphates are essential for building up and repairing nervous tissue. Brain workers require a large amount of phosphates with their food ; egg, fish etc. are rich in phosphates.

About 70 per cent of the human body is composed of water. Water is passing out of our body with the urine, the sweat and with the expired breath as water vapour. This loss of water is to be always made good by drinking a quantity of water.

Ordinary people have a misconceived idea that if much water is drunk, it will dilute their blood and thus diminish the vigour of their health. But on the contrary, sufficient water is essentially necessary for keeping good health. The water we drink, of course, first enters the blood but no sooner they enter than the kidneys are set into activity and an almost equal amount of urine passes out of our body within 2 or 3 hours. A very small portion of the water taken enters the intestines, but by far the larger quantity is absorbed into the blood and enters into the circulation of our vital fluid. If the blood gets thick and sluggish, it will readily absorb water to a certain extent to keep up its normal fluid condition and become more mobile. During the passage of the water through the kidneys, it washes off all the dirt and waste materials that were clogging the kidneys. Thus a good amount of water helps to flush

our kidneys properly and in this way the drainage system of our body is kept in a good and smooth working order.

The quantity of water which is drunk is largely dependent upon individual habit. Some people are always wanting something to drink and they drink not only during their meals but at all hours. This sort of habit is not good. You should make it a point not to drink much during your meals. If you feel too much parched up, you can take a sip or two when you have finished with your food. But your drinks should be taken at regular intervals, say at least two hours after your principal meals. An average healthy man or woman who does his or her ordinary works and takes some form of physical exercise or habitually live in a high temperature, should take at least 3 to 4 pints or  $1\frac{1}{2}$  to 2 seers of water daily. People who live in colder climates and who do not perspire much, are apt to drink too little amount of water. But those who live in hot and sultry climates and who have to sweat almost the whole day long, require a larger quantity of water. Those people who have the least chance of kidney or urinary troubles or who had ever suffered from any kidney-disease should take a good amount of water to keep their organs in a clean and healthy condition. It is a very good plan to drink a glass of water upon rising and the same on retiring at night.

Water, pure and simple should be the drink of a man who wants to lead a sober and healthy life. But

under the influence of complex and feverish modern civilisation, many kinds of artificial drinks have been invented and these drinks such as Tea, Coffee, Cocoa, *Sherbat*, beer and wine are growing more and more into popularity day by day. Apart from the economical point of view, these artificial drinks, at least some of them, have distinct detrimental effect on our health. Many of the masses have an idea that beer or some spirituous drink will "make them strong" or "keep the cold out" or "give them a good pick-up", but neither of these holds good. These questions, had been troubling the mind of the scientific people all over the world, and they have now by actual experiments shown that though the spirit makes the man a little bit of over, active or rowdy during the first stage, still his capacity for work and his total output of energy are decidedly diminished. And again the experience of the pole-explorers conclusively prove that the expeditioners could tolerate the cold better when they went without any liquor than when they had revelled in spirituous drinks. We know also of many other stories of marching armies who became invalid and worn out, simply if they stuck to their alcoholic habit, but who gained back their strength as soon as they were made to keep aloof from it.

Besides such physical deterioration, what dreadful effects are seen in a drunkard's mental and moral conditions. His power of digestion is gone, blood impoverished, eyes lustreless, organs of sense all blunt, his

liver—such an important organ has been altogether destroyed. His brain is inert, conscience gone and passions are unbridled. He is after all a veritable wreck !

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## CHAPTER.—XIII.

### *Respiration or Breathing.*

#### Nose and Pharynx.

In the last three chapters I have narrated to you how the food we take is employed in nourishing and building up the tissues of our body. In this chapter I am going to tell you of a still more important agent without which we are not able to exist for a few minutes and this is nothing but the air which we are continually breathing in and out. It is a more essential food for our body than the ordinary food we take, though we do not attach so much importance on this, and this is because we have neither to pay for it nor to undergo any hardship in obtaining it.

We are taking in and giving out some air every 4 seconds *i. e.*, we are inspiring and expiring 15 times a minute but how many of us, we wonder, care to learn where the air goes to and what it does there ?

The air normally enters the body through our nostrils. The air we breathe in is not always suitable

into one of your nostrils and let the air you breathe out through the glass tube, bubble through the lime water. After a while you will find that the clear water has become quite turbid or milky in appearance. This shows the presence of carbon dioxide in your breath which comes out of your lungs.

Learned men have devised very careful experiments to know the composition of the air that enters and that comes out of our lungs. The air as it goes in contains—

Oxygen ...	...	...	21 parts
Nitrogen	...	...	79 „
			<hr/>
			100.

This is the composition of atmospheric air. The air which comes out contains—

Oxygen ...	...	...	16 parts
Nitrogen	...	...	79 „
Carbon dioxide	...	...	5 „
			<hr/>
			100.

In addition to Carbonic Acid Gas or Carbon Dioxide, the expired air contains ammonia and other unknown substances of a poisonous nature.

The air has therefore become dirty by making the blood clean, much of its oxygen has been taken up and a proportionately large amount of carbon dioxide has been added to it.

Now what changes have taken place in the blood that has come in contact with the air-cells and imbibed

the inspired air? It has much cooled, lost its water vapour, gains 8 to 12 per cent per volume of oxygen, and relieves about 7 per cent per volume of  $\text{Co}_2$  from itself.

What is the real mechanism by which the air is forced to enter or leave the lungs? But before telling you how respiration actually occurs in the body, I shall ask you to perform the simple experiment given below. The diagram on the next page will show the method of arranging the apparatus.

The bottom of a large sized bottle has been removed and closed by a sheet of India rubber to the centre of which is attached a piece of string as shown in the diagram 39. The mouth of the bottle is closed tight by a cork through which passes a tube terminating in two branches inside the bottle. To each branch is tied a toy rubber balloon. The bottle represents the closed and air-tight thoracic cavity. The glass tube with its two branches communicating with the external air represents the trachea and bronchi and the two balloons represent the lungs. It will be found that the space inside the bottle does not communicate with the external air.

If the string attached to the rubber-sheet be pulled, the capacity of the bottle increases and the pressure inside naturally diminishes. To equalise the pressure air will rush in through the glass tube and will inflate the balloons. This corresponds with the act of **inspiration**.

If the string be now released, the capacity of the bottle diminishes and the pressure inside rises with

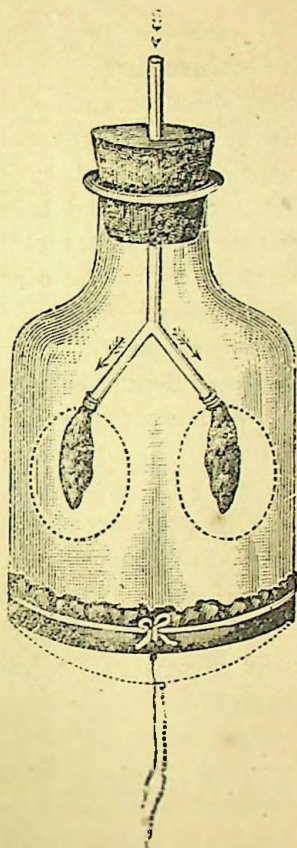


Fig 39.—The tube with its two branches represents the trachea and bronchi.

The space with bottle represents the thoracic cavity.

The rubber sheet tied to the bottom represents the diaphragm.

The dotted line represents the lowered position of the diaphragm.

The oval dotted lines round the two rubber balloons represent the expanded lungs

the result that air is driven out of the balloons. This corresponds with **expiration**.

Like the rubber sheet there is a sort of dome shaped muscular partition in our body which separates the chest cavity from the abdominal cavity. The apex of the dome is pointed towards the chest cavity. On its upper surface rest the two lungs, separated in the middle by the heart ; touching its under surface are the liver on the right and the stomach on the left. The diagram (Fig. 40) shows very clearly the relations of the diaphragm. Now when the muscular partition contracts, by the nervous mechanism of respiration, the dome becomes flattened out and the whole diaphragm descends, in this way increasing the capacity of the chest. The result is that we get the act of inspiration. On the contrary, when the diaphragm relaxes, the capacity of the chest-cavity decreases. This diaphragm as well as the elastic tissue of the lungs which contract easily and almost without any effort, is solely responsible for the ordinary act of expiration.

The lung surface which is very delicate is most likely to be hurt during its alternate dilatation and relaxation. To prevent this, nature has provided for a smooth serous lining which coats both the surfaces of the lungs as well as the inner side of the chest wall (Pulmonary and costal). This delicate smooth lining is called the *Pleura*. In the space between the two layers of the pleura is a lubricating fluid, the *serum*. In the disease called *Pleurisy*, the pleura becomes inflamed by much exudation and rough, and a friction

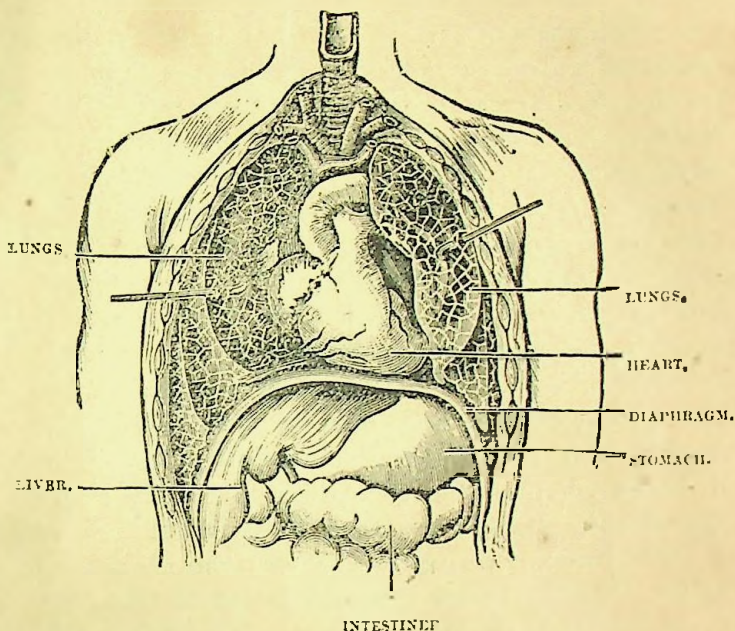


Fig. 40.—Diagram showing the Diaphragm and abdominal organs and Heart exposed, and Lungs retracted side-wise by hooks to expose the heart.

sound is caused by the both surfaces rubbing together and the patient feels almost agonising pain during normal breathing.

The regular and rhythmical breathing of a normal person is entirely under the control of a portion of the nervous system which is situated in the Medulla oblongata. This is called the **centre for respiration**. This centre is ordinarily influenced by many factors. If the temperature of the blood be raised as in fever,

the respiration quickens. During exercise certain substances are formed in the body which being carried by the blood reach the respiratory centre and excite it into greater activity. It is by this means that deeper breathing and a greater supply of oxygen are ensured during exercise. Also when from any disease of the lungs particularly pneumonia the air that enters the lungs, cannot sufficiently impregnate the impure blood with oxygen, nature tries to make good this defect by increasing the number of normal respiration per minute. The patient may be seen simply to gasp for breath. But unfortunately we very often find these patients in rooms to which pure and fresh air has but little access. If you do not allow the poor patient to have the fresh and pure air, which he is trying his level best to gain, you will be only paving the way for throttling him to death. Open a window which will usher in the pure, sweet and invigorating atmospheric air and you will see that the patient is comparatively at ease. Records of worst cases of this type have shown that recovery from disease takes place within a wonderfully shorter period when the patients are kept in a good atmosphere than when kept in a closed room. Consumptive patients sometimes even in their last stages recover wonderfully when kept in fresh open air. No less important, however, is open air, for preserving the health of a normal healthy individual. If you breathe in a closed room you are breathing in the poisonous gas called Carbon Dioxide that you yourself have been giving out. Always, therefore sleep in rooms

which are well-ventilated, and then your physical stamina will be increased and you will be less susceptible to disease than before.

### The Capacity of the Lungs :—

In an adult during ordinary quiet respiration, the volume of air which passes in and out at each breath is about 25—30 cubic inches. This is technically known as the *Tidal air*. The tidal air contains oxygen enough to support us a few seconds. After an ordinary inspiration (*i. e.*) after the tidal air had been taken in, we can by forced inspiration draw into our lungs a further quantity of air amounting to about 100 cubic inches. This is known as *Complemental air*. After an ordinary quiet expiration we can by effort drive out a further quantity of air amounting to about 100 cubic inches. This is utilised by a singer in sustaining a prolonged note. This is called the *Supplemental* or *Reserve air*. Even after the most forcible expiration there remains a quantity of air in the lungs amounting to over 100 cubic inches. This is known as the *Residual air*. By staying longer in the air-cells it gives the little blood vessels—Pulmonary capillaries more time to get the oxygen they want. It is also warm ; hence when we breathe some chilly cold air, it would have damped our lungs, had it not been for the warm residual air.

The total quantity of air that can be expelled after the fullest possible inspiration represents the *vital*

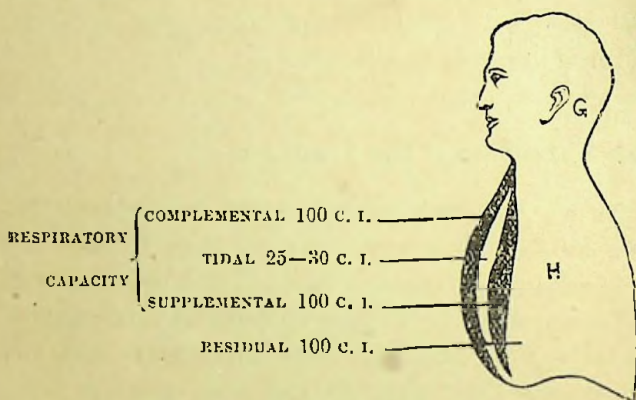


Fig 41.—Diagram showing the vital capacity of the lungs.

*capacity* of the lungs. The vital capacity is thus a measure of the efficiency of respiration or of the vital activity of the lungs. In health it amounts to about 225—230 cubic inches. Age, size of chest, height, ill health etc., regulate the standard to a great extent. In diseases like phthisis and bronchitis, the vital capacity becomes decidedly low. In certain other diseases, such as emphysema, the lungs contain a greater amount of residual air than normally. Deep breathing exercise if regularly performed, increases the vital capacity of the lungs, makes them healthy and is a great preventive against phthisis and other chest troubles.

## CHAPTER. XVI.

*The Blood.*

In some of the previous chapters you have come across the word blood perhaps many times and oft. It is such a common term and so closely associated with your life that you did not bother yourself with such questions as "What is blood?" "Of what things is it composed?" etc. Really, if you examine your knowledge of blood, you may find that you know very little about it.

The blood, in short, is a warm red liquid which carries nourishment to every part of our body. To be more technical, the blood is the red, homogenous alkaline fluid of saltish taste and liquid medium which runs through our arteries, veins and capillaries and supplies nutrient materials including oxygen, proteids, carbo-hydrates, fats and salts to the protoplasm in every minutest tissue and cell of our body. And it also carries away from the protoplasm—effete materials including carbonic acid and urea. It is clear from this that a supply of normal blood in our system is an essential necessity for our life.

If all the blood that is in our body could be collected in one single pot and weighed, it would be found that the weight will come up to about one-tenth of our entire body weight or in other words a little less than 10 pints in a man of average size. Every part of our body is, so to say, steeped in blood. If you prick a

pin into the tip of your finger, then and there will ooze out a drop of blood. Now allow this blood to remain on the tip of the finger and after a time you will notice that no more blood is coming out. The point of injury has been sealed up by a red solid substance on which on careful inspection, you will find a drop of clear yellowish liquid. What change has taken place in the blood? It has *clot*. The liquid part of the blood has separated out. Now if the red looking solid clot be examined, it will be seen to be composed of

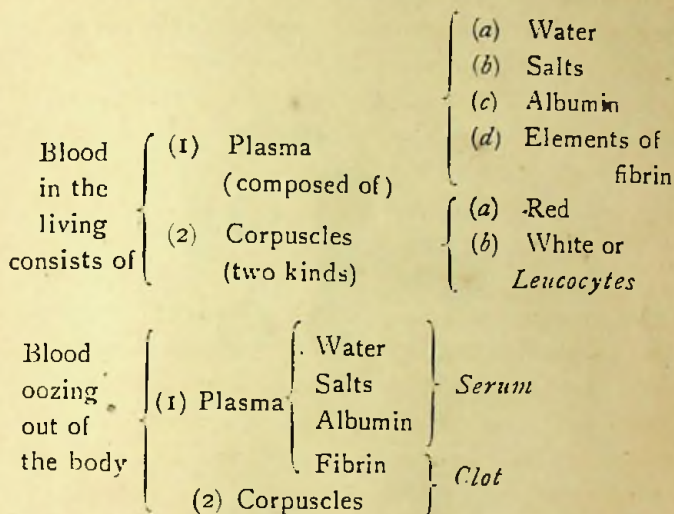
### Corpuscles,

entangled in mesh-work, like a spider's web, of fibrin.

The corpuscles float about in the liquid portion of the blood as long as it is within the body. But once by some injury or any how the blood comes out of its proper channel, it will clot within a few minutes. Hence when you get some scratch or small wound over your body, the blood comes out for a minute or so and then when it begins to clot, it blocks up the wound and prevents any further hæmorrhage. In the chapter on diet it was observed that calcium salts quicken the clotting process of blood. Hence doctors try to prevent hæmorrhage from internal organs, say from the lungs of a phthisical patient by administering calcium salts per mouth.

Now again take another drop of fresh blood on a piece of glass-slide and examine it through a high power microscope. You will then see that innumerable

corpucles are floating on the plasma or the blood liquid. In order to understand the composition of blood, you should study closely the following chart :—



We shall first speak of the liquid portion of the blood. It is called the **Plasma** or *blood fluid* (liquor sanguinis). It is chiefly water to which is added certain mineral salts and other matter. The food after digestion and absorption mixes with its blood and makes it very rich in nutriment. It is from this part of the blood that a yellow jelly like meshwork is deposited when the blood clots. The liquid that remains of the blood fluid after it has clot is known as the *Serum*. In hydrocele or dropsy it is this serum which accumulates.

In the blood fluid float two kinds of corpuscles—the white and the red. You will see that **white corpuscles** are larger than the red ones but still they are so small that no human eye can see them. If you look at the white corpuscle in a specimen of freshly drawn blood

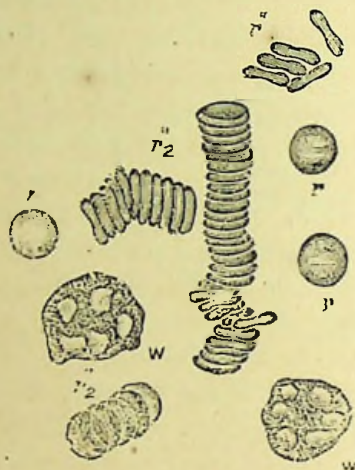


Fig. 42. Blood corpuscles as seen through a strong microscope

- r. RED CORPUSCLES LYING FLAT.
- r'. SAME, EDGE-WISE.
- r2. RED CORPUSCLES IN ROULEAUX.
- w. WHITE CORPUSCLES OR PHAGOCYTES.

or if you just take a tadpole and focus its tail and find out a white blood corpuscle then you will see that it is continually changing its shape; now it is round, now pear shaped, now it is hexagonal and so on. The white blood corpuscles are also called *phagocytes* or

*leucocytes*. The word phagocyte is derived from a Greek verb which means to eat. What things do these phagocytes eat? They eat up some of the waste products of our body. Therefore they have been called in common parlance "goblin scavengers." What a funny term it is! We should, however, give the phagocytes a better rank. They may be called our sanitary police force or body-guards. As soon as any poison or any *microbe* (microscopically tiny disease-germ) enter our body, these body-guards at once stir up to action. They muster strong in the place where the enemy has dug out its trenches and at the same time they collect all the soldiers like that gallant Kitchener's 50 lacs and start their campaign in right earnest against the enemy. They will not rest until they have completely overpowered the enemy. The brave men who die during the campaign become the *Pus cells*. The doctor, when he opens an abscess, only removes these defunct white corpuscles in the shape of pus cells and thus clears the way for the brave leucocytes to finish their work.

Occasionally however, discomfiture awaits these brave body-guards of our body, and in that case almost all the leucocytes meet with a glorious death, and the frame thus lies at the mercy of the invading germs. The process known as *inflammation* is no specific disease, but represents the body's attempt to defend itself against the ravage of the disease-producing germs having come to a certain locality of our system.

Roughly speaking there are 10,000 white blood corpuscles per cubic millimeter of blood. In normally healthy person they are in proportion of 1 per 500 red corpuscles; their number little increasing soon after a meal and gradually diminishing during fasting. Each phagocyte is a living cell measuring  $\frac{1}{1000}$  inch in diameter containing one or more nuclei and protoplasm, and as such, possesses a kind of a semi-independent existence in the blood. A white corpuscle, as we have said before is known to alter their shape and is seen to move through the contraction of protoplasm, and making themselves subtly elongated can issue forth from the wall of even minute blood vessels in large numbers.

The Red Blood corpuscles are very tiny. They are little disc-like bodies a bit thicker at edges than at the centre. The diameter of each corpuscle is about  $\frac{1}{2500}$  the part of an inch and its thickness is nearly one third of its diameter. When you look at a single corpuscle, it looks somewhat yellowish, but when a number of them are collected at one place, it has a distinct red colour. When somehow or other, blood is shed, the red corpuscles have a tendency to pile one over the other. These piles of red corpuscles resembling, as they do, piles of coin, have been called *Rouleaux*—this being the French word for heaps of coins. The Fig. No. 42 shows some of the corpuscles in rouleaux. The red blood corpuscles have no nuclei or limiting membrane, and consist of (1) the *Stroma*—

a transparent soft frame work of protoplasm and  
(2) *Hæmoglobin*.

The colouring matter of the red blood corpuscles (forming about 90 per cent of them) is the *Hæmoglobin* which contains an appreciable amount of iron. A peculiar property of this substance is that it has a great attraction for oxygen. When the blood travels through the lungs, it gives up Carbon Dioxide to and takes up oxygen from the surrounding air cells. It is this hæmoglobin which forms a loose combination with the oxygen taken up, and again when the blood goes to any other organ of the body, it readily gives up its oxygen to the tissues of the organ which are thereby nourished and enlivened. Hence the red blood corpuscles perform the function of a *carrier of oxygen* from the lungs to the tissues.

Of the three things necessary for the life of a living creature—*air, water, and food*, air or oxygen in it, is the most essential. Living tissue becomes dead when it is deprived of oxygen. In certain diseases, all the tissues of our body and therefore our body itself begins die simply of air hunger. A bad type of *anæmia* is such a disease. The term anæmia generally connotes, a diminution in the quantity of the blood. But virtually it means either diminution in the number of Red Blood Corpuscles, of which we normally have 5 millions per cubic millimetre of blood, or it may mean real loss of Hæmoglobin from each individual R. B. corpuscle. Anæmia occurs after an attack of malaria,

because in malaria a large number of Red blood corpuscles are destroyed and practically eaten up by the malarial parasites which take shelter in the corpuscle itself, and thus the total number of red blood corpuscles in the body is diminished. This form of anæmia is a simple type of anæmia and can be easily cured by proper diet and outdoor exercise and some efficacious household remedy. It is the really bad and chronic type of anæmia that causes almost certain death. There is appreciable decrease in the number (known to decrease sometimes to 1,290,000 per cub. mille from 5 millions) of Red Blood Corpuscles, as well as in the amount of Hæmoglobin; the tissues cannot therefore be supplied with the requisite amount of oxygen and this proves fatal to the individual.

The red blood corpuscle yet discharges another duty. It has been exclusively proved that blood gathers effete or waste from the tissues, this waste representing the outcome of our constant physical wear and tear. A large portion of this waste forms carbonic acid gas ( $\text{Co}_2$ ) which is carried by the blood to the lungs—the exchange office of our body, and finally breathed out. So like a good mother, the blood corpuscles on one hand *feed* our tissues with oxygen and *clean* them of dejecta in the shape of  $\text{Co}_2$ . Our artery which comes *from* the heart, when marked, will be found to convey bright light and pure ruddy blood, and the vein which goes back *to* the heart, to carry impure blood of muddy dark colour, the carbonic acid gas having united with the hæmoglobin.

Bone marrow is the ordinary place for the manufacture of red blood corpuscles. Spleen (Fig. 29) is the grave where they finally find themselves. Those cells which are unfit for further work are broken up there. The colouring matter, hæmoglobin, is shed into the blood after the destruction of the red cells and it is carried by the Splenic vein to the Portal vein and the Portal vein conveys the blood to the Liver manufactory where the colouring matter is used up in preparing the green coloured fluid, the bile.

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## CHAPTER XVII.

### *The Heart or the Central Pump and the Blood-vessels.*

Place your hand over the chest near the left nipple and you will feel something throbbing against the chest-wall. It is the *heart*, or the central pump of our body which is beating on ceaselessly, knowing no stoppage even when every other part of the body is silent and inactive. It has begun beating when you were in your mother's womb and it will go on beating up to the last breath of your life; but what does it really do all the time?

The **Heart** is a pear shaped (more like a small betel-leaf) hollow muscular organ situated in our chest between the two lungs. It is hollow, because it receives the blood and it is muscular so that it may contract itself to throw out its contents through the

blood-vessels in all directions. It is placed not exactly in the middle but is deviated a bit towards the left. Clench your fist and the size of your fist will be a little less than the size of your heart. It will be about 5 inches in length,  $3\frac{1}{2}$  inches at the place of greatest breadth and  $2\frac{1}{2}$  inches at the place of greatest thickness. Its average weight in a grown up man or woman varies from 9 to 11 ounces.

The heart is conical, with its apex pointing downwards and to the left and its base pointing in the reverse direction. A glance at the heart of a goat or a sheep at the butcher's, will show us clearly that the substance with which it is composed is similar to the animal's flesh. Both are composed of muscles with the difference that the heart is composed of the involuntary (*non-striated*) muscle fibres like the lungs, liver, stomach, kidneys etc., that is, it acts in spite of our will, whereas the ordinary muscles of our arm, leg, face, buttocks etc. are termed voluntary (*striated*), because they cannot be brought into action unless and until we wish or exert them to move. The cavity of the heart is divided into four chambers with contractile walls, two on the left and two on the right side. And the whole heart is surrounded by a membranous sac—called the *Pericardium*, in which it works and which enables it to contract and relax without friction. This sac has a double line (fibro-serous) of membrane and is attached to the muscular fibres of the diaphragm below and outer coats of some great blood-vessels connected with

the heart above. The two chambers on the left are quite distinct from the two on the right; there is no passage leading from the right side of the heart to its left side. But the upper chamber of each side communicates with the lower chamber of the same side of the heart. So the heart may be compared to two adjacent houses, each house being a two storied one. There is no door from one house to the other. The upstairs rooms of the two houses correspond with

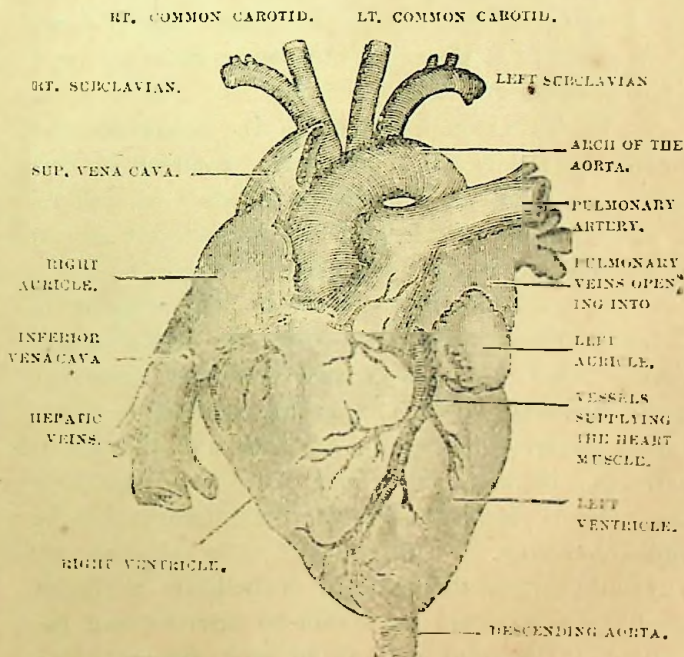


Fig 43—Diagram of the heart with the great vessels carrying blood to and away from the heart.

the two *auricles*, and the downstairs rooms with the two *ventricles* of the heart. So, the heart has—

the right auricle—(the upper right room)

the right ventricle—(the lower right room)

the left auricle—(the upper left room)

the left ventricle—(the lower left room)

Just now you have learnt that there is an opening leading from the right auricle to the right ventricle and there is also an opening between the left auricle and the left ventricle ; but there is none leading either from the left auricle to right auricle or from right ventricle to left ventricle.

The heart's action in propelling the blood consists in the successive and *alternate* contractions and dilatations of the muscular walls of its two auricles and two ventricles. The auricles contract and retract simultaneously, so do the two ventricles.

Each room or cavity of the heart has to dilate to receive the blood, the auricles—from the blood-vessels pouring blood into them and ventricles from the auricles themselves. The expansion or dilatation of the cavities receives the name of *diastole*, and the act of contraction is known as *systole*. The sounds made by them almost correspond with the utterance of the word—*Lubb-Dup*,

It is the duty of the left side of the heart to supply pure blood everywhere by means of arteries, and the function of the right side is to send impure blood brought to it by the great veins, to the capillaries or

minute blood-vessels of the lungs for purification in contact with oxygen of the air.

Now to understand more fully the manners and mechanism of the heart ; all the blood that has been circulating in the body comes back to the right auricle by means of the upper and lower big veins (*Superior and Inferior Vena Cava*) ; from the right auricle the blood enters the right ventricle through an opening which is situated between the two. After the right ventricle has been filled completely, its muscular wall contracts and out goes the blood from the right ventricle to the lungs through the big lung artery or the *Pulmonary artery* which ends in a net-work of capillaries. But why does not blood go back again into the right auricle on the systole of its Ventricle ? Because at the junction of the right auricle with the ventricle there is a trap-door by way of preventing any reflux of the blood in the wrong direction, called the *Three Flap Valve* or the *Tricuspid Valve*. The trap door opens when the blood goes from the right auricle to the right ventricle but it closes tight up in a way as soon as it tries to go up in the opposite direction. The two diagrams given in page 150 show two sections of the heart. In the first diagram blood is shown to enter the right ventricle, and the valve only two flaps of which can be shown in the section, is open. In the second figure the ventricle is just squeezing out the blood which has flowed in ; so the Three Flap Valves have closed and the valve guarding the pulmonary artery has opened

to allow the blood to flow through the Pulmonary artery.

We have followed the blood into the lung artery (*Pulmonary artery*), but you do not yet know what

SUP. VENA CAVA.

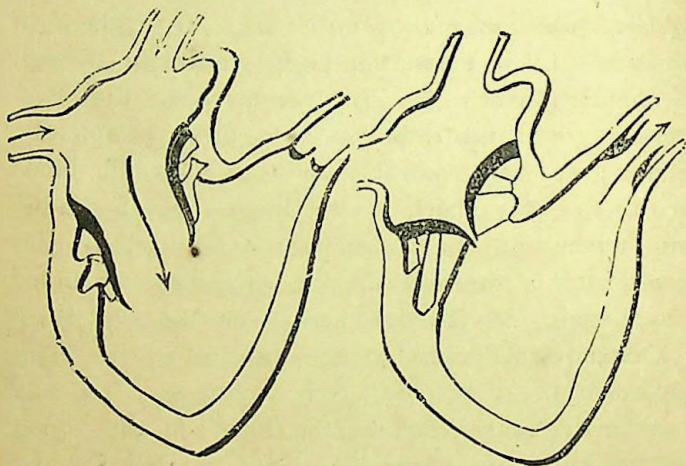


Fig. 44—Showing the position of the valve when the blood is just passing into the ventricle.

Fig. 45—Showing the position of the same valve, when the blood is pumped out from the ventricle into the pulmonary artery.

an artery is like. An artery is a thick strong contractile blood-vessel or pipe which possesses a fairly well developed coating of muscular fibers in its walls and *always carries blood away from the heart to convey it to the capillaries*. Unlike an ordinary pipe carrying water, this pipe is elastic as an India rubber tube is. If you cut a section of an artery you will find

three coats in it. The Fig. should in the next page is the diagram of an artery cut transversely across.

The outer coat or *Tunica Adventitia* is rough and very strong consisting of fine connective tissue with a slight amount of elastic tissue arranged longitudinally.

The middle coat or *Tunica Media* is the thickest of the three coats and is composed of involuntary or wilful muscle fibres which run circularly as well as lengthwise round the artery. The middle coat also contains a fair amount of yellow elastic tissue. The larger the size of the artery, the greater this elastic fiber predominates. The muscle fibres are all at the beck and call and under control of a portion of the nervous system—the *Vaso-motor nerves* which are always exerting their influence over the whole of the arterial system.

The inner coat is almost wholly composed of elastic tissues covered by an epithelial layer of thin

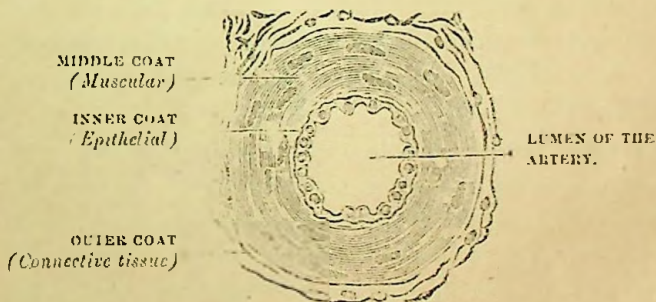


Fig. 46—Transverse section through an artery showing the three coats.

elongated cells with nuclei. It is lined by a delicate and somewhat brittle membrane so that the blood may have a smooth surface to run over.

We should remember in this connection that the smaller arteries are more contractile (though less elastic) on account of the excess of muscular tissue in their walls, than the larger arteries (though more elastic) which are by far less yielding. The amount of *elasticity* allows the arteries in proportion to dilate during the *systole* or contraction of the heart-muscle (when it sends out blood to the lung artery), thus diminishing any risk of rupture; and to assist in maintaining the circulation during the *diastole* in almost a continual stream which otherwise would have been intermittent when supplying the capillaries. The *contractability* which is predominantly possessed by the smaller arteries, can regulate the supply of blood to a particular organ when occasion wants to, assists in arresting bleeding when an artery is severed by closing, like the sphincter muscles, the divided ends, and by propelling the wave of blood through the walls of the vessel sets up the phenomenon of *pulsation*.

We had, however, followed the blood from the right ventricle into the Pulmonary or Lung artery. The main trunk of the Lung artery after a course upwards of an inch or two divides into two arteries which diverge from each other to enter into the two lungs. In the lungs again each branch of the pulmonary artery divides and divides into finer and finer branches. Ultimately they

divide into numerous hair-like branches called **Capillaries** that can only be seen by the aid of a microscope. These capillaries are very tiny network of blood-vessels with extremely thin walls and convey the blood to the minutest cells and tissues. In the lungs the capillaries are situated between contiguous air cells. Now the thin wall of the capillaries and of the air cells naturally allows certain gaseous things to pass out and certain others to get in. The impurity in the form of carbon dioxide of the blood carried by the lung artery passes out into the air cells, and the oxygen sucked in by the air cells gets into the blood of the capillaries making it all the more pure and rich.

The capillary walls have no muscular elements, but consists of a single layer of elongated epithelium continuous with the internal coat of the arteries. Their average diameter in the human body is about  $\frac{1}{2500}$  of an inch, but they differ of course in different parts of the body.

The flow of blood in the capillaries is very slow and constantly even. Such tardy flow is necessary because, otherwise, the process of purification in the lungs cannot be carried out thoroughly. The blood which travels in the biggest artery at the rate of 1 foot per second, travels only an inch in about one minute when passing through the capillaries. How is this change in the velocity of blood brought about? When the small arteries divide into capillaries, the channel through which the blood can flow becomes very wide, for very tiny though an individual capillary may be, still when

we take into account the very numerous capillaries that arise from a single twig of an artery, their united capacity becomes many times greater than the capacity of the artery. We may therefore rightly compare the blood as it flows from the small arteries into the capillaries, with the water of mountain stream as it pours down a big lake of water. How rapid is the current of water in the mountain stream but how slowly does the ripples in the lake move on! The capillary system represent the lake in our comparison, and so the flow of blood in the capillaries should have been reduced considerably.

After the blood has been purified and enlivened with oxygen in the lung capillaries, it has to return through the *Pulmonary Veins* into the left side of the heart from which it will be sent to all the organs of the body to keep them active and strong. And *Aorta* acts as the sole distributor of arterial blood to the system.

The blood surcharged with all sewage of the system has to go back to the heart through a *Vein*. From the heart that blood has been sent off through an artery and to travel back through a vein *which carries blood to the heart from the capillaries*. Now how does the blood get from one to the other? It is by the capillaries which serve practically as bridges between an artery and a vein.

A *Vein* resembles an artery very much, the only difference is that its walls are thinner than those of an artery and are of greater capacity.

The vein has got the same three coats as those of an artery :—

An outer Coat      (*Connective tissue*)

A middle Coat      (*Muscular*)

An inner Coat      (*Epithelial lining*)

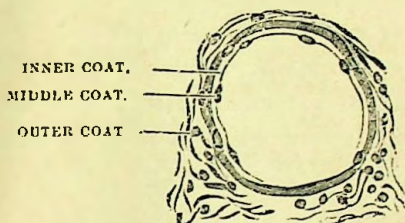


Fig. 47—Transverse section through a Vein.

The *outer coat* in a vein is constructed of connective tissues like that of the arteries and more or less of elastic or muscular fibers and it is thicker than the latter.

The *middle coat* is very poorly developed in the veins. It is less muscular, containing more white fibrous tissue than the same of arteries.

The *inner coat* is smooth and is composed of a lining membrane of epithelial tissue, and closely resembles that of the arteries.

Now, so far we have followed the blood from the right ventricle and thence by the Pulmonary artery into the Pulmonary capillaries where it has been purified, and next the pure blood is to return to the heart by the *Lung Veins* or the *Pulmonary Veins*.

By the bye, the students should always keep in mind that the Artery always carries pure blood *away* from and the Vein impure blood *to* the heart, save and except the Pulmonary Artery and Veins which exactly act the reverse.

Of the Pulmonary veins there are four, two from each lung, all falling into the *Left Auricle*.

The left auricle next pumps the blood into the *Left Ventricle* through an opening situated between the left auricle and the left ventricle. Here the opening is guarded by a valve called

### The Bicuspid Valve or Mitral Valve.

You should remember that there was a similar valve in the right side of the heart but that valve had three flaps and so it was called the *Tricuspid valve*. But the valve on the left side of the heart has two flaps or cusps, and so it is called the *Bicuspid valve*. This valve is also called the *Mitral valve* possibly due to its resemblance to a bishop's mitre. These flaps, you know, are formed of a duplicature of the lining membrane of the heart strengthened by connective tissue and hang down into the cavity of ventricle, to the muscular prominences of the walls of which they are attached by very thin yet strong cords. When blood passes downwards from the auricle into the ventricle, these flaps falling down allow the free down-flow of the blood and when the ventricle is filled, the flaps of the valves float up on the top of the blood, so

that their edges meet accurately to the *Auriculo-Ventricular Orifice* and are brought into perfect apposition forming the ventricle for the time an water-tight compartment.

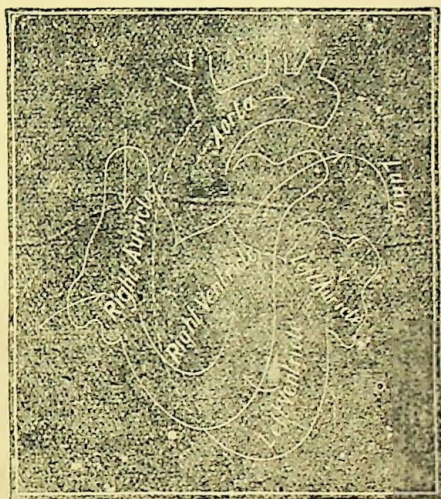


Fig 48 - Diagram of the circulation in the heart.

Now, when the left ventricle becomes full of blood and the Mitral valve closes up the opening between the auricle and the ventricle, the muscle fibres of the ventricle contract and out goes the blood from the left ventricle into the aorta or the biggest artery in the body. The amount of bloods which is

sent out by the Left Ventricle at each heart-beat is from 3 to 3½ ozs. in an average person.

The following diagram and formula will help you very much to recapitulate the method of the circulation of blood in the heart.

### Remember

THE BLOOD FROM THE WHOLE BODY APPROACHES  
THE HEART BY THE TWO BIG VEINS ( SUP. &  
INF. V. C. )  
FROM THE BIG VEINS THE BLOOD GOES TO THE  
RIGHT AURICLE.  
FROM THE RIGHT AURICLE TO THE  
RIGHT VENTRICLE,  
FROM THE RIGHT VENTRICLE BY THE PULMONARY  
ARTERY INTO THE LUNGS.  
FROM THE LUNGS BACK TO LEFT AURICLE BY  
THE PULMONARY VEINS,  
FROM THE LEFT AURICLE INTO THE  
LEFT VENTRICLE,  
FROM THE LEFT VENTRICLE INTO THE AORTA,  
FROM THE AORTA INTO ALL THE ARTERIAL  
BRANCHES.

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## CHAPTER XVIII.

*Circulation of Blood.*

In the previous chapter we have seen that more or less three ounces of pure red blood, is jerked out of the *left* ventricle at each beat of the heart into the biggest artery in the body, namely the

**Aorta.**

The aorta is nothing but a stout wide pipe of about one inch in diameter. It resembles very much an artery in structure which it really is, the only difference being that there is a great preponderance of fine yellow elastic tissue in its middle coat. You can very well understand why there is so much of elastic tissue in the wall of the aorta. The aorta has to bear the brunt of the whole force with which blood is pumped out of the heart. Had there been not so much elasticity in the wall of the aorta, it would not have been able to bear so much storm and stress.

Once the three ounces of blood is in the aorta, the latter swells up to accommodate the amount of blood. Then the elastic tissue recoils and the muscular tissues contract pushing on the blood throughout the arterial channel. As the blood travels on, on passes the wave of dilatation which has been started at the mouth of aorta, along all the arteries and this wave of dilatation is felt in the arteries as the

*Pulse.\** Thus each beat of the heart is responsible for each single pulse which is felt in an artery. The artery which the doctor generally selects for examining the pulse with his three middle fingers, is the *Radial artery* which is situated at the outer side of the forearm and which can be easily felt a little above the base of the thumb near the wrist. From the number of throbbings in the artery you can know how fast the heart is beating. Generally the Radial artery will be felt to expand beneath the finger some 70—75 times a minute. It is possible also to say from the pulse whether the heart is contracting regularly and with equal force every time. When the arterial wall loses its elasticity, we do not feel a smooth pulse, but the pulse comes on with a sudden jerk and drops down suddenly. This sudden pulse when it strikes the inelastic walls of the arteries may cause a rupture in the wall and this is specially serious if it occurs in the arteries of the brain, for then it causes apoplexy.

Now to come back to the aorta, it springs from the left ventricle, passes upwards and a little towards the right for two inches or so and there it takes a bend arching across the bronchus and the gullet till it comes to lie by the side of the spine. Before the blood has time to pass through this arch, a part of it has to enter

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\* This pulse wave travels at the rate of 15-30 ft. per second along the arteries and is finally lost in capillaries. The more rigid the arteries, the faster the wave travels; the more distensible, the more slowly it runs.

the three principal arteries which spring from the arch of the aorta. ( See fig. 43) of these three, the one that goes towards the extreme right called *Innominate artery* has to bend off rightward going to supply the right upper limb after having changed its name into *Right Subclavian* and sending up one twig which goes to the right side of the head and neck ( *Right Common Carotid* ). The middle branch passes vertically upwards towards the left side of the head and neck and this is called the *Left Common Carotid artery*. The branch towards the extreme left is the *Left Subclavian* which is intended for the supply of the left upper limb. It may be well-worth remembering in this connection that there is no *Innominate artery* on the left side of the heart, the *left common carotid* and the *left subclavian* issuing directly from the arch of the aorta (make a careful study of the fig. 43). Each of the *Subclavians* has to come towards the humerus down up to the finger tips, taking several names in different phases of its course; thus near and about the *Deltoid* it is called the *Auxiliary Artery*; then it sends down a branch towards trunk side, called the *Superficial Profunda Artery*. There in the middle portion of the upper arm it is termed as the *Brachial Artery* and under the elbow joint divides itself into two branches, the one known as *Ulnar Artery* and the other *Radial Artery*. About the significance and utility of the latter, I have spoken in the preceding page.

So after all, we see, the first portion of the blood which is sent out into the aorta goes to supply the

head, the neck and the upper limbs. The remaining part travels down along the *Descending aorta*. The aorta as it goes down, becomes imperceptibly smaller and smaller in calibre, and why? Because it is continually giving off branches which are going to supply all the muscles, glands, skin, bone and every other tissue in the body.

In the abdomen it gives off numerous branches to the liver, the stomach, the spleen, the sweetbread, the intestines, the kidneys etc. and just in the middle of the body basin it divides into two which supply the Lumbar Region. These two branches are called *Superficial Iliac Arteries*, which again a few inches below send off two smaller off-shoots to run near and around the region of Coccyx, called *Interior Iliac Arteries*. Each of the *Superficial Iliac Arteries* which however, when comes hardly beneath the Eschium, divides into two to supply each of the legs. One of these goes to the front of the thigh of the same side, where it is known as the *Femoral artery* and this supplies the whole of the leg. The other branch passes on into the back of the leg to supply some of the thigh muscles such as—*Biceps Femoris* etc. and the lower portion of the buttocks.

The *Femoral Artery* when reaches the middle part of the thigh, sends another off-shoot to nourish the inner side, and when comes under the knee still gives off another branch called *Popliteal Artery* under which it again sends another branch downward and comes up in front of the leg with the name of

*Anterior Tibial Artery* and the branch running behind the leg is known as *Posterior Tibial Artery*; the latter again giving off another branch called *Peroneal Artery* to supply the muscles on the fibula side, proceeds towards the sole to nourish the remaining portion of the limbs.

Now, the blood goes on through the various channels and even into the tiniest arterial branches, but how will it return? "It goes by the right arm and will return by left arm through the veins" said a foolish boy, for his teacher had shown the radial artery in his right hand and an enlarged vein in his left. "But how is it going to skip over from one limb to the other?"—asked the teacher. No one could answer.

The veins and arteries usually go side by side in every part of our body; there being a few exceptions such as the Hepatic Veins, Sinuses of the skull and veins of the Spinal Cord. *The blood goes by the arteries and returns by the veins.* Between the arteries and the veins are the immense network of *Capillaries* or hair-like tubes. The blood travels through these capillaries at a very slow rate and it is while the blood is in these capillaries that it performs all the functions which it discharges in the body. The red blood corpuscles give off their oxygen which the tissues utilise for their nourishment; also some of the liquid portion of the blood (serum) is exuded from these capillaries. The tissues are flooded with this nutritive serum and out of this they take up what nourishment they would require, and the

part of the fluid which is in excess, is then carried away by the Lymphatic system.

### Lymphatic System.

Now I shall try to speak at some length about what Lymph and the Lymphatic system are. The *Lymph* is formed by the excess of fluid constituents of blood passing through the walls of the small blood vessels. They are practically *plasma* without any R. B. corpuscles and they directly nourish the most minute structure of the body where the blood vessels have no access. The Lymphatic system of the human body, is in reality a supplementary circulation. The lymphatic system unlike the general circulation, begins its career from the tissues of the body, steadily converging towards the centre of the body and ending in the depths of the chest. They carry back into vascular system any excess of plasma not required for the nutrition of tissues, *i. e.*, the Lymph.

The *Lymphatic capillaries* commence in various ways in the tissues; by their junction they form the larger lymph vessels which from all sides finally join the **Thoracic Duct**, by means of which they empty their contents into the *Left Subclavian Vein*.

Anatomically considered the Lymphatic system consists of three or to be more accurate, four agents,—(1) Lymphatic capillaries (2) Lymphatic vessels (3) Lymph spaces (4) Lymphatic glands.

*Lymphatic capillaries* consists of channels for the most part larger than the capillaries of the vascular system, their walls made up of a single layer of flattened

nucleated epithelium. Sometimes a small artery may completely be surrounded by lymphatic capillaries.

*Lymphatic vessels* are delicate tubes with transparent walls formed of the same three coats as the arteries and found in all parts of the body excepting the nails, the upper layer of skin, hair and cartilages. The lymphatic capillaries empty themselves into these vessels. They are provided with numerous valves almost like veins.

*Lymphatic spaces* are cavities, almost all of them of microscopic size, situated between the cellular elements of tissues. They are mostly found under the skin, mucuous membranes in the diaphragm, lungs, liver etc. The cavities are directly in contact with the lymphatic vessels or capillaries by minute holes called *Stomata*, and by means of these holes fluid matter enters the lymphatic system.

That lymphatics arising in the villi of the small intestine are termed *lacteals* and that during digestive process absorb fatty and oily matters and to a small extent soluble albumen, we have told you in page 88. The *chyle* that the lymphatics of villi absorb from the small intestine is not yet in proper condition to be combined with blood; so it has to pass from the lacteals into the Mesentric glands. These glands (there are about 150 of them, each about the size of an almond) are situated in the *mesentric* wall—a loose membrane suspended from the rear wall of the abdomen. There in the mesentric glands, the chyle is filtered; afterwards it flows through lymphatic vessels into a

reservoir known in the medical world as the *Receptaculum chyli* placed against the front of the spinal column (Second Lumbar Vertebr.) in the upper portion of the abdominal cavity.

Practically the *Receptaculum chyli* is the dilated part of the Thoracic Duct—which terminates in the *Left Subclavian Vein* in the neck near its junction with the *Jugular Vein*. The Duct is from 15 to 18 inches long in the adult and is guarded at its termination by a double semilunar valve as in other great cardiac vessels. On the right side of the neck symmetrically placed with the termination of the Thoracic Duct, is a short but large lymphatic vessel called the *Right Lymphatic Duct*. All the lymphatic vessels of the *right side* of the head, chest and heart terminates in this latter Duct. It also discharges its contents into the *Right Subclavian Vein*.

Thus we see, the whole of the liquid blood perspired out of the capillaries as excess and the filtered chyle (rudimentary form of plasma mixed with fatty matters) are ultimately brought into the venous system to be afterwards combined as a finished product with the arterial blood.

Situated in the course of their Lymphatic and lacteal vessels, are small solid, round or oval bodies called Lymphatic glands. These glands are equipped with an outside capsule composed of fibrous and involuntary muscular-tissues, and this capsule sends out trabecular elongations from all sides *inward* into the substance of the gland, and between these elongations lie the

*Gland-pulp* or *Lymphoid tissue*. It forms a fine network of fibers, in the meshes of which *lymph corpuscles* come to lie. We find these glands prominent in the spaces near the larger joints, such as—in the groin, knees, arm-pits, elbows and in the sides of the neck and other parts of the body. The lymph corpuscles or lymph-cells resemble in every particular the white corpuscles of blood, having got their nuclei and exhibiting amoeboid movements. Some presume that these lymph-cells are practically the parents of W. B. Corpuscles.

When a lymphatic vessel arrives near by a lymphatic gland, it breaks up into several branches which enter the gland through the trabeculae or Septa and for a time lost into it further dividing into a network of very minute microscopic vessels resembling the capillaries of blood circulation. When about to leave the gland, these tiny vessels within reunite into several tubes and just coming out of the gland unite to form again a single lymphatic vessel continuing its way to the centre of the body.

### The Venæ Cavæ.

Now, again to continue with the course of the blood, it travels from the capillaries into the *Veins*. What is it that cause the blood to move in the veins? Primarily it is the push of the central pump or the heart forcing the blood from behind; this force is called *Vis a tergo* or force from behind. And there is the aspiration of the thoracic cavity which is termed *Vis a fronte* or force

from the front. Besides that, the walls of the veins being very thin, any muscular or external pressure forces the blood on along in the veins. By pressure on the veins the blood could go either towards or away from the heart. So there must be some contrivance so that the blood would only go in the desired direction, *e. i.*, towards the heart. The small flap-like valves which are present throughout the course of the veins are only such contrivances. The valve allows the blood to go only towards the heart; but whenever by pressure the blood is forced in contrary direction, the flaps of valve prevent their flow and the vein becomes distended at the region of the valves. The veins of

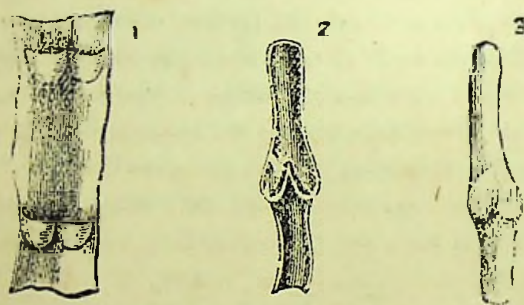


Fig. 49—Diagram showing the valves of veins.

- |  |   |  |
|--|---|--|
| <p>1. Part of a vein laid open and spread out with two pieces of valves. Mostly there are two pockets <i>pari passu</i>.</p> | <p>2. Longitudinal section of a vein, showing the apposition of the edges of the valve in their closed state.</p> | <p>3. Portion of a distended vein, showing a swelling in the region of a pair of valves (outside view)</p> |
|--|---|--|

the upper and lower extremities, neck, and the upper surface of the head have numerous such valves, while

they are wanting for the most part in the deep seated veins of the abdomen, chest and head. The Venæ Cavæ, Portal, Hepatic, Renal, Pulmonary veins are practically destitute of valves. You can just see what takes place if you press some of the blue veins in your forearm. Then the parts which is toward the hand will be swollen and stand out in bold relief and if you look very carefully you may even detect the position of the valves.

The smaller veins unite as they near the centre of the body, to form bigger and bigger veins which ultimately open into either of the two veins:—

**Superior vena cava** (*The upper large vein*)

**Inferior vena cava** (*The lower large vein*)

The *Superior vena cava* returns the blood from the upper limbs as well as from the head and the neck.

The *Inferior Vena cava* returns the blood from the lower limbs, the body basin, the kidneys, and also from the stomach, intestines, pancreas, spleen etc.

There is another large vein—the *Portal vein* which returns blood from the digestive organs and carries it to the Liver (see pages 95, 96, & 98).

From the arch of the Superior vena cava like that of the aorta, arise on the right side the *Innominate vein* from which the *Right Internal and External Jugular Veins* (going like the common carotid arteries to the head and neck) and the *Right sub-clavian vein* (to supply the upper extremities) issue forth. Similiar to the Left common carotid and Left sub-clavian arteries, the *Left Jugular Veins* and *Left Sub-clavian Vein*

have no Innominate Vein ; the former taking their origin from the arch of Sup. vena cava itself and the latter being only a continuation of the Sup. vena cava projected towards the left. Near the Glenoid Cavity (Shoulder Joint) the sub-clavian vein divides itself into two branches ; one is called the *Cephalic Vein* and the other *Basilic Vein*. These two uniting in an archwise fashion under Elbow joint give off three twigs, known as *Radial Vein*, *Median Vein* and *Ulnar Vein*.

In the Inferior Vena Cava there is the same sort of arrangement as in the Descending Aorta, *i. e.* from the two *Common Iliac Veins* there are projected two *Internal Iliac veins*, and each of these superficial veins coming under the Hip joint assumes the name of *Long Saphenous Vein* which supplies the whole of the lower extremities with its divergent off-shoots

The Superior and Inferior Venæ Cavæ taking delivery of the carbon-dioxide and other effete materials given off by the tissues and carried up by the different branches, finally open into the right auricle ( See page 149 ) and thus the journey of the blood is completed

It takes only 15 seconds to complete this journey although it takes you many minutes to read an account of this journey. Fig. 50 on the next page is a schematic representation of the whole of the journey which the blood makes in the body.

The dark part represents the venous blood or blood which is charged with carbon dioxide, and the white part the pure arterial blood. The diagram shows that

the whole blood circulation can conveniently be divided into four parts :—

1. Pulmonary circulation.
2. Systemic circulation.
3. Portal circulation.
4. Renal circulation.

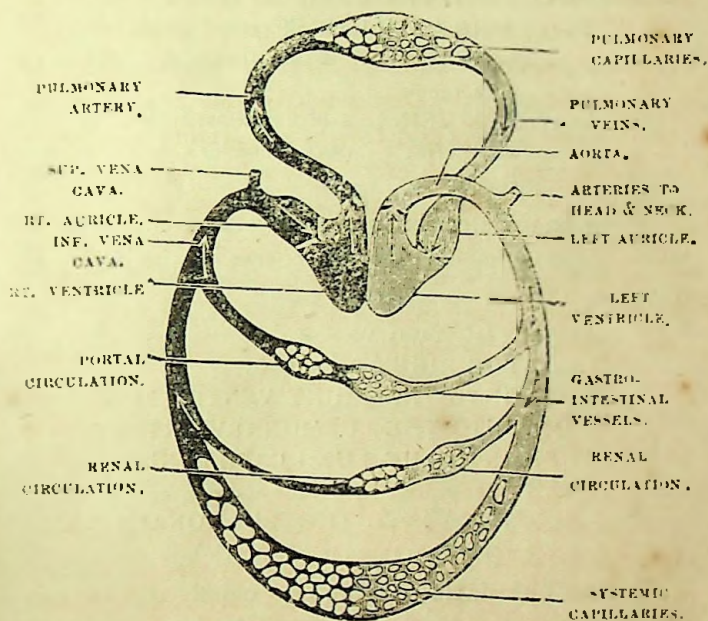


Fig. 50 Diagram of complete circulation

Systemic circulation is that portion of the circulation which is responsible for the supply of the entire

body with blood except some of the abdominal organs and the kidneys. Its course is as follows :—

FROM THE LEFT AURICLE  
 INTO THE LEFT VENTRICLE  
 THEN INTO THE AORTA  
 THEN INTO THE SMALLER ARTERIES,  
 (which go into the upper and lower limbs, the  
 head and the body)  
 THEN INTO THE CAPILLARIES,  
 FROM THE CAPILLARIES (after giving off oxygen  
 and food material to the tissues and picking up  
 waste products)  
 INTO THE VEINS (which ultimately join to form  
 two veins called Superior and Inferior  
 venæ cavæ)

**Pulmonary circulation** consists only of the circulation in the region of lungs. Its course can be followed from the diagram.

FROM THE TWO VENÆ CAVÆ  
 INTO THE RIGHT AURICLE  
 THEN INTO THE RIGHT VENTRICLE  
 THEN INTO THE PULMONARY ARTERY  
 THEN INTO THE LUNG CAPILLARIES  
 THEN (after picking up oxygen and disgoring carbonic  
 acid gas) INTO THE PULMONARY VEINS  
 (which open into the left auricle).

**Portal circulation** :—concerns chiefly the circulation in the stomach, the spleen, the pancreas, the intestines.

The blood is carried to these organs by branches such as, the *Gastric Artery*, *Hepatic Artery*, *Splenic Artery*, *Abdominal Artery*, *Mesenteric Artery*,

*Renal Artery* etc., from the lower big artery or the descending aorta. Such as—

FROM ARTERIAL BRANCHES OF AORTA,  
 INTO THE CAPILLARIES OF STOMACH,  
 INTESTINES, SPLEEN, PANCREAS,  
 THEN INTO SMALL VEINS,  
 THEN INTO THE PORTAL VEIN,  
 THEN INTO THE LIVER (where changes occur :  
 see chapter on Liver, page 93),  
 THEN INTO THE HEPATIC VEIN (vein of the  
 Liver)  
 THEN INTO THE INFERIOR VENE CAVE,  
 THEN FINALLY INTO THE HEART.

Renal circulation only concerns the circulation in the Kidneys. This we shall deal with in the next chapter when when we shall talk on the Kidneys.

All this that I have told you about circulation, was first discovered by a great man, *William Harvey* who devoted his whole life in finding out the simple truths about our circulatory system, some of which I have narrated to you in this and the previous chapters. The following are some of the arguments which he put forth in order to prove the course of the circulation :—

1. If a vein is cut, we can stop the flow of the blood by tightly pressing it at the side *furthest* from the heart.

2. If an artery is cut, bright red blood comes out by rhythmic jerks and we can stop its flow by pressing at the side *nearest* the heart.

We have seen that both these data are proofs

that the blood leaves the heart by the arteries and returns to its by the vein.

You should also remember these two simple truths, for they will be of much practical importance to check bleeding from wounds.

3. In the veins are little valves which are arranged in a manner only to allow the blood to travel in one direction, *i. e.*, towards the heart.

4. The pulse corresponds with the beating of the heart. Put your finger on the Radial side of your wrist and you will feel a small regular jerk which is the contraction wave of the systole of the left ventricle.

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## CHAPTER XIX.

### *Excretory System.*

#### The Skin and the Kidneys.

You may remember that in a previous chapter, it was said that the human body is an aggregation of a multitude of nucleated microscopic cells. Each cell is a separate being, imbibing nutrition from the blood, and throwing off some products which are of no use to itself or the body at large and which, therefore, represent the waste products of a chemical industry or the sewage of a city. This process is going on every moment and every where in the system; consequently the blood stream not only contains the nutriment which is essential

to the carrying out of our bodily functions, but also carries the sewage which has accumulated in our body during the vital processes.

The waste materials which are carried by the blood stream are to be removed as soon as they collect in sufficient amount, otherwise, these will produce distinct poisonous symptoms in our body. In a disease called *Uremia*, in which there is retention of urine, there accumulates so much waste material in the blood that the patient becomes almost delirious and ultimately senseless due to the poisoning action of the accumulated waste materials and finally the patient even succumbs to these toxic conditions.

It is, therefore, necessary that simultaneously with the giving off of waste materials from the multitudinous cells which constitute the human body, there must also be at work a purification plant inside our body which will always maintain the blood in a state of purity. The task is set upon the lungs (of which you know fully well by this time), kidneys and the skin, so that the three form a kind of physiological trio whose action is that of purifying the system and excreting waste matter from the body, the lungs of course acting in a highly important fashion because they likewise perform the function of absorbing oxygen. Metaphorically considered, this trio together with the heart constitutes the Nature's Municipality in our system.

The functions of the **Skin** are of varied character. In addition to serving as a body covering, the nerves

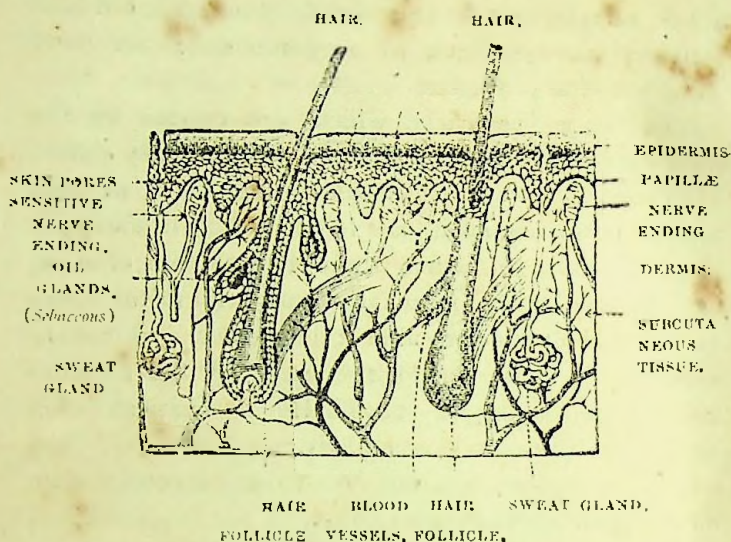


Fig. 51—section through a piece of skin.

(highly magnified)

of its under layer (*Dermis*) supply us with the means of exercising the sense of touch. The (*Sweat and Subcutaneous*) glands of the skin constitute it an organ of excretion for getting rid of waste matter. For the purpose of description, the skin may be divided into three layers: (1) The outermost one called the *Epidermis* or *Cuticle*. (2) The middle one—the *Dermis* or *true skin*, and (3) the *Subcutaneous layer*.

The *Epidermis* is subjected to all sorts of rubbing and pressure from all outside agents and possesses neither nerves nor blood-vessels, consisting of epithelial cells constantly renewed from the

upper surface of the under skin. The dead epithelial cells thus constantly cast off carry with them, no doubt, many excretory products including poisons. Thus we find gouty eczema, which is probably an effort of the nature to throw off poison through and with the skin. Thus too we find eruptions of the skin in small pox, scarlet fever, typhoid and many other infectious diseases. In the innermost layer of the epidermis, we find the coloring matter (*color-pigments*) which gives the lightness or darkness of shade to the human skin. Sun's rays has the effect of causing more coloring matter to be deposited in the skin upon which it shines. Climatic conditions, habits etc., have also been known to regulate to a certain extent, the color pigments of one's body.

Our nails are but more compact and flattened projections of this epidermal layer of skin. The hairs, like the nails, are modified portions of the epidermis. Each hair consists of a root with shaft ensconced in a deep narrow cavity, known as *Hair Follicle* (See fig. 51). The base of the follicle is generally placed in the subcutaneous layer (of which I am speaking to you presently) and the mouth ends in the free surface of the Epidermis. Each hair has attached to its base a very minute muscular fiber, through the contraction of which it may be raised to an erect position, as in a sudden case of fear or exciting pleasurable sensation. Into the deeper part of the hair-follicles, there generally open two to five glands called the *Sebacious glands*, which secrete an oily substance

to give the hair and the outermost skin a shining appearance.

The second layer of the skin the *Derma* consists of two layers. First, the *Papillary layer*, situated upon its free surface, presents innumerable little eminences, called the *Papillæ* which are full of tiny blood-vessels and whose average size is  $\frac{1}{100}$ th of an inch in length by  $\frac{1}{200}$ th of an inch in diameter at the base. In the *Papillæ* we find termination of nerves of touch (sensitive nerves) in peculiar bulbous enlargement known as *Tactile corpuscles* or *end-bulbs*. Second, the *Reticular layer* made up of fibrous mixed up with elastic tissues, encircles the neck of Hair-follicles and contains lymph spaces and capillaries. Beneath this is the *sub-cutaneous layer* which consists of a net-work of fibrous tissue with innumerable fat-cells held in its meshes.

### Sweat glands.

We find multitudes of glands called the *Sweat glands* embedded in the Subcutaneous layer. The secretion of these glands is called the sweat or perspiration. Perspiration is continually going on but we may not be sensible of it. It is only when the secretion is increased or when evaporation of the secretion is retarded, as in a sultry weather, that drops of sweat appear on our skin and we say that we are perspiring. The glands which secrete the sweat are, however, always busy in separating out some of the waste materials from the blood and to throw it out of the

body (See Fig. 51) through the numerous pores which we find on the skin and which are the openings of the pipes that carry the sweat *i.e.* of the sweat glands. A section of skin shows the sweat glands opening on the surface of the skin at the numerous pores. So numerous are these pores that there are often to be found 3000 of them in a portion of the skin not larger than that which would be covered by a Rupee. In the whole human body there are no fewer than 3,000,000 of these tiny pipes ; thus if you count one of these pores every minute, it would take you six years to count them all, and moreover, if the tiny perspiration tubes were placed end to end, it would cover a length of 28 miles. Just fancy 28 miles of perspiration tube in your skin only !

On the average, two or three pints of fluid are excreted by the sweat glands every twenty four hours ; but in the case of a man doing manual work in hot weather five to eight times the normal quantity may be excreted. Sweat consists of a little less than 99% of water. The rest of it is composed of ordinary salt and some other inorganic salts. It also contains minute quantities of *urea* which is chiefly excreted in the urine.

There is a great interdependence between the secretion of sweat and the secretion of urine which can be shown by the simple fact that more the perspiration on the skin, the less fluid is eliminated by the kidneys as urine and *vice versa*. In very hot and dry weather when there is much perspiration (mostly *insensible i.e.*, drops of sweat seldom accumulate on our skin but the sweat is evaporated and taken

into the atmosphere as water vapour, as soon as it is formed), much of the water of the body passes out by the pores of the skin, so the urine becomes very concentrated and of a pungent odour.

In the winter, when the skin does not perspire as freely as in summer, secretion of kidneys is greatly increased. In certain diseases where the kidneys are active, such as in diabetes, the skin becomes rough and harsh, and perspiration is very scanty. Again, when very little excretion takes place in the kidneys as in the disease already referred to in page 175, namely, *Uræmia*, the percentage of urea rises in the sweat; the sputum and the saliva also contain urea under these circumstances. And what does the physician do in such case? He further stimulates the skin to action by means of hot sponging, hot air baths and even by steam baths and also by use of certain drugs which stimulate the sweat glands into further activities. Besides that, he orders purgatives for his patient so that the alimentary canal can be kept open. In short, what the physician does in such cases is only to open up and clear up other passages of excretion in the body. In some of these cases the skin secretes urea so abundantly that when the sweat dries on the body, the patient is covered up with a coating of urea crystals. Therefore, we advise persons who chronically suffer from kidney disease, to be very particular in keeping their skin in a good healthy order by removing all forms of dirt, by a tepid bath and then by massaging the skin with a dry towel.

We have hitherto learnt about two principal functions of the skin *i. e.* (1) *Protection* of the delicate organs lying underneath, (a) mechanically by means of the epidermis, and (b) by means of the sense-organs which by transmitting the sensations of pleasure or pain, heat or coldness to the central nervous organism serve as a warning to the individual economy. (2) *Excretion*—of which we possibly know enough by this time.

Besides these two, it has two other duties to perform; namely—(3) *Regulation of the temperature*. As we know, the body when alive is constantly hot and maintains ordinarily a temperature of about 98·4 Fahrenheit (37 C.), the heat being generated through constant oxidisation process going in our system. Now, heat is constantly passing away through the skin by three-fold processes. (a) evaporation of the perspiration (b) radiation and (c) conduction. It is evident at once that the conductivity of the skin must have much to do with the regulation of this passage of heat. If the skin be a good conductor, heat will pass rapidly away, if a poor conductor slowly. It is possible even to kill a man by accelerating the conduction of heat through his skin. In a procession to celebrate Pope Leo the tenth's ascension to the throne, a child was covered all over with gold leaf to represent the golden age, and within six hours he died. (4) *Respiration of the skin*. The skin plays the part of an organ of respiration subsidiary to the lungs. Like our noses, it perpetually *breathes, i. e.*,

it absorbs oxygen and gives off carbon dioxide (depurating about one fiftieth as much as do the lungs.) To cover the skin, as is so often done with garment after garment, is to deprive the skin of its two great organic functions, both of respiration and circulation.

Now, to begin with the **Kidneys**, they are the largest of the excreting glands in the body. They are situated at the back of the abdomen, one on each side of the spine (See Fig 29.) Hence back-ache is sometimes referable to some disorder in the kidneys. The best treatment for back-ache is to take a big glass of hot water every now and then which will thoroughly flush the kidneys and restore it to its normal condition. Life and health is possible with only one kidney; but if both kidneys are cut out, death occurs within a few days.

How does the kidney carry on the work of blood purification? Of course it is a very complex phenomenon; we shall however deal with it very simply and in a rudimentary manner. In the first place, the kidneys are supplied with very large arteries—much larger than any other organ in the human body, in proportion to their size. These arteries which are called the *Renal arteries* are given off directly from the aorta which you know, is the largest artery in the body. The consequence is that the pressure of the blood in the kidneys is naturally greater than any other portion of the human body except the aorta and the heart. Hence the blood reaches the kidney

with a tremendous force. As soon as the large artery enters the kidney it divides and subdivides and each of the branches again bifurcates into two which gives it the appearance of the letter T. These branches unite with each other to form an *arterial arch*. From the arterial arch, vessels travel towards the periphery, as well as backwards into the central portion of the kidney. The vessel that goes towards the periphery now gives off many offshoots. Each one of these off-shoots next breaks up into numerous capillaries. These capillary vessels in the kidney, like capillaries in other portions of the body, are only passive tubes which allow the blood to flow freely through, and which can stretch if the blood pressure rises and can shrink if there is a fall in blood pressure.

If much stretched these capillaries will allow the portions of the blood to pass through. This is going on everywhere in the body to some extent but particularly in the kidneys because of the tremendous blood pressure and the great abundance of capillary vessels.

Now there is a difference between the liquid that oozes out in other parts of the body and the liquid that comes out through the kidney as urine. If you recall your knowledge about the journey of blood, you may remember that the liquid that flows out through the capillaries in other parts of the body is the nutrient fluid called the *serum* but the fluid that oozes out through the particular capillaries in the kidney do not contain any nutrient material and hence the fluid

that oozes from the tuft of capillaries or *glomeruli* as they are called, consists of water.

The capillary tuft is enclosed in a sac or capsule consisting of a homogenous membrane lined by flattened epithelium. This capsule was first described by Bowman and hence it bears the name of *Bowman's capsule*. Through this capsule the water that has oozed out enters

### the Kindey Tubule.

There are thousands and thousands of these microscopic tubules and these numerous tubules are gathering the drops of water as they are oozing out from the capillary tufts. These tubules do not follow a straight course but they wind round and round through the substance of the kidney and they go under different names in different portions of their course. In the diagram you can see that the same tubule has been given various names as it winds up and down forming loops and somewhere taking a convoluted course while at other places pursuing a more or less straight course. However we need not go into the details of this.

Now, what does each of these long kidney tubules do? It is not like a simple drainage pipe. It is lined by active and living cells. The water that enters the tubule in the capillary tuft is practically pure water. It contains little or none of the salts in the blood. As it passes down the tubule, by the activity of the *renal cells*, poisonous and waste materials of the blood are added to

Bowman's capsule. Neck 1st. Convoluted tubule,

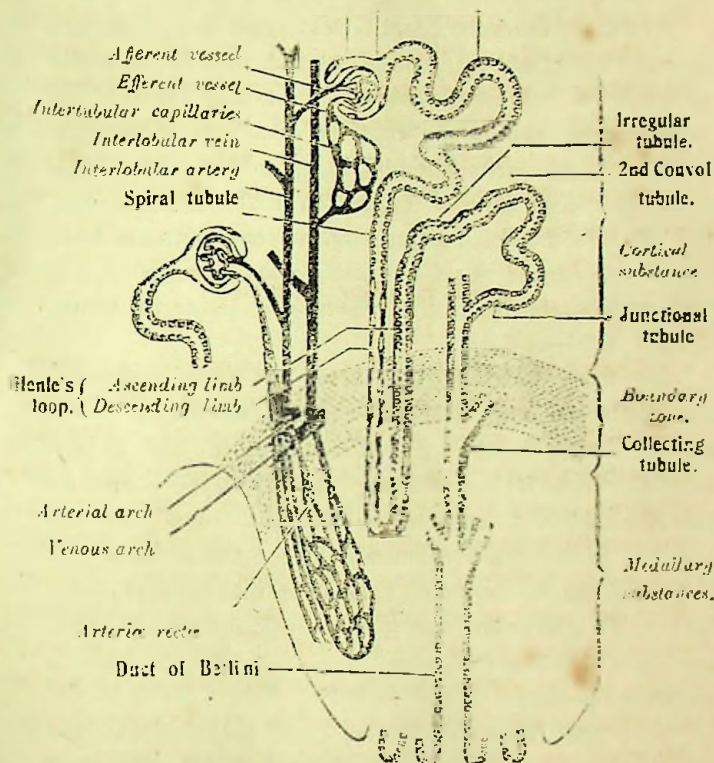


Fig. 52—Scheme of kidney tubule and its vascular supply, (after Gray)

the water. Now to follow the course of the blood it comes out from the capillary tuft, after being robbed of a portion of its water through a single vessel. This vessel again breaks up into capillaries which ramify in between the tubules forming what is known as the

### Inter-tubular capillaries.

These intertubular capillaries again unite to form a single vessel and this forms the rudiment of the Renal vein. It is while the blood is passing through the inter-tubular capillaries that the renal cells take up the salts and urea from the blood and add it to the water which has been already separated in the capillary tuft. So the blood which returns by the renal vein has been completely freed from the poisonous sewage of our body and is returned to the general circulation by means of the Inf. Vena Cava.

We have followed the stream of water through the kidney tubule and it at last reaches the pelvis of the kidney which is a cavity into which all the kidney tubules open. If the walls of the cavity were smooth there would not have been sufficient room for the opening of so many tubules. Hence the walls of this curiously shaped cavity is raised up into conical elevations. This increases the wall and floor area to such an extent that there is room for each tubule to have a separate opening.

Thus the urine which has been prepared in the kidney finds itself into the dilated chamber referred to above. From the lower end of this chamber runs down a long slender pipe of the calibre of a goosequill. This tube is called

the Ureter.

It conveys the urine from the kidney to

the Bladder,

there being, of course a separate tube for each kidney.

The ureter takes an oblique course through the muscular wall of the bladder so as to prevent the possibility of any return of the urine from the bladder to the kidney. The bladder is the receptacle for the urine and when the urine has collected in sufficient quantity, there pass up certain sensations and by our voluntary action the circular muscle which guards the opening of the bladder, relaxes, and the urine is voided. In certain nervous condition which generally affects young children, the control over this circular muscle is lost and these children are apt to wet their cloths and beds involuntarily.

Great fright and sudden emotion may cause the blood pressure to rise to such an extent as to cause a copious discharge of urine as clear as ordinary water ; because the unusual amount of water forced out into the tubule has very little time to absorb the poisonous substances from the blood.

### Urine.

It is a straw yellow coloured limpid liquid, weighing normally about one and one fortieth time the weight of pure soft water (specific gravity 1020). It has a peculiar mild odour and distinctly acid reaction. The urine is constantly being oozed out by the kidneys ; a healthy adult will pass between twenty four hours about fifty two ounces (about 500 c.c.), of urine, although the quantity and quality vary according to other physiological processes of life, the outer temperature, moisture etc. For example, as we have just now

said in summer when the skin of the body owing to external heat is filled with blood, sweating is profuse and so decidedly the quantity of urine is diminished. In winter when the skin is chilled and blood-vessels under it greatly contracted, the amount of urine is increased.

In infants the amount is 12-15 ozs. in 24 hours. The principal constituents of urine besides water is 2 percent Urea, 1 per cent of Sodium Chloride (common salt), a very little quantity each of the Uric Acid, Kreatinin, Hippuric acid, Ammonia, Sulphates, Phosphates etc.

Alcoholic stimulants and certain drugs in medical parlance known as *diuretics*, increase the quantity of urine but there is no definite proof that the poisonous substances of the blood are also excreted in greater amount. Even the drinking of a large quantity of water may so increase the volume of blood as to raise the blood pressure, producing an appreciable effect upon the amount of urine. This is specially true if the water is drunk slightly warm. There is no better diuretic in the world than a cup of tepid water. People are generally too much frightened by the colour and brightness of their urine. If they find their urine forming a deposit, they simply run for the patent medicine, the quack or wiseacre friends. A very slight sediment is apt to be deposited after normal urine has been kept for some time. There may sometimes be large quantities of this sediment. This does not signify, of course, in ordinary cases, any grave kidney disease. It is simply the result

of eating too much concentrated and delicious food, drinking too little water and taking very little physical exercise. All that the patient has to do is to cut short the rich dishes, and to drink sufficient quantities of pure water ( better, if lukewarm water is drunk in empty stomach and before sleep ) and to take someform of outdoor exercise. This correction of the patient's habits will rectify the defect which he thinks to be a grave kidney disease. There are no more potent remedies known to the doctor and the pharmacist for kidney diseases than big draughts of tepid water and a thorough fasting regimen from 3 to 5 days during a renal colic.

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## CHAPTER XX.

### *Head and Neck.*

#### LESSON I

#### Bones and Joints of the Head and Neck.

The head is one of the most important parts of the body. It contains the brain which is the seat of all consciousness and intelligence. The organs of sight, smell, hearing and taste are all situated in the head. Besides that, the head presents the openings of the nose through which enters the life-giving oxygen and is also furnishes the opening of the mouth through which we take our food that nourishes and sustains us. Such an

important part of the human body is the head. The head is divided into two parts.

### The Skull (cranium) and the Face.

The **skull** is a bony box which contains and protects the brain. The cranium is truly a wonderful structure, considering the protection it affords for its possessing a certain elastic quality. The arched or upper part of the skull is called the *vault*, whereas the lower portion is known as the base of the skull, being very irregular and provided with many projections and openings. The skull is composed of eight pieces of bone firmly united to one another, such as —

The Occipital bone.

2 Parietal bones.

The Frontal bone (*Forehead bone*).

2 Temporal bones (*the Temple bones*).

The Sphenoid (*Wing bone*).

The Ethmoid (*Sieve-like bone*).

8 in all.

The *Occipital bone* is situated at the back and partly also on the under surface of the skull. It joins below with the first piece of the vertebra and presents in its centre a big circular hole  $1\frac{1}{2}$  inches in diameter. Through this hole passes the oblong marrow (Medulla oblongata) which becomes continuous with the spinal cord that is contained in the spinal column.

The *Parietal bones* form the sides of the roof of the cranium.

The *Frontal bone* (Forehead bone) forms the

forehead and the prominence of the brows as well as a part of the sockets for the eyeballs. The forehead bone covers the forepart of the brain which is said to be the seat of intelligence. Hence we commonly find people saying "This man is very clever as he has got a very broad forehead." A broad forehead however not necessarily implies a clever brain but it is only a well-used brain that makes a man clever.

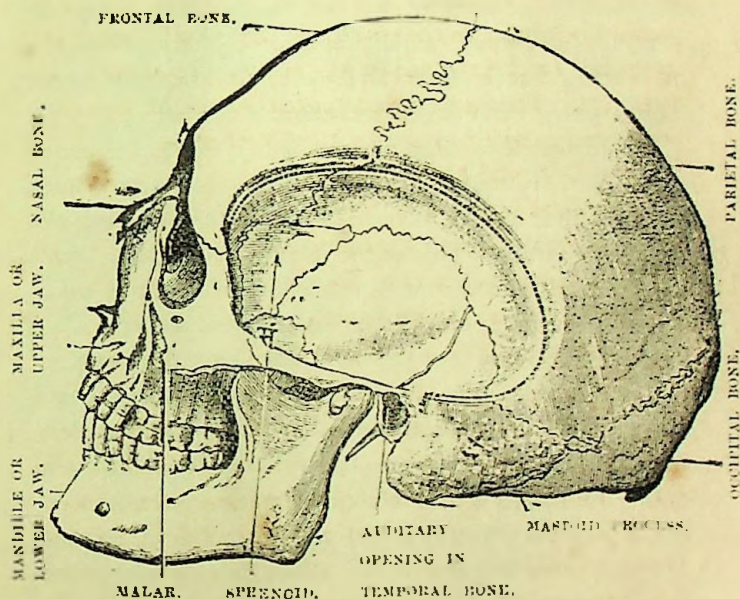


Fig. 53—Side view of the skull.

The *Sphenoid* (Wing bone) connects the different bones of the skull and is placed just behind the eyeballs whose sockets it forms. On the surface of the head the

position of the wing bone is near about the place where the hairs make their appearance on the temples.

The *Temporal* ( Temple bones ) form the portion of the skull which lies in front, above and a little behind the ear. The organ of hearing is lodged inside the temporal bone. It presents behind the opening of the ear, a stout process called the *mastoid process*.

The *Ethmoid* (Sieve like bone)—This is a very light bone which is situated at the roof of the nose. It presents numerous small apertures through which filaments of nerve enter the nose. It is these nerve filaments that carry smell sensation to our brain.

The diagram in Fig. 53 shows how firmly the bones of the skull are united to one another. Let the reader interlace the fingers of one hand with those of the other very firmly. This is the way in which the skull bones are interlocked with each other and the place at which they are joined like this is called a *Suture*.

If the skull bones of the baby were so firmly sutured with one another as in an old man, its little brain could not grow to its proper dimensions. Therefore, in very young sucklings the bones are only joined to one another by means of thin elastic membrane covered over with skin. So if you just feel the head of a six months' old baby, your finger will sink down at one place just behind the forehead bone ( See Fig. 54 ). It is not until the child is seven years old that the skull or brain-box is really hard and its component bones are fitly joined together. You will now understand why it is not only brutal but foolish to box a boy's ears or to

strike a young child on the head. At this time the bones are soft and scarcely strong enough to protect the brain.

One thing more regarding the baby's skull. You should never make the baby lie on the same side of the body always: for then, only one part of its head touches

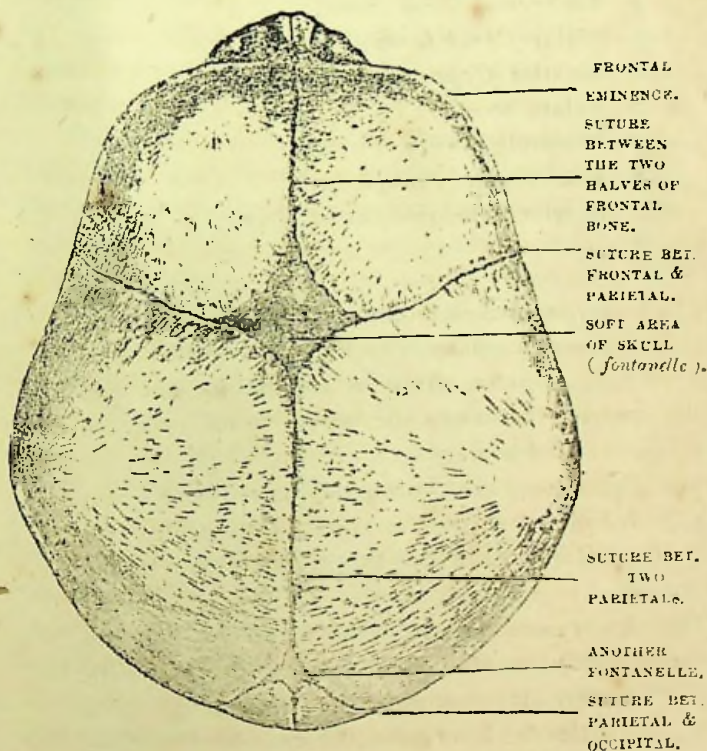


Fig. 54—The skull of the child viewed from the top.

the pillow. It might cause one side of its head to be smaller than the other and this would make a permanent deformity both in the baby's head as well as in its brain.

Coming to the **Face** it is composed of 14 bones in all. The following is a list of the bones of the face :—

- 2 Nasal bones.
- 2 Lachrymal (*Tear bones*).
- 2 Malar (*Cheek bones*).
- 2 Maxilla (*Upper Jaw bones*).
- 2 Palate bones.
- 1 Mandible (*Lower Jaw bone*).
- 1 Vomer bone (*Ploughshare*).
- 2 Inferior turbinated bones (*Scroll-like bones*).

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Total = 14

The reader is advised to learn the position of the bones of the face by reference to Fig. 53 as well as the diagram of the skeleton given in the frontispiece and also by studying the bones themselves in his own face or the face of his friend.

The *Nasal bones* are two small pieces of bone which form the bony portion of the nose. They unite with each other in the middle line thus forming the bridge of the nose.

The *Lachrymal* (Tear bones) can be felt by pressing deeply on the inner side of the eye with the little finger. It is grooved for the passage of a duct that carries the tears from the eyes to the nose. It is due to the flowing of the surplus tears down into

the nose that people who are weeping frequently blow their noses.

The *Malar* (Cheek bones) form the prominence over the cheek as well as the outer wall of the sockets of the eyes. These bones are connected with the temporal bones by means of a narrow arch of bone—the *Zygomatic arch*—the horizontal ridge which can be felt with the fingers just under the temples. They are very prominent in old and emaciated people.

The *Maxilla* (Upper Jaw bones) when they unite with each other, leave a central gap which is the opening of the nose. They also help to form the front part of the hard palate and they present the sockets of our upper teeth.

The *Palate bones* are placed behind the upper jaw bones at the roof of the mouth. They separate the cavity of the mouth from the cavity of the nose. In those people who have a cleft palate the two palate bones do not unite with each other and in them the mouth cavity communicates directly with the cavity of the nose.

The *Mandible* (Lower Jaw bone) resembles a horse shoe with its two extremities curved upwards. It presents the sockets for the lower teeth and it is the only movable bone in the head. It continually moves up and down during the process of mastication. It can also move sideways. It joins with the temporal bone of the skull to which it is united by distinct connecting bands. This *joint* is placed just in front of the opening

of the ear, hence in painful diseases of the ear we feel great pain in opening our mouth or chewing any solid food.

The Vomer bone (*Ploughshare*) is so called because it looks like that part of the farmer's plough that goes under the ground. It is a thin plate of bone that divides the nasal cavity into two halves. The greater this bone is developed, the more is the bridge of the nose well marked. A good sized vomer bone is therefore always associated with a large well formed nose.

The Inferior turbinated (*Scroll-like bones*) are very thin plates of ridgy bone which cannot be seen on the surface. It is placed in the inner region of the nasal cavity. It is situated there simply to expose a greater surface for the air that is entering the lungs by the nose. The more the air comes in contact with the warm mucous membrane of the nose, the more likely it is to be warmed so that the lungs will not be chilled by the cold or damp air taken in.

I have described to you the bones of the face. As no two faces in the world are exactly similar, so the bones of the face are not exactly similar to one another. Even it is possible, by studying the bones of the face, to say to what nationality the skull belongs. The bones of a Chinaman will differ from that of an Englishman, and the bones of a European will differ from that of a Negro.

The face has its elegance in art and painting. Still deeper features, however, are noticeable in the expression of the face. It is the image of the real man

that is inside the body. A strong upright character will shine through the beam of eyes and a cowardly dishonest soul will be disclosed from the repulsive appearance of the face. But we should not be guided too much by the face, for who knows that there may not be a serpent underneath the rose ?

The bony framework of the *neck* is formed by the upper vertebræ of the spinal column. As these vertebræ are situated in the region of the neck they are called cervical (from *cervix*=neck) vertebræ. The first cervical vertebra is called the **Atlas**.

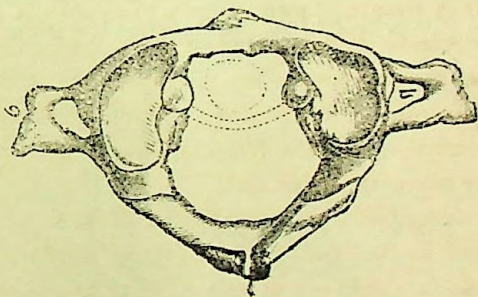


Fig. 55—The Atlas or the First Cervical Vertebra.

This is so called because it supports the globe of the head ; for, Atlas, you should remember, was the name of the mythological giant who was supposed to carry the earth on his shoulder.

Fig. 55 shows the shape of the Atlas as viewed from

above. It is a ring-like bone. The aperture of the ring is divided into two compartments by a transverse band of fibres (marked in the figure by dotted lines). In the back large compartment is lodged the oblong marrow or the *Medulla Oblongata*, while the small front compartment shown by dotted lines is meant for a bony process of the second cervical vertebræ called the

### Pivot or Axis Vertebra.

The diagram (Fig. No. 56) shows the Pivot vertebra from the side. It is on the pivot that the ring of the atlas and along with it the head to a great extent rotate. But extreme rotation is prevented by strong ligaments stretching from the pivot. The Pivot vertebra, as has been said before, occupies the front compartment within the ring of

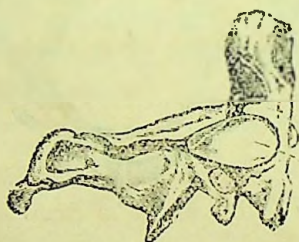


Fig. 56—The Axis or the Second Cervical Vertebra.

the atlas and so it lies just in front of the oblong marrow. It is, however, not allowed in any way to press on the oblong marrow as it is separated by means of the trans-

verse ligament. In the modern method of hanging, this transverse ligament is torn asunder and the pivot strikes against the oblong marrow which is the seat of all the vital functions of the body and hence the person meets with instantaneous death.

The other neck-vertebræ have a shape like that shown in the Fig. 57.

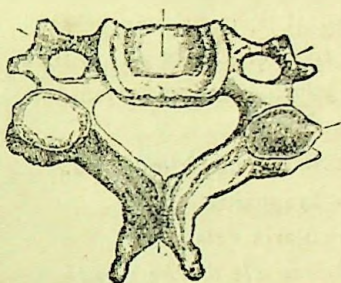


Fig. 57—A Cervical Vertebra.

The vertebræ are united with each other by bands of fibrous ligaments, Each of them having a central cavity called foramen (as said before), when placed one upon the other forms a canal, through which the Spinal Cord passes. In the neck the vertebræ are very freely moveable so that we can twist our neck in all possible manner.

CHAPTER XX. (*Contd.*)*Head and Neck*

## LESSON II.

## Muscles.

There are so many muscles in the head and neck that I think, it is quite unnecessary for the readers of this book to learn about all of them. So I shall only describe to you the few important ones. They are :—

- |   |   |              |
|---|---|--------------|
| 1. Splenius.  | } | In the neck. |
| 2. The Sterno-cleido-mastoid.                                 |   |              |
| 3. The Trapezius.   |   |              |
| 4. Orbicularis oris.<br>( <i>The muscle of the mouth.</i> )   | } | In the face. |
| 5. Orbicularis oculi.<br>( <i>The muscle round the eye.</i> ) |   |              |
| 6. The Masseter.  |   |              |
| 7. The Temporalis.—In the region of the temples.              |   |              |

The *Splenius muscle* arises from the large ligament—Ligamentum Nuchæ that passes down the back of the neck over the spine and proceeding upward from the last cervical and the upper six dorsal vertebræ, broadens on the way upward. As it broadens, the Splenius divides into two broad band of associated muscle (near the sixth cervical), called the *Splenius capitis* and the *Splenius colli*, the former having its insertion at the Temporal bone over the ear, while the latter at the second cervical

TEMPORALIS.

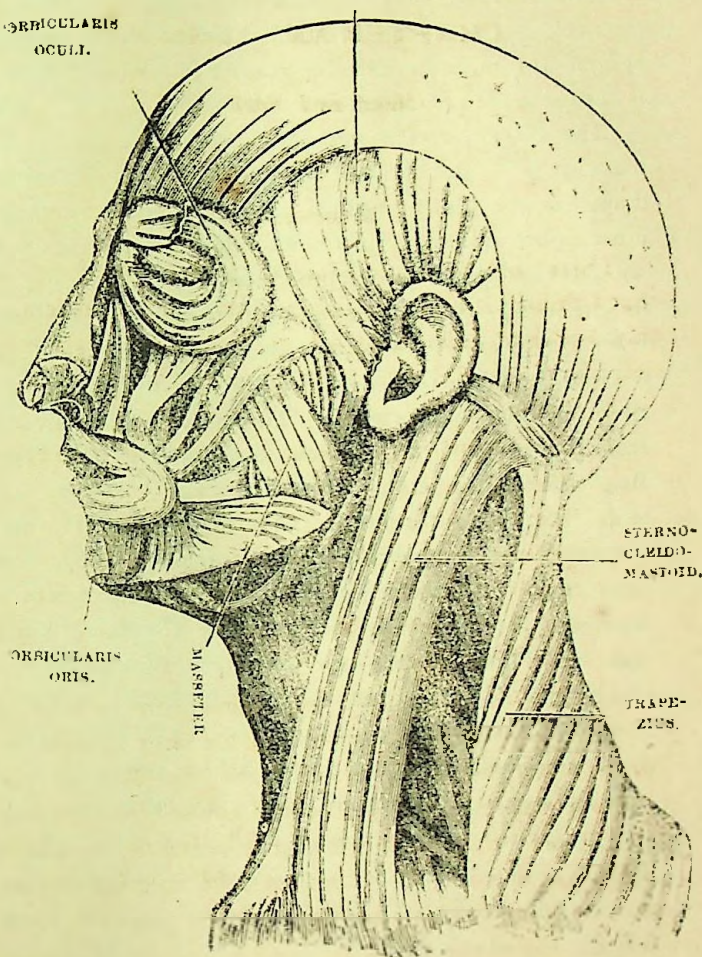
ORBICULARIS  
OCULI.

Fig. 58—Diagram showing the principal muscles of the Head and the Neck.

vertebra. They may be easily felt on the back of the neck between the Mastoid muscle and the cervical spine. Its motions can be readily felt when the head is turned aside or nodded in front.

The *Sterno-cleido-mastoid* muscles—what a big name it is! But I shall tell you what significance the name has got. But first of all you should know where the muscles are situated. Just bend your head towards your shoulder and you notice a prominent muscle standing out on either side of your neck and this prominence extends from the lower depressed portion on the front of your neck to the back of the ear. This is produced by the Stern cleido-mastoid muscle. The muscles run obliquely from both sides of the neck downward to the front. At the centre they are thick and narrow and feel like ropes beneath the fingers. At each extremity they are broader and thinner. They arise both from the front part of the head of the Sternum (breast-bone) and from the Clavicle (collar bone). This accounts for the two words *sterno-cleido*. What does the third word stand for? It must be their place of insertion and it is so. It is a projection of the temporal that is behind the ear. Thus from the name of the muscle you get a clue to the origin and insertion of the muscle, and therefore lengthily though the name may be, it conveys to you in a concise form a lot of ideas. This muscle bends the neck towards the shoulders.

The *Trapezius* is a muscle which is situated in the back. It is so called because the two *trepezius*

muscles of the two sides which are united in the middle, from a sort of trapezium, or a diamond-shaped quadrilateral, two angles corresponding to the two shoulders, a third to the protuberance on the occipital bone and the fourth to the spinous process of the last vertebra of the thoracic region. The insertion is on the clavicle and on the acromion process of the shoulder blade. The end of the muscle at points of origin and insertion are found in tough tendons. The trapezius muscle bends the neck backwards to one side, if only a single muscle is acting. When however both the muscles are acting together, they bend the neck directly backwards. In lifting or pulling, the trapezius plays an important part.

*Orbicularis oris* (The muscle of the mouth)—This is an elliptical muscle that surrounds the aperture of the mouth. It thus contributes to the formation of the upper and lower lips. Many other muscles of the face blend with the fibres of the *Orbicularis oris*, and so when this muscle acts, it acts against all the other muscles which converge towards it. Its main action is not to close the lips directly.

*Orbicularis oculi* (The muscle round the eye)—This is a sphincter muscle and consists of concentric loops of muscle fibres which surround the eye-ball. The portion of this muscle which enters into the formation of the eye-lids closes the eyelids involuntarily. When the rest of the muscle acts, it draws the skin of the forehead, temple and cheek throwing the skin into numerous folds and forcibly closing the eyelids.

*The Masseter* (Masticating muscles)—This is a thick quadrilateral muscle situated a little in front of the ear. Press your teeth against each other as if biting at a very hard substance and you will notice an almost quadrilateral prominence stand out over your lower jaw bone a little in front of the ear. This is produced by the contraction of the masseter muscle. Masseter is thus a muscle of mastication or chewing. Each time you chew your food you are making your masseter muscles act.

*The Temporalis* (Temporal muscles)—This is another muscle which is employed for the purpose of chewing. It covers the bone of the skull, all over the temporal area. If you place your finger over the temporal area and make movements as if you are chewing something then you will feel a little elevation each time the teeth strike against each other. This elevation is produced by the thickening of the muscle as it contracts during the process of chewing.

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## CHAPTER XXI.

### *The Nervous System*

#### LESSON I.

General features—Coverings of the Brain.

To-day we begin the most important and interesting part of our story—the Nervous system. The Nervous system as is known, consists of the brain, the spinal

cord, all nerves and nerve-cells in connection therewith. It is closely and mysteriously connected with every movement, with every sensation and with all the physiological processes of the body. To be more terse but explicit,—like the government of a country, it is an organisation whose only function is to control the affairs of the human body. This controlling system is developed, more or less in all the higher animals, being absent in the lowest types of living beings. In man, the development and organisation of this controlling system reaches its maximum. With the progress of civilisation and culture, the nervous system in man has gradually been developed into perfection. The aim of education has been to make this organisation work more smoothly and with greater regularity and precision than it does work in a savage's brain.

Two nervous systems exist in the bodies of all back-boned animals. The more important of these two systems consists of the *Brain* and *Spinal cord*. This may be described as the main line of the nervous system, lying protected within the skull and the spine and the *nerves* that issue out from the brain and spinal cord are the means of communication between this central nervous system and the human body with its environments.

The second system is known as the *Sympathetic system*. This consists of two strands of nervous tissue lying one on each side of the spine. This latter system, although it is a separate system is still connected at certain points with the brain system of nerves.

The presence of two separate nervous systems brings us into the question of division of labour in the human body. The brain system controls all those functions which are specially associated with voluntary movements and the exercise of the will. In other words, the power of doing as we like, depends upon our possession of this nervous system. Thus the commands which the brain sends out are capable of being executed by the different organs of the human body ; whilst in the same way information conveyed by the senses from the outer world to the brain can be appreciated, and if necessary, the body may be accordingly acted upon. To give you a concrete example, say, you see a poisonous snake running towards you, your sense of sight at once informs your brain of this matter. Order is instantaneously sent out from the brain to the various muscles of your body and specially to your feet and you at once run away from the vile serpent as fast as you can.

The sympathetic system on the other hand may be designated as the "*involuntary*" nervous system. It cannot be directly brought into play by the exercise of the will but can be stimulated indirectly. Thus, say, when you take some food into the stomach, the organ makes some movements and contractions and these are controlled by the sympathetic system. We shall speak more fully about the functions of the sympathetic system later on.

After you have learnt this much about the nervous system, I shall tell you how this delicate system is protected from external violence and injury. The brain

is enclosed in a hard bony box called the skull and the spinal cord lies within the canal of the vertebral column. The skull is further protected by a thick layer of skin and muscles and the hair which grows so luxuriantly over one's head is an additional protection to the brain under the bony skull.

On the inside of the skull there are three coverings which protect and cover the brain surface. They are

1. *The Dura Mater.*
2. *The Arachnoid Mater.*
3. *The Pia Mater.*

We shall talk about each one of these coverings separately.

### The Dura Mater.

The *Dura Mater* is a very tough membrane, either side of which is different. The side which touches the skull bones is rough and uneven. It clings to the inner surface of the skull bones forming, as it were, a undulating lining for them. On its other side, *i. e.*, the side which is towards the brain, it is glistening and very smooth. The *Dura Mater* dips in between the two halves of the cerebrum as well as between the other divisions of the brain and these lend a great support in keeping the brain in position.

### Arachnoid Mater.

The *Arachnoid Mater* is a very delicate network of connective tissue. It is loosely spread over the brain surface like a spider's web. Beneath the arachnoid is a

fluid which much resembles serum. This is the *cerebro-spinal fluid*. If by any accident the head receives a stunning blow, this fluid will go some way to prevent the brain from feeling the shock of it. In a disease called *Meningitis* or the inflammation of the meninges (the brain coverings), the cerebro-spinal fluid is increased in amount due to an exudation from the inflamed meninges. The fluid being heavier in quantity therefore presses hard against the brain and some of the symptoms of the disease are due to this pressure of the cerebro-spinal fluid. Underneath the arachnoid is the third covering called

### The Pia Mater.

The *Pia mater* is the innermost lining of the brain and it covers the brain surface completely. It is a membranous sac resembling in its formation the pleura of the lungs. The surface of the brain, however is not flat, but it is raised up into elevations which are separated by intervening clefts. These elevations are called the *convolutions of the brain*. The *pia mater* covers each convolution individually dipping in between the clefts that separate it from neighbouring convolutions. As the *pia mater* so closely invests the brain area, it carries with it the vast network of blood vessels that are intended for the supply of the brain surface.

The spinal cord which is situated within the canal of the vertebral column is also covered by the same three coverings as the brain. The nerves as they

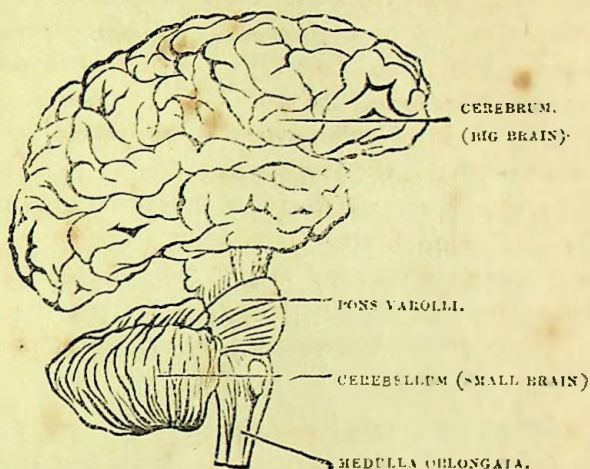


Fig. 53—Side view of the big brain, the Cerebrum with its convolutions, separated from the rest of the brain.

emerge from the brain or the spinal cord, have to come out after piercing these membranous sacs and in doing so, they derive a sheath from them.

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CHAPTER XXI (*Contd.*)*The Nervous System.*

## LESSON II.

## The Neurons and the Nerves.

The whole of the nervous system is made up of a collection of cells which have some special characteristics of their own. The cells which make up this complex nervous mechanism of our body resemble the ordinary cells of the body in containing some *protoplasm* and a *nucleus*. But the difference is that in this case fine processes are given off from the cells. The nerve cells having varying number of processes are accordingly called unipolar, bipolar and multipolar. The cell itself is granular and besides having protoplasm and nucleus, it has a great number of fine fibrillæ passing across it.

Below in the diagram (See Fig. 60) are shown some of the nerve cells with numerous branching processes which resemble very much the branches of a growing tree. The *nerve cell* with its branching processes form the units of our nervous system and they go under the special name of a

## Neuron.

A neuron therefore consists of two parts—the nerve cell and its branches. Many of these branching processes are short, only one being much longer than the others. The short processes resemble the branches of a shrub and so we shall call them

### The Dendrons (*shrub-like processes*).

The dendrons of a neuron touch with the dendrons



Fig. 60—Diagram showing two nerve cells with their branching processes.

of other cells in the neighbourhood in all sorts of artistic manner, though unfortunately we cannot see these things unless we stain them on a slide with particular dye-stuffs and observe them under the microscope. Each neuron is discontinuous or has no anatomical continuity with other adjacent neurons. The smaller branches of a dendron is called *Dendrites*.

The long process that comes out of a nerve cell is called

### The axon.

The axon is a very long process and it forms the axis cylinder or main portion of a nerve fibre which is nothing but the axon of a nerve cell enwrapped in a special sheath. To the description of the nerves we shall revert later on.

The neuron is the conducting apparatus for a nerve impulse. Just as the tram-car wires conduct electricity, so these neurons also conduct a nerve impulse. The electricity which is conveyed by the tram-car wires is generated at the power house of the tramways company. The nerve cells are the local *power houses* where a nerve impulse is generated. Suppose you want to move your arms ; at once the power house in the brain starts working. Some sort of nutritive changes takes place in the nerve-cells of the brain and this causes a nerve impulse to be sent down from the brain. The nerve impulse travels from the brain along a nerve and this nerve ends in the spinal cord by coming in contact with the dendrons of another nerve-cell situated there. These dendrons now take on the nerve impulse and transmits it along the axon which starts from the nerve-cell in the spinal cord. This axon comes in contact with the nerves that supply the muscles of the arm and thus the nerve impulse which has been generated in the brain ultimately reaches the muscles via the contiguously arranged neurons, and the muscles readily make the necessary contractions and the arm is accordingly moved.

In order that there may not be any anomaly in the passage of nerve impulses within the nervous system, there must be some fixed direction in which the nervous impulse must travel in a neuron. This direction is from the dendrons towards the cell and then from the cell along its axon. So in a complete neuron the dendrons always form the receiving instruments and the axons the discharging process. So the dendrons are the "receivers" in a telegraph office and the axons are the "transmitters" *i. e.*, instruments which send out messages. And the local telegraph office itself is the nerve cell. The telegraph office has to receive messages as well as to send them out, so the nerve cell also receives its impulse through the dendrons and sends it down along its axon. What actually takes place inside the nerve cell, and how the nerve cell can generate a nerve impulse or can transmit the impulse which it has received through its dendrons to its own axon—of all these things we are nearly in the dark. We are simply guessing this or that, giving this example or the other, to make you understand how complex is the subject of our nervous mechanism.

We have constantly referred in this lesson and sometimes also in previous lessons to the term, **Nerves**. I shall presently tell you what nerves are like. Nerves are generally white strands of fibres which are very glistening and soft to the touch. They will, if minutely examined be found to consist of finer threads of the thickness of cotton fibers. Each thread would appear something like a very tiny glass tubule filled with oil.

If you go to some harbour or port, things which attract your notice most, are the big steamers and sea-going vessels standing calmly over the flowing stream of water. You may also see one of the big cables by which the ships are fastened to the piers. A nerve resembles very much the big cable, in as much as the cable though it seems to be a single rope, consists of many strings each lying side by side or intertwining each other.

But a greater similarity exists between a nerve and the telegraph cable which carries messages from one part of the world to another under the vast oceans. The telegraph cable like a nerve is composed of many strings. Deep within the strands of the cable and covered up on all sides, is a metallic wire that carries the messages. A *nerve fibre* similarly consists of a central portion which carries the nerve impulse or the messages to and from the brain and an outer portion which has the function of protecting and nourishing the central conducting core. In the case of a white nerve fibre, found mostly in the cerebro-spinal system this outer sheath is very well developed and is differentiated into two distinct sheaths. A nerve fibre, therefore, consists of three parts:—

1. The **Central part** (*axis cylinder*)
2. The **Medullary sheath** or **Sheath of Schwann** surrounding the central part.
3. The **Primitive Nerve-sheath** or **Neurolemma** surrounding the whole nerve-tubule.

The **Central part** (*axis cylinder*) of a nerve cons-

titutes the essential portion of a nerve fibre. It is one of the long processes of a nerve-cell situated in the brain or somewhere in the cerebro-spinal system. The impulse or nervous force which is generated in the nerve cell from which the particular axis cylinder arises, is carried along this central part to its point of destination. Every moment of your existence some nervous impulse is flitting forth along some of the nerve fibres of the body, in the same way as telegraphic messages are incessantly being sent from one part of a civilized country to another. As the

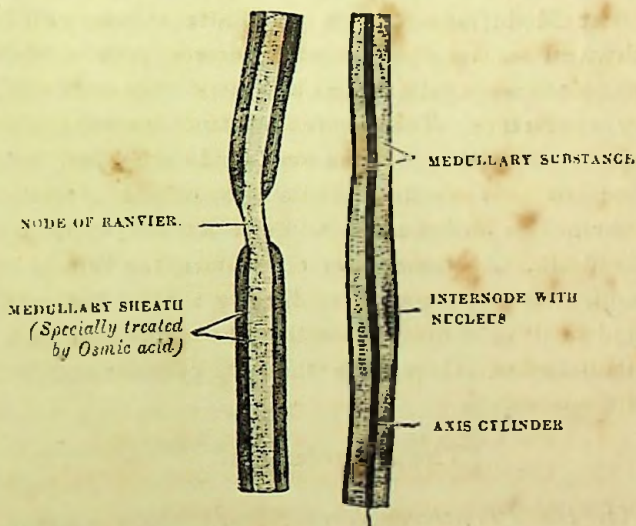


Fig. 61—Lengthwise sections of nerve fibres treated with special stuff.

telegraphic messages and despatches of a civilized government make its constituent parts and work in harmony with the central governing head; so the nerve impulses which are travelling up and down the nerves of our body and regulating every bit of work that is being performed by any muscle, or any gland or any other organ situated anywhere in this human body are constantly originating from or controlled by the Brain—centre of all nervous activities, the so many nerve units, ganglions and plexuses as sub- or branch offices acting under it. The axis cylinder processes are the immediate agents in the transmission of these nervous impulses.

**The Medullary Sheath or White substance of Schwann** makes the ordinary nerves look white, whereas the nerve cells and its processes have distinctly grey appearance. This white substance protects the central Axis cylinder. It is semi-fluid during life, but coagulates after death and said to consist of fatty matters. It is absent at the Nodes of Ranvier, specially after death. At these nodes of Ranvier, the Primitive sheath, therefore, comes to lie directly against the axis cylinder. It is at these nodes that the nerve fibre give off its branches. Over both the Axis cylinder and the white substance is

### **The Neurolemma.**

*Or the Primitive Nerve Sheath* which is a very thin homogenous membrane.

If by any accident the axis cylinder is cut or injured, no more impulse can travel along the nerve

and if this nerve is going to an area of skin, that portion of the skin loses its sensibility or if that nerve is going to supply a muscle, then the muscle will no longer be able to contract under the influence of the will, and will thus be paralysed.

Only that portion of the nerve which is away from the nerve-cell of origin will degenerate, but the portion which remains attached to its cell of origin will remain intact and healthy. This process of degeneration lends support to the view that the nutrition of a nerve-fibre is intimately dependent on the cell of origin. As there is a process of degeneration in the life arrangement of the nerves, so there is also a process of regeneration in which the axis cylinder again grows out, generally following the course in which the degenerated portion of the nerve fibre ran. Thus after an injury to a nerve, it has been found to be restored to its previous condition after a few days or weeks. In paralysed conditions of some limb or some particular muscle, it is customary to apply electric currents. The reason is this. The muscle which has been deprived of its nerve-supply, no longer contracts and if it has nothing to do for a long period, it becomes very dull and even when its nerve has been restored to its previous condition, it may fail to contract. The electricity itself being a stimulus for the muscle, will restore it to its former working order; so that by the time its nerve has become regenerated, it will be in a fit condition to respond to natural impulses reaching it along its nerves normally as before.

It will not be out of the place to mention here that the body is really an electric machine. The life and vitality that it possesses are electrical in nature. The impulse that comes to any part of the body, which is the cause of activity in that particular part, comes from the brain through the nerves by some force very much similiar to electricity. In fact electricity has been externally applied to the muscular tissue of animals that have been dead for some time and the muscles have, to a certain extent, manifested action similiar to that which they would while alive.

The nerves have to carry on the work of messengers. In all parts of the body are to be found these nerves—not only in the limbs, the trunk, the face and the neck, but also in the glands, the heart, the lungs and in fact in every minutest organ of the human body. Each organ of the body has therefore its respective messengers to keep it active, well-informed and up-to-date.

There are two classes of messengers, one class of messengers engaged in reporting to the brain what is taking place in a particular part of the body and the other class has the duty of serving the orders of the brain to the organs. Thus we have to distinguish between two kinds of nerves:—

1. *Afferent* nerves. 2. *Efferent* nerves.

The *afferent* (from *ad*=towards, *ferro*=to carry) nerves carry impulses or messages derived through the five senses from the outside world towards the brain; whereas the *efferent* nerves are those that carry the

messages or the orders of the brain to the different parts and organs of the body.

Somebody treads upon yours toes and you at once remove your leg. "What is it that causes you to remove your leg?"

"Why, because I see that some one is treading upon my toes?"

"But even if you had been asleep you would have done so and why?"

It is your afferent nerves that have carried the news as sensation of pain to your brain and your brain has at once sent out an order through the efferent ones "move the leg away." It is an efferent nerve which comes from the motor region of your brain that has carried the impulse via the spinal cord and then along a nerve issuing from the spinal cord to the muscles of your leg. They have in obedience to the order of the brain responded to its commands and thus the motion of your leg has been produced.

Any stimulation in the afferent nerves causes a brainward propagation of some sort of molecular excitement which physiologically affects the brain, and any stimulation of efferent nerves causes some sort of molecular excitement which is conducted in a direction away from the brain to produce some physiological effect in some more peripheral part. The physiological effect of the afferent nerve is sensory and that of efferent ones is very often motor, so they are also called *Sensory* and *Motor Nerves* respectively.

Generally the afferent and efferent nerve-fibers are

contained in one nerve trunk. When this is the case, the nerve is called a **Mixed nerve**. Almost all the nerves of our body are mixed nerves.

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## CHAPTER XXI.—(Contd.)

### *The Nervous System.*

#### LESSON III.

##### The Spinal Cord—Reflex action.

In the last lesson, we mentioned how you remove your leg when it is trodden down by somebody's boot. The sensation of pain caused by the pressure of the boot was carried by a set of nerves which carry sensations from the outside world to the central nervous system. The afferent nerves, as these are called, carried the sensation of pain to the brain. But it did not go directly to the brain, for it has first to enter the spinal cord and through the spinal cord it travels up and then through different portions of the brain and ultimately it reaches the big brain with its convolutions—the Cerebrum, which is practically the central government or king's cabinet. It is after the nervous impulse carried up by the afferent nerves have reached the cerebrum that we actually *feel* pain. But the sensation of pain seems to come on almost instantaneously and so we cannot imagine how it is

necessary for the nerve impulse to travel up through such a complicated structure before we can actually get any painful sensation. If you did, however know how fast these nerve impulses travel up and down the nerves, then you would have no difficulty in reconciling these two facts which now seem to you to be quite impossible. The rate at which a nerve force passes along nerve fibres has been estimated in warm-blooded animals at more than 200 feet per second. This is a very slow rate as compared with that of electricity or the speed of high air-waves which pass thorough space at a rate of 186,008 miles per second.

The poet's following lines, *viz.*—

“How fleet is a glance of the mind!  
Compared with the speed of its flight,  
The tempest itself lags behind,  
And the swift-winged arrows of light....”

are, therefore, to be accepted in a relative sense only, for it has little to do with the actual velocity of a nerve impulse.

Still the rate at which our nerve force speeds along nerve fibres is quite sufficient for the perfect carrying out of the work of the nervous sytem.

Once the painful sensation has reached the brain, the brain-cells send out orders to different muscles of the body and these orders are manifested by the moving of the leg and also by a screaming voice that makes the man who has trodden upon your foot, start and spring up. The orders of the brain,—how are they going to reach the different muscles? No doubt, the efferent

nerves act as the couriers carrying the news of the brain. But these efferent nerves also have to travel down the spinal cord before they reach the muscles which are to be thrown into contraction.

We all know by this time that the muscles do not and cannot act of themselves, but only through the nerve-impulses transmitted from the brain, and we can scarcely avoid the conclusion that the actual power which operates in these muscular tissues is nothing short of an electrical power or dynamic energy which comes from the spinal cord and the brain which serve as a storage battery, and which, when partly exhausted, is much regained through the building up and rejuvenating process of sleep. The oxygen of respiration carries with it an electrical charge, which then carried through all the tissues of the body by the blood is absorbed by millions of nerve fibers permeating every tissue and stored away in the spine.

The spinal cord is a collection of nerves in the interior of which are to be found some nerve-cells too. It begins above at the brain near the Medulla oblongata. It is fully 17 inches in length in the adult and often weighs as much as  $2\frac{1}{2}$  ounces. It extends from the base of the skull where it connects with the brain through the Medulla to the upper border of the small of the back, where it terminates in a number of nerve fibers which pass down the balance of the spinal canal, below termination of the spinal cord. The shape of the spinal cord



CEREBRUM

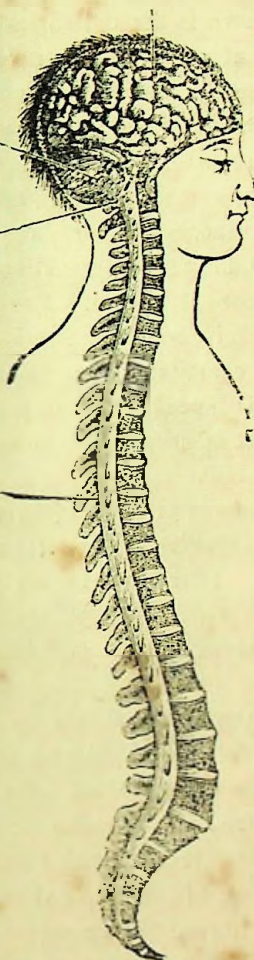
*(Fore brain or big brain)*CEREBELLUM  
*(Small or hind brain)*MEDULLA OBLONGATA  
*(Oblong marrow)*SPINAL CORD  
WITH SPINAL NERVE  
TRUNKS.

Fig 62—Diagram showing the brain and spinal cord.

varies considerably according to the part of the backbone and the foramen of the vertebræ it occupies.

The spinal cord is the cylindrical tail like part of the cerebro-spinal system. It is invested by the same three membranes as the brain and is encased along with its membranes inside the canal of the vertebral column. If you just try to think of a vertebra, you will remember how it presents a pretty big hole called *foramen*. The successive vertebræ placed one over the other thus contain a long canal and it is in this canal that the spinal cord is lodged. The material of which the spinal cord is constructed, is exactly the same as that which constitutes the brain, the particulars of which I will speak to you presently. In short, the cord consist of grey matter in the centre and white substance externally.

In Fig. 62 you see 31 nerves (only trunks of which are represented therein) issuing out from one side of the Spinal cord. There are in all 62 Spinal nerves. 31 for the right side and 31 for the left side. A pair of these nerves come out between each one of the vertebræ.

Each one of these spinal nerves is attached to the spinal cord by two roots placed on the same level but one behind the other, called :—

*Anterior root* (front root)

*Posterior root* (back root)

The two roots of the spinal nerve contain two different kinds of fibres. The anterior root consists of efferent fibres. The posterior root consists of afferent

fibres. Or, to put in more plain terms, the anterior root conveys the orders of the brain to the periphery (*motor* action), whereas the posterior root carries information from the periphery to the brain (*sensory*).

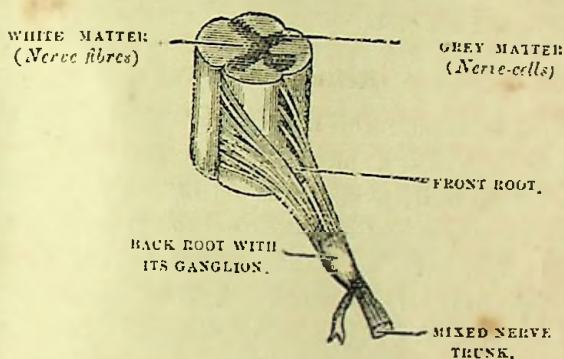


Fig. 63—Segment of the spinal cord showing the two roots of a spinal nerve.

In the above diagram is shown a segment of the spinal cord which shows how the two roots are attached to it. Shortly after coming from the spinal cord the two roots unite to form a single Nerve trunk. From the trunk it again splits up into bundles of nerve-fibers which are distributed to every tissue of the body. After a nerve reaches a tissue, it splits up again in separate fibers and each of these proceeds to the special part of the tissue which it is intended to serve. Here at its final end, there is a specialization of the nerve fiber, called *Terminal end organ*, which may be compared to the terminus of a telephone line.

This end organ has three special pieces of work to perform: to communicate energy of motion to either voluntary or involuntary muscular tissue, to receive sensations of feeling and pain and to recognize perceptions of special sense, such as—light, heat, sound, smell and taste.

### Reflex action

What is meant by this expression? Shortly speaking, by *reflex action* we mean those actions which take place involuntarily without the aid of the will or consciousness whose seat is in the cerebrum (fore brain).

How does such an action take place? The nerve cells, we have already mentioned, are the small power stations of our nervous system. Some of these nerve cells when grouped together at one place form a *Nerve centre*. These nerve centres are situated both alongside the spinal cord and the brain. These centres can act

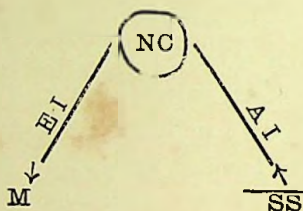


Fig. 64—Diagram representing a Simple Reflex act.

SS.—A sensory surface in connection with an afferent nerve from which afferent impulse (AI) is travelling towards the Nerve-centre (NC). The nerve-centre translating it into an efferent or motor impulse throwing it to some muscle, muscular tissue or sometimes a gland.

without the command of those other cells of the cerebrum which are really actuated by our volition or will. Thus, when any afferent impulse reaches such an independent nerve-centre, the impulse is, as it were, reflected back to the periphery through the efferent channels, almost exactly as a ray of light is reflected back from a mirror.

Somebody takes a stone in his hand and makes such a posture as if he is going to throw it at you and at once you shut your eyes. Your eye informs some of your nerve-centres in the brain of the possible danger, and from these nerve centres the impulse is passed to the muscle that surrounds your eye and involuntarily you shut your eyes. Involuntarily, I say, because the afferent impulse which was carried through the eye has not to go by round about ways to that portion of your brain where the seat of sensation is located, but it goes directly to some of these independent nerve-centres that send out like a District Magistrate the necessary orders without consulting the Governor of a brain. This is a *Simple Reflex*, as only one muscle is affected in this case.

Similar when you are hungry and you see some delicious food, your mouth begins to water. Your salivary glands have been reflexly stimulated in this case, the afferent impulse having passed up through the nerves of smell and the efferent impulse having been sent back by those nerve-centres that make the gland secrete. This is also a simple reflex.

In the case of the child that screamed and cried and ran about, after she had put its hand on the hot kettle,

the act was of a reflex nature, but it was a case of *purposeful act*. The child screamed and cried in order that her mother would come to the rescue and she ran away in order to avoid the hot kettle and the pain attending upon its touch. So in all the actions of the child there was an underlying purpose.

Somebody tickles you, and if you are a little ticklish, you will atonce jump up and shrug you shoulders and in fact bring every muscle of your body into action. Though the stimulus is from a very limited area of the skin, still it is so effective as to cause all the muscles of the body to contract. This is called a *Convulsive Reflex*. Such reflexes are very common in Strychnine poisoning and in Hydrophobia. A slight noise, a mild breeze will throw a person poisoned by Strychnine or Nux Vomica into a convulsion.

I have just now said that if you were ticklish, you would jump up, and shake your sides with laughter and make all sorts of grotesque movements. But there are some persons who can sit quiescent even if you tickle them as hard you can. They can control the natural reflex movements, and this control is effected by impulses coming from the brain. These impulses put a check on the ordinary actions of the Spinal cord. If by any accident the spinal column is broken and the spinal cord contained within it, is injured, then the impulses which are ordinarily sent down from the brain to control and check the affairs of the spinal cord, do not come into play and the spinal cord thus severed

from its controlling centre shows its activity in exaggerated reflexes. If you tickle a normal man on his sole, perhaps the only effect will be slight bending of the toes. But once there happened to be a poor mason who fell from a high scaffolding as he was laying the bricks and he broke his vertebral column. He had to be at once removed to the hospital. While he was in the ambulance car, some of the attendants, accidentally touched his sole and he kicked out forthwith. His spinal cord had become too stimulant to tickling reflexes by being severed from the control of the brain. So we find that in man the spinal cord is in most cases subservient to the brain.

What takes place in alcoholics? Their condition is something like that of the poor man who had fallen from the scaffolding. You know a slight amount of alcohol, brandy or wine makes people too much rowdy and boisterous. The cause of this rowdiness is to be found in the depression of the higher centres *viz.*, the centres for self-control—located in the brain. Centres for judgment, perception, discrimination, civility, agreeableness, eventuality, order and calculation which are situated in the front part of the Cerebrum—these are depressed by wine; so they cannot exert their controlling influence over the lower centres of the brain or of the Spinal cord. These being set free from cerebral control, act in whatever way they like.

There are certain centres in the lower part of the

spinal cord which regulate the functions of the bladder, rectum and sexual organ. In injuries or diseases of that region of the spinal cord, the functions of the above organs become deranged.

Some important examples of reflex act are given here: (1) Contraction of iris or the brown spot on the eye—little smaller than a two anna bit, (2) Winking, (3) The first respiration after birth, (4) Secretion of the saliva, (5) Sneezing from a draught of cold air, (6) Swallowing, (7) Vomitting from tickling gullet etc.

Some reflex actions are performed without our consciousness as the contraction of the pupil; others are attended with consciousness, such as—winking or swallowing. Some reflex acts can be controlled more or less by will, such as—coughing, sneezing or passing of urine; a few others are entirely beyond our control. The rapidity with which a reflex act is performed varies from  $\frac{1}{28}$  to  $\frac{1}{17}$  of a second; the stronger the stimulus applied, the shorter will be the time.

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## CHAPTER XXI. (*contd.*)

### *The Nervous System.*

#### LESSON VI.

#### The Brain and its Divisions.

That portion of our central nervous system which is enclosed within the cavity of our skull is known as

the *Brain*. The brain is a very insignificant and undeveloped in the lower vertebrates, namely the fish, frog, the lizard or the bird. In the mammals, as for examples—the sheep, the cow, the goat, the horse, etc., the brain attains a greater development, but still it does not come up to the brain of man. The brain of the higher apes, gorillas, orang-outangs etc., resemble very much the brain of a man. But still the human brain is more highly developed and more complex than the brain of the highest types of monkeys. It is on account of this remarkable development of his brains that man has been able to take the lead over all animals in the creation of God.

The weight of the brain of an ordinary individual averages about 46-49 ounces. But in those intellectual people who have thought much or who have given their brains a good deal of exercise, the brain may weigh even 55-60 ounces; while in an idiot the weight of the brain may be as little as 18-23 ounces. The greater mass of the brain is formed by the *Cerebrum* with its convolutions. Still the other parts of the brain, though they may not be as bulky as the cerebrum, are nevertheless as vitally important as it is.

To understand the different portions of the brain, it would be better for you if I tell you something about its development from the *fœtus* to the adult.

The whole of our brain and spinal cord is represented only by a slender and delicate tube situated at the back of the back-bone in a *fœtus* of a month. The portion of this tube which is towards the head of

the foetus gradually swells up and this swollen portion of the tube is subsequently divided off into three *vesicles* or hollow balls. These three hollow balls represent the three chief portions of the brain. The ball which is placed foremost will develop into

*the fore-brain,*

and the ball in the middle will grow out to form

*the mid-brain,*

and out of the ball which is situated at the back of the former two will be developed into

*the hind-brain.*

The hind brain becomes continuous lower down with the spinal cord.

The developed brain of an adult can therefore be divided into the following parts :—

1. Fore brain or **Cerebrum**.
2. Mid brain or **Mesencephalon**
3. Hind brain or **Cerebellum** and **Medulla Oblongata**.

So you see that the hind brain of the foetus gives rise to two distinct portions in the adult brain.

The *Cerebrum* is a very complicated portion of the brain and it has got numerous functions ; so we think it better to speak of it in a separate lesson.

The *Mesencephalon* is that portion of the human brain which lies between the *cerebrum* and the hind brain or the *cerebellum* and the *Medulla oblongata*. Between the *Medulla* and the mid brain there is the brain-bridge or the *Pons Varolii*. The figure No. 59 will clearly show how the

mid brain is situated with respect to the other parts of the brain.

The mid-brain cannot be seen in the ordinary position of the different parts of the brain. The cerebellum must be drawn apart from the cerebrum in order that the mid brain can be viewed from all sides.

What is the function of the mid-brain? In the mid-brain are situated the centres for vision as well as for hearing. The centres for origin of those nerves which regulate the movement of the different muscles of the eyes are also situated in the mid brain. The mid brain is thus very intimately associated with our apparatus for vision. Besides being connected with the eye and the ear, the mid-brain also contains numerous fibres which are either bringing news from the periphery or which are carrying the orders of the cerebrum to the different organs of the body. So the mid-brain, here, acts as a middle man between the cerebrum on the one hand and the various organ and tissues of the body on the other hand.

The fibres passing through the mid-brain which are either coming from or passing to the periphery have to course through

### Pons Varolii. (*The Brain Bridge*)

The Pons Varolii is a very distinct structure which is visible in the centre of the head under the cerebrum and on the top of the Medulla oblongata. It really deserves the name of brain-bridge as it forms the chief source of union between the different parts of the

brain. We have spoken above how the fibres from the medulla oblongata have to pass through the Pons and then through the mid-brain before they can reach the cerebrum. Besides that, the Pons affords passage for fibres which chiefly connect the two halves of cerebellum. Apart from being a brain bridge, the Pons contains within its centre a mass of grey matter from which many of the cranial nerves ( or nerves issuing from the brain ) take origin.

We next come to the

### Cerebellum.

As regards its size, cerebellum is next to the cerebrum. It is situated below the back part of the cerebrum under the protection of the occipital bone from behind. It extends from the back of one ear to the back of the other, on the opposite side of the head and is about as big as a medium sized orange.

We do not know as yet all the functions of the cerebellum. But it has been decidedly proved that it has got to do much with our act of walking, running, jumping etc. Cerebellum is a factor for the coordination of muscular movements, specially in maintaining equilibrium. To stand upright is a difficult task. It seems, I daresay, quite easy to you ; but if you notice, you will see that most animals with four limbs use them all for standing. Whereas the human being uses only his hind limbs for this purpose leaving free the other two limbs to do more useful work.

You will understand how essentially important is

this cerebellum in the ordinary act of standing erect or walking, if you ever have a chance to see a patient who has got an injury over the cerebellum or whose little brain has been diseased. If you see such an unfortunate person walking, you cannot but pity him, for he will be reeling all over the ground like a drunken man and can hardly walk fifteen or twenty paces at a stretch. Perhaps he will be striking against the table or the wall. He cannot judge his position. If he is standing erect he will think as if he is leaning on one side or the other.

How are we normally able to stand erect or walk or run? When we are moving our muscles or even when our muscles are doing no work as in standing, sensory impulses are travelling up to the cerebellum from the muscles and from the joints, and these impulses have to reach the cerebellum in order that we may stand erect or walk or run. If these impulses cannot reach the cerebellum the effect will be the same as in the case of the patient with an injury of the cerebellum. Thus in a certain disease in which the sensory nerve-roots or path of the spinal cord undergo degeneration, the patient reels in the same manner and walks with a stamping and staggering gait as if he is not sure that his legs have touched the ground.

The cerebellum is divided into two hemispheres or lateral halves, and these are connected by transverse bundles of nerve fibers with each other; on the other hand each half of the cerebellum is connected in a similar manner with the hemisphere of the

cerebrum on the same sides above, with the Pons in the middle and with the Medulla below. It is formed with the grey matter or nerve-cells on the outside, thrown into small folds or convolutions. The nerve-fibers or white matters are situated in the interior portion with a nucleus of grey called *Corpus dentatum*. They give the appearance of a small tree-trunk with dense fine leafless branches and it is called the *Arbor Vitæ* or "the tree of life."

I shall now speak on the *Medulla Oblongata*. The Medulla is placed at the top of the back bone through which, you will remember, the spinal cord runs. Indeed the medulla oblongata is the upper expanded portion of the spinal cord just as it enters the head through the Atlas vertebra.

It is the most vital of all parts of the brain; for if any how the medulla is injured, death will instantaneously follow. Just, as the cerebellum governs the muscles of the legs, so the Medulla generally governs the muscles of the lungs, the heart, as well as those that are used in swallowing. In it are situated the Respiratory, Vaso motor and Vagus Centres.

The *respiratory* centre is necessary for the alternate inspiration and expiration. The *vaso-motor* centre is so called because it governs the vessels all over the body. It is due to the vaso-motor centre that the arteries of our body are always kept in a state of contraction. If this centre is destroyed, the arteries dilate, there is a great fall of blood pressure, and death is the consequence. The *Vagus* centre is a centre governing the

heart. The vagus nerve which supplies the heart is inhibitory to heart muscle. So when the vagus nerve centre is stimulated the heart stop beating. The poisonous drugs cause death either by depressing the vaso-motor or respiration centre or by stimulating the vagus centre. In the modern methods of execution death is produced by the destruction of the vital centres of the medulla. Indeed this inch and a half bit of brain is an important governor in the kingdom of our body.

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## CHAPTER XXI.—( *Contd.* )

### *The Nervous System.*

#### LESSON V.

#### The Cerebrum and its Function.

The cerebrum is the biggest portion of the brain. It occupies the whole of the vault of the skull and its shape and relative development in different persons can therefore be judged by the form and dimensions of the skull of the particular individual. In average persons the cerebrum is as big as a medium-sized melon.

The cerebrum consists of two half-round masses or

#### **Hemispheres**

connected together intimately by a layer or band of white nerve fibres running transversely. Then there are white nerve-fibers passing from one portion of each side of

the cerebrum to other portions of the same side and also running downward from each hemisphere of the cerebrum in the form of a cable which afterwards divides into two cables, one connecting with the hind brain and the other with the Medulla ; this cable is known as the arm of cerebrum. In each hemisphere of the cerebrum there is a large irregular space known as a *cerebral ventricle* (as distinguished from the *cardiac Ventricle*) which is more or less filled with a serum like substance called the *cerebro-spinal fluid*. The cavity serves as a water-cushion, and is meant for bearing up with any shocks that may come to the brain.

Each hemisphere of the cerebrum is connected with the voluntary workings of opposite side of our body (excepting of course the face). In ordinary right-handed persons the left hemisphere is more developed than the right, for the left side of the brain has to come too frequently into operation owing to the greater use of the right limbs. But in left-handed persons the reverse is the case, *i. e.*, the right hemisphere grows larger than the left hemisphere.

The surface of a man's brain is thrown into a series of distinctly marked folds or

### Convolutions.

These convolutions are arranged in practically the same manner or the same pattern in all human beings. Though the convolutions in one brain may differ in details of structure from those of another brain, still they maintain a close anatomical similarity and

resemblance. Medical men and scientists have assigned different names to the different convolutions in order to study the functions of the different portions of the cerebrum. The surface of the brain has been also divided into certain areas or regions corresponding with the bones of the skull, though not exactly. We thus speak of the *frontal* or forehead region of the brain the *parietal* or the upper region, the *temporal* region at the side of the brow, and the *occipital* region at the back of the head. Modern Phrenologists have observed that the frontal region is the seat of intellectual capacities, the parietal that of moral sentiments, temporal that of animal propensities and the occipital that of domestic properties.

In the spinal cord we have seen a central core of grey matter surrounded by peripheral white matter, but in the brain the opposite is the case. On the surface of the brain is seen a thick layer of grey matter which incloses within it a central core of white matter. If we make a section of the cerebrum, we find the grey matter to be composed of brain cells and also that the grey matter dips in between the convolutions of the brain thereby affording a large amount of cell-material than would be the case in a smooth brain. The white matter which lies within the grey matter is composed of nerve fibres carrying messages to and from the brain cells. The brain cells are however not scattered at random but are arranged in groups which form the different brain centres, that are guiding the human body. It may be said that the most important brain-

cells are those of the outer layer of the cerebrum. They exist in millions; one estimate giving over 800,000,000 as an approximate number.

Buried deeply down below the cerebrum almost about its centre we find a mass of gray matter called the **Central Ganglia** or (*Basal Ganglia*). The function of these parts as well as certain other parts of the brain have not been rightly understood; but we may compare them as deputies who have to discharge intermediate duties between the brain and the other organs of the body. A certain portion of the central ganglia called *Corpus Striatum* is believed to act as the "*brain clearing house*" through which the motor messages are assorted and sent out while proceeding from the cerebrum to the body. Whilst another portion of it called *Optic Thalamas* is supposed to act as "*a receiving house*" where the messages from the body passing to the cerebrum are received. There they are altered or shaped somehow or other and thus fitted for the appreciation of the brain cells above. It is very probable that in persons who have been hypnotised or mesmerised, the central ganglia may act independently of the cerebrum which is, so to say, switched off for the time being.

The cerebrum has very complex functions. It controls either directly or indirectly every portion of the human body. Different portions of the cerebrum perform different functions and a large amount of research and investigation has been carried out in order to find out what area on the brain corresponds with what

portions of the body. Experiments on the cerebrum have been mostly carried on monkeys of the higher type whose brains much resemble the human brain. Accurate observation of the diseases of or injuries to different parts of the brain convolutions in man has also considerably helped the physiologists in localising the different functional areas on the brain.

The front part of the *frontal lobe* is regarded as devoted to the higher operations of the mind. It may be considered as the seat of will or consciousness. Association of ideas, thought and perception are mediated through this portion of the brain. This section may therefore be termed the *intellectual area* of the brain.

The back part of the frontal lobe is called the *motor region* or *motor area* of the brain. This is, so to say,

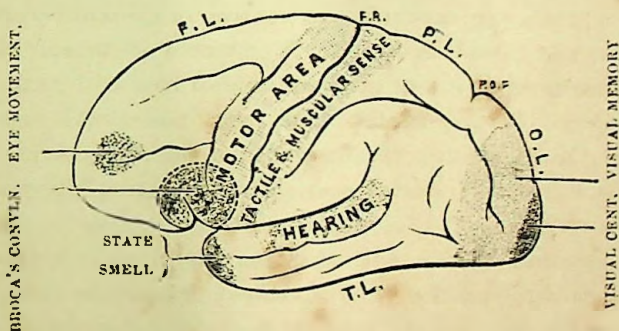


Fig. 64—Outer surface of the left hemisphere.

F. L.—Frontal. P. L.—Parietal. O. L.—Occipital.  
T. L.—Temporal lobe ( *after Halliburton.* )

the storehouse of bodily energy. Every voluntary movement is the manifestation of energy from this portion of the brain. As you wish to do any work, the idea of doing that work must arise in the front part of your brain. Once the idea occurs in the brain, the nerve cells in the motor area are spontaneously thrown into activity. A nervous impulse is generated, which travels down the nerve fibres situated in the central portion of the brain and these nerve fibres communicate the orders of the cerebrum either to some of the nerve centres of the cranial nerves or the nerve-cells in the spinal cord from which the spinal nerves arise. Thus the nerve energy is ultimately transformed into muscular energy.

Behind the motor area of the brain is situated the body-sense area, or the **Sensorium** of the brain. It is that portion of the brain which translates, so to speak, the impulses carried by sensory or afferent nerves of the body, into sensations. You would not be able to feel anything—pain or pleasure, cold or heat etc., if this sensorium of your brain were not there. As soon as you touch an object, a nervous impulse is generated along the afferent nerves passing from the tips of your fingers; but still you cannot feel that you are really touching the object until that impulse carried by your afferent nerve has reached the sensory area of your brain. The motor and sensory areas of the brain do not overlap each other but they are so related to each other by association fibres that impulses reaching one area of the brain, say the sensory area, can modify the

activity of the other *i.e.*, the motor region. Suppose you are walking on a very slippery ground and you naturally put some pressure over your toes, lest your feet may slip. As soon as you come to tread on such a ground, a peculiar sort of sensation is carried to the sensory area of your brain. The cells of the sensory area give intimation of this fact to the nerve-cells of the motor area through the association fibres and the motor cells are set into activity to send out urgent orders to the muscles of the foot asking them to press the toes firmly against the ground.

Besides these three areas on the brain, there are other more or less ill-defined areas, connected with the special senses, namely vision, hearing, smell and taste. The visual impressions are located in the extreme back part of the cerebrum and visual memory is situated in about the whole of the surface of the occipital lobe. You had seen a man, say, one year ago. An impression has been left on the occipital lobe when you saw the man. If the retentivity of your brain cells is long enough, then you may perhaps recognise the man's face. But it takes a good deal of operations before you are able to recognise. Thus an image of the person's face now falls on the retina of your eye and a nerve impulse is generated in your nerve of sight (Optic Nerve) and this impulse is carried to the centres of vision situated in the mid-brain. These are the lower visual centres. They again transfer this impulse on to the higher centres situated in the occipital lobe of your brain. It is after the nerve impulse has reached the occipital

lobe that you are able to form a visual impression. But you may not be able, if your brain is not so very alert and quick, to recognise the man at first sight. In the mean time there occurs some mysterious operations between your higher visual centres and the centres for visual memory of which we know nothing and if your visual memory centres have still retained the impression of the man's face, it is then only that ultimately you are able to recognise the man.

The higher centres for hearing are situated in the region of the temporal lobe and in the lobe is also situated, but we cannot exactly say at what spot, the centres for auditory memory. In some forms of epilepsy due to degeneration of the (*cortex*) surface of the brain, the patient either feels or sees or hears something before the actual fit comes on. There was a patient who used to hear bells ringing all aound him as if hallooing him to some other land. There was another woman who always used to see a nude girl with shaggy hair and glistening eyes standing by her side and with this, her fit came on. These hallucination or phantoms are associated with diseases of the various regions of the cortex which are associated with special senses involved.

The centres for taste and smell have been located in the front part of the temporal lobe, for it has been found that in animals who have a keen sense of smell, such as the dog, the cat etc, this portion of the braif is more welldeveloped than in the case of man.

The centre for speech was located by a gentleman named Broca on the lower convolution of the frontal

lobe on the left cerebral hemisphere. This portion of the brain surface, has therefore been called *Broca's convolutions*. But recent investigations on a disease called *aphasia* in which the power of speech is lost, while that of the other faculties remain unimpaired, have not confirmed this situation of the speech-centre. It is not limited to a small area like that, but has a more extensive representation midway between the temporal and parietal lobes. In right-handed persons, the left hemisphere which controls the right side of body, takes the lead over the other hemisphere specially on account of the situation of the speech-centre on the left side. But in left-handed men in whom the speech centre is located in the right hemisphere, the right one becomes the bigger and more important of the two hemispheres of the brain.

We shall finish this lesson by speaking of the 12 pairs of **cranial nerves** that leave the brain. They either carry messages to the brain or the orders of the brain to the different parts and organs of the body. They are as follows :—

- |    |  |   |
|----|--|---|
| 1. | The sensation of Smell called the                            | <i>Olfactory nerve</i>  |
| 2. | „ „ Sight  | „ <i>Optic</i>  |
| 3. | Movements of the eye muscles                                 | } „ <i>Oculo-motor</i><br>} „ <i>Trochlear</i><br>} „ <i>Abducens</i> |
| 4. | „ „ „  |   |
| 5. | „ „ „  |   |
| 6. | Sensation of face, movements<br>of the jaw and of the tongue | „ <i>Trigeminal</i>   |
| 7. | Movements of face muscles                                    | „ <i>Facial</i>   |
| 8. | Sensation of Hearing   | „ <i>Auditory</i>   |

9. Sensation of Taste called the *Glossopharyngeal*  
 10. Supplying the throat chamber,  
 the heart, the stomach, the liver, the  
 intestine etc. and on account of its  
 wandering course ... .. *Vagus*  
 11. Movements of Neck muscles *Spinal accessory*  
 12. Movements of Tongue ... .. *Hypoglossal*
- 

## CHAPTER XXI.—(Contd.)

### *The Nervous System.*

#### LESSON VI.

#### The Sympathetic System.

The sympathetic system of nerves has been called the *involuntary* nervous system, for it is a portion of our nervous system which we cannot control at our own sweet will. The sympathetic nerves exert their influence mostly over involuntary muscles of the stomach, intestines, the arteries, the heart muscles and such other vessels or organs of the body whose activity is more or less automatic or machine-like. Hence the sympathetic has also been called the *autonomic* nervous system in so far as it is not dependent on the brain for its functioning.

The sympathetic system consists essentially of two strands of nervous tissue lying one on each side of vertebral column. Fig 65 shows the sympathetic chain.

of one side of the body. If you examine it, you will see that the chain is beaded *i.e.*, it shows enlargements almost at regular intervals. So the sympathetic chain is composed of chains and knots. The knots are the points of enlargements in the sympathetic chain and they are due to a collection of nerve cells. Hence these knots are nothing but ganglia on the course of the sympathetic nerves.

These ganglia are connected to the brain and the spinal cord by two roots :—

1. The white root.
2. The grey root.

The *white root* passes from the spinal or cranial nerve to the sympathetic ganglion. The fibres composing the white root are derived from the cells situated in the brain or the spinal cord and these fibres end by ramifying around the cells of the sympathetic ganglion.

The impulses conveyed by the white root are then taken up by the sympathetic nerve cells and from these nerve cells the nerve impulses are sent to the plain muscles by way of the axons of sympathetic nerve cells. The axons of the sympathetic nerve cells do not possess the white substance which forms a chief part of an ordinary nerve fibre. Hence the sympathetic nerve fibres have a more or less grey colour. The sympathetic nerve fibres may reach their destination either independently or with the cerebro-spinal system of nerves. Those fibres which go to the cerebro-spinal system of nerves to be distributed along with them form the *grey root* of the sympathetic ganglion.

What is the function of the sympathetic system of nerves? Their function is to carry impulses to the plain or involuntary muscles throughout the whole body and thus regulate their activity, The sweat glands, the salivary glands, the liver, the pancreas or the sweat-bread are all connected with and are controlled by the sympathetic system of nerves. But what sort of influence the sympathetic nerves exert upon these glands and organs, it will be very difficult for you to understand. This much you should know that the sympathetic system controls the movements of the alimentary canal and the activity of the organs only by a reflex means. You cannot by the exercise of your will make any influence over the sympathetic system or the organs supplied by it.

All that I have said before about the functions of the sympathetic system represents only an insignificant portion of their work. Its chief influence is over the

### Heart and the blood vessels.

In connection with the heart and the vessels of abdomen and the body basin or the pelvis, three important nerve plexuses are formed in the front of the vertebral column between the two sympathetic chains. These plexuses from above downwards are

- (1) The **Cardiac** plexus (*heart*)
- (2) The **Solar** plexus (*abdominal vessels*)
- (3) The **Pelvic** plexus (*pelvic vessels*)

The *Cardiac plexus* is a rich network of nerve fibres formed by the sympathetic and the Vagus nerves or the tenth cranial nerve. From this plexus, the heart

muscle derives its nerve supply. This double nerve supply has very great importance in regulating the action of the heart. The Vagus carries *inhibitory* (checking) impulses to the heart whereas the sympathetic carries just the opposite kind of impulses namely *acceleratory* (increasing).

The heart under this twofold control may be compared to a horse under the control of the reins and the whip. The Vagus is the reins and the sympathetic, the whip. If you remove the reins from the horse it will run with mad speed and it will be difficult to check it. The same sort of thing happens when the vagus or the reins of the heart are cut off. The inhibitory influences of the vagus no longer come into play and the heart beats on at a very quick rate. The reverse takes place when the sympathetic is severed; the heart then beats slower and slower. If however the sympathetic nerve be stimulated by electrical current, the heart will again resume its normal beat and may even beat faster than normal.

For the control of the arteries throughout the whole body, a special system of nerves are developed in connection with the sympathetic system which has been called the *Vaso-motor* nervous system. The vaso-motor nervous system consists of

**a vaso-motor centre  
and vaso-motor nerves.**

The *Vaso-motor centre*, we have mentioned to you when speaking of the Medulla oblongata, is situated along with the Respiratory and the Vagus centres in the medulla. The vaso-motor centre is continually sending

down rhythmic impulses along the various vaso-motor nerves. These impulses on reaching the arterial muscular coat maintain them in a state of contraction. Such a contracted state of the arteries is necessary for the blood pressure to be maintained at a constant level. If instead of being in a contracted state, the arteries become relaxed, then they will dilate, thus affording a larger room for the blood to fill up. The result of this, obviously, is fall of blood pressure. If the blood pressure becomes very low then very small amount of blood circulates through a given portion of the body in a given interval. Such poor circulation manifests its bad effects first of all in the brain centres. The brain centres being deprived of their blood supply cannot carry on their work all right and the person with low blood pressure becomes unconscious. Such abnormal fall of blood pressure does not occur except in severe injury of very extensive operations.

In our daily life, the organs of our body are exposed to a variety of circumstances and the vaso-motor impulses come into play in regulating the amount of blood-flowing through an organ in proportion to its needs. During digestion, for instance, shortly after meals, it is necessary that the digestive organs should be supplied with a large quantity of blood; for this purpose the small arteries in the abdomen are relaxed and there is a vast amount of blood in this area, and therefore a correspondingly small amount in other areas, such as the skin; this accounts for the sensations of chilliness after full meal. The skin vessels form

another good example ; one of the most important uses of the skin is to get rid of the heat of the body in such a way that the body temperature shall remain constant ; when excess of heat is produced, there is also an increase in the loss of heat ; the skin vessels are then dilated, and so more blood is exposed on the surface, and thus an increase in the radiation of heat from the surface is brought about. On the other hand, when it is necessary that the heat produced should be kept in the body, the loss of heat is diminished by a constriction of the skin vessels as in cold weather. The alteration of the calibre of the vessels is brought about by the action of the vaso-motor nervous system on the muscular tissue of the small arteries.

The control over the arteries of the body is thus very important. The vaso-motor nerves are situated along with all the arteries of the body except at certain localities which require a constant supply of blood. These are the brain, the heart and the lungs. So the arteries supplying these organs are free from any control. Their calibre is never altered normally. But in the case of the abdominal and pelvic organs the vaso-motor control is developed to perfection. For the control of these abdominal and pelvic arteries, two important plexuses are developed—the solar plexus and the pelvic plexus.

The *Solar plexus* is situated just in front of the aorta behind the stomach. It is a very important nerve plexus and it controls not only the abdominal vessels but also the plain muscles of the intestines. Between

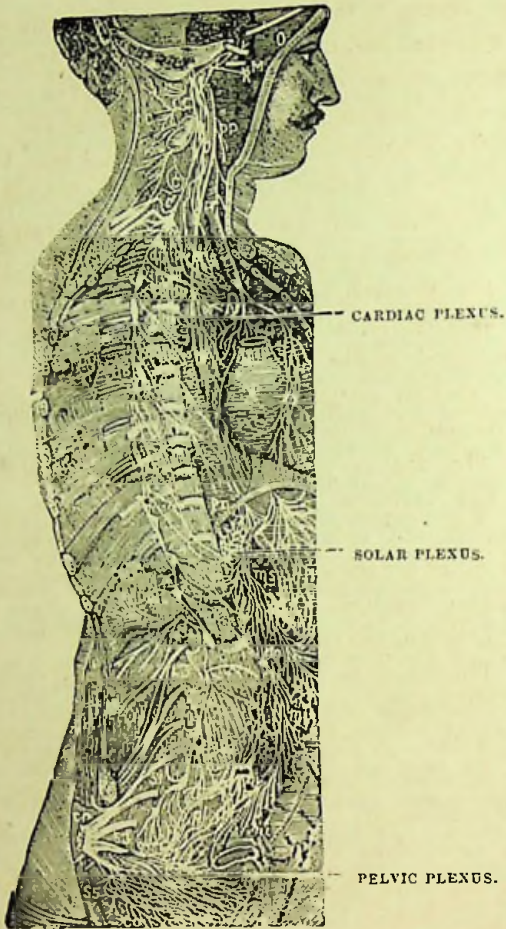


Fig. 65—The sympathetic chain of the Right side in connection with the principal cerebro-spinal nerves and plexuses.

the layers of the intestines, twigs from the solar plexus are carried and these twigs with other twigs from the Vagus nerves or the tenth cranial nerve form a special plexus which controls the movements of the musculature of the whole of the alimentary canal from the stomach down to the colon. The presence of food particle is sufficient to call forth the activity of this plexus and simultaneously with the arrival of the food, the muscles of the stomach and the intestines begin to contract and relax rhythmically. Thus the peristaltic waves are generated in the muscles which carry the food through the various portions of the gut where digestion and assimilation of food take place.

The *Pelvic plexus* is situated lower down in front of the vertebral column but behind the bladder. It supplies not only the vessels of the pelvis but also all the other organs situated in the body basin namely the bladder, rectum, anus and the uterus or the womb and the ovary in the female.

The absence of vaso-motor control in the brain vessels make the brain very susceptible to various influences. A slight rise in blood pressure will increase the velocity of blood flow through the brain as during any excitement. A fall in blood pressure, may injure the brain how dangerously, we have narrated above. Persons who generally suffer from constipation suffer very much from headache. The reason of this trouble is again to be found in the absence of vaso-motor control in the brain vessels. The impacted fæces or the stools in the intestines, offer a great resistance to

circulation and any resistance to circulation means a rise of blood pressure. This rise of blood pressure accounts for the engorgement of the brain with blood and consequently headache. But this headache may be also due to self-poisoning from absorption of poisons, produced by the decomposition of the accumulated fæces inside the bowels. These poisons after absorption attack the various tissues of the body, the result being general uneasiness. The delicate tissue namely the nervous tissue of man is however very susceptible to these poisons. Hence we see Neurasthenia, loss of will power generally associated with very costive bowels.

The Vaso-motor nervous system is influenced to some extent by conditions of cerebrum, some emotions such as fear, causing pallor (*i.e.*, constriction of vessels), and others causing blushing (dilatation of vessels).

From as much as you have learnt about the functions of the sympathetic system, you will agree with me, if I say, that the sympathetic system is connected with the so called vegetative system of the body *i.e.*, the life processes in man, namely, the digestion and assimilation of food, the circulation of blood, the action of the heart and also to some extent of the lungs. But how the sympathetic system controls the action of the lungs we cannot say.

Still while we are on the subject of the sympathetic system, I should like to touch here on the two little bodies called

### The Adrenal Bodies

which cap the kidneys. These are developed from the same structures as the sympathetic nerves. But they take on the function of glands. The secretion they pour out contains an active body *adrenaline*, whose normal action is to maintain the vessels of the body in a contracted state. This secretion does not come out of the gland through a tube or duct but passes at once into circulation. So these glands are classed as **Ductless glands**. There are various other ductless glands in the body which are coming more and more into importance with the advance of our knowledge. I shall speak at some length about these wonderful glands which regulate our growth, personality and activities, in a separate chapter at the end of the book.

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## CHAPTER XXII.

### Organs Of Special Sense

#### *Taste and Smell.*

The tongue is the organ of taste. It is a muscular structure situated within the cavity of the mouth. The muscles which make up the substance of the tongue help it in making various delicate movements which the tongue is capable of during the act of chewing or talking. There are other big muscles which connect the tongue with the hyoid bone, the lower jaw bone etc.

These muscles by their contraction produce the bigger and round movements of the tongue as in swallowing.

The whole of the substance of the tongue is covered by a layer of mucous membrane which like the skin of our body that protects our exterior, covers the organs inside the body. The mucous membrane, however, is very thin so that the tongue looks much more bright and rosy than the forehead, or the cheek or the palm.

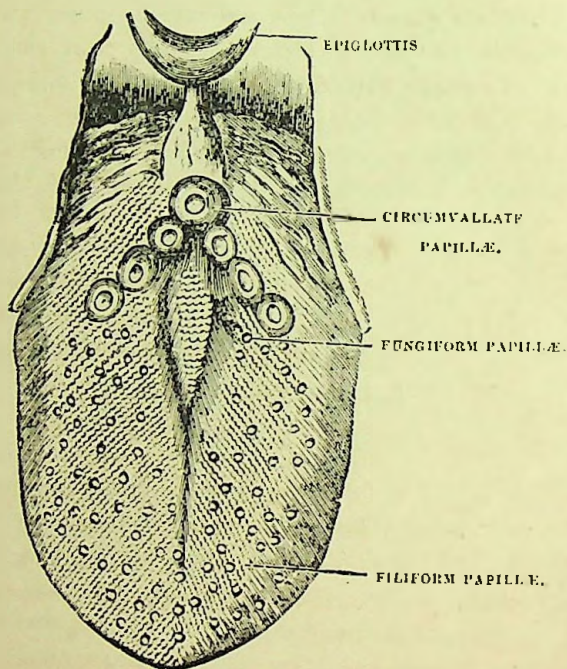


Fig. 66—Upper surface of the tongue.

Look at the picture of the tongue and then look at each other's tongue and compare with what you see with the picture. The upper surface of the tongue which is shown in the picture, is very rough compared with the under surface, and why? Because on the upper surface of the tongue are situated many "hillocks" or *Papillæ* as they are properly termed—some fine like threads, others more like mushrooms. Now, these hillocks are the parts of the body with which we taste, and the hillocks are of three kinds :—

1. Filiform *Papillæ*.
2. Fungiform *Papillæ*.
3. Circumvallate *Papillæ*.

The *Filiform papillæ* are very numerous and are widely distributed all over the tongue surface.



Fig. 67.—Diagram of filiform Papilla.

Look at the diagram of the filiform papillæ and see how it consists of only fine thread like projections. These projections of the filiform papilla develop into very fine horny spines in carnivora. This makes their tongue feel gritty to the touch. The threadlike hillocks perhaps have no function in carrying taste sensation. Their function is simply mechanical and tactile (*i.e.*, carrying sensation of touch).

The *Fungiform papillæ* are more conspicuous objects than the filiform papillæ. They are situated

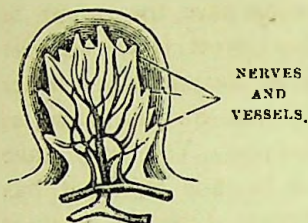


Fig.—68. Diagram of  
Fungiform papilla.

chiefly at the tips and sides of the tongue. They contain inside their core a few extremely thin blood vessels and filaments of fine nerve fibres that carry the sensation of taste.

Next we come to the *Circumvallate papillæ*. Here is a picture of one of them; from it you will see



Fig. 69. Diagram of  
circumvallate  
papilla.

that the reason it is called in common parlance—'the rampart hillock' is, because it is shaped like a coarse-edged wall or rampart. These papillæ are situated at the wider end of the tongue in almost a V-shaped manner. They are circular elevations,

from  $\frac{1}{30}$ th to  $\frac{1}{12}$ th of an inch wide. They therefore form very conspicuous objects when the tongue is protruded. Those people who do not know of the existence of such things on the back of every body's tongue have become frightened by seeing these round elevations on the back of their tongue and have even sought for medical advice to cure this defect of the tongue. But you can now see how foolish it was for them to ask the doctor to remove those elevations which are the chief organs of taste.

Different portions of the tongue have the power of judging different tastes. Thus sweet tastes are best appreciated by the tip, acid at the side, and bitter tastes at the other end of the tongue. Most of you, I think, have taken quinine. You may have noticed, how you do not seem to taste it, till it has all but gone down your throat. Bitter as it is, it passed all the hillocks in front of the tongue without affecting them at all. But when it reached the rampart hillocks they were influenced by it. The twigs of nerves that you see in them have carried the impulse to the brain where it has been interpreted as bitter.

The substance to be tasted must be dissolved. This phenomenon presents a striking contrast when we consider how smell sensations are developed. Of this we shall speak later on. The more concentrated the solution, the larger is the surface acted upon and the more intense is the taste; some tastes are perceived more rapidly than others, saline tastes ( salt ) most rapidly of all. Very high and low temperature deaden the sense of taste. You cannot therefore enjoy to its fullest extent a cup of very hot tea or very cold lemonade.

The glossopharyngeal or the ninth nerve and a branch of the Trigeminal nerve—are held to be the carriers of sensation of taste. Branches from the glossopharyngeal enter the circumvallate papilla whilst the branches from the other nerve are distributed to the front portion of the tongue.

## Smell.

The nose is the organ of smell. It is triangular in shape, partly made of bone and partly of cartilage. The tip of the nose and the sides of the nostrils are made of cartilage and so can be easily bent or twisted. The two nasal bones and a portion of the upper jaw bone form the bridge of the nose. In the floor of the nasal cavity we meet with the palate bone; in the roof is situated the *Ethmoid*. The little *lachrymal* bones run down the sides of the smell chamber and the *Vomer* bone divides the cavity exactly into half. It is the *Inferior turbinated* which twisting in and out divide the chamber into two portions.

1. A lower portion ( *Respiratory chamber* ).
2. An upper portion ( *Olfactory chamber.* )

Through the lower portion, the air we take in through the nostrils passes right to the pharynx on its way down to the trachea and the lungs. At the nostrils there are hairs which protect the nasal chamber from the entrance of irritating particles of dust, vermins etc. But these hairs allow too much tiny particles or gas to go on undisturbed.

The air that enters the nostrils mostly goes into the lungs, only a portion of it ascends into the upper olfactory chamber which is situated above the Inferior turbinated bones and the mucous membrane of which is provided with somewhat modified columnar cells with which the end organs of the Olfactory nerves (*i.e.*, of smell) are connected. Here, if the air is laden

with any odour, it will irritate the fine nerve twigs that spread in a network in this olfactory tract.

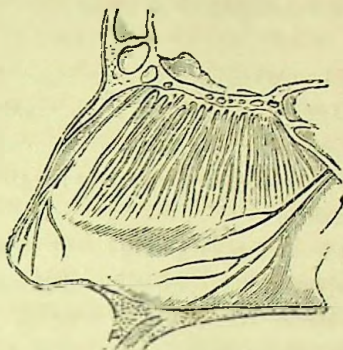


Fig. 70—Nerves, ramifying in the mucous membrane of the nose.

These minute nerve-twigs uniting above the roof of nose to form olfactory nerves or the first cranial nerve, receive and transmit the sensation of smell which is carried to the brain; but until the nerve impulse has reached the brain we are not able to say that it is the smell of the rose or it is the smell of meat-curry etc.

In the case of the tongue, the substance to be tasted must be in the form of a solution, but in the case of the nose the substance to be smelled must be in the form of vapour or gas. If some lavender water be syringed up your smell-chamber to the full, you won't be able to feel any smell of it, though when it is placed in front of your nose, you will smell of very fragrant odour. This experiment proves not only that substances must be present in a gaseous form in order that they may affect the

terminals of the olfactory nerve, but shows the necessity of oxygen in the excitement of the sense of smell.

Cold prevents people from smelling. And why, can you guess ?

"My nose is stuffed up" they say "I can't smell anything." And it is true the cold makes the mucous membrane lining the nasal chamber to swell so much so that the odour cannot get in touch with the termination of olfactory nerves.

In man the sense of smell is not so acute as in the lower animals, say for instance the dog, as the olfactory region of the latter are more developed. Still it has been calculated that  $\frac{1}{100,000,000}$  of a grain of pure musk can be distinctly smelled by a man.

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## CHAPTER XXIII.

### *Voice.*

Voice is produced in the voice-box or *larynx*. The larynx of man, though it is a very small structure can, if properly trained, produce almost all the different notes that a piano is capable of generating.

The *larynx* is the upper dilated portion of the respiratory passage. If you just look up the chapter on Respiration, you will see that only the first two rings of cartilage are concerned in the formation of the

voice box. The first one is the **Thyroid cartilage**. You can see it in anybody's throat where it forms a projection known as Adam's apple.

Standing immediately above it is the slender U-shaped piece of bone called the

### **Hyoid Bone.**

You may recapitulate these different parts from Figs. 36 and 37.

The second ring is the **Cricoid cartilage**. This is a complete ring. It does not therefore move out of the way when the gullet requires more room.

Sitting on the back of the cricoid cartilage are two pieces of cartilage resembling the pyramid in shape. These are called the

### **Arytenoid Cartilages.**

At the place where they sit on the cricoid cartilage, they form distinct joints with that bone. The arytenoid and the cricoid cartilages are great friends and they follow each other in their movements. The arytenoid can also turn or twist while it is seated on the cricoid ring.

You must not imagine that because the arytenoid cartilages follow the cricoid in all its movements, it has no connection whatsoever with the thyroid cartilage. On the contrary they are firmly attached to it by two bands of elastic fibres covered with flimsy mucous membrane, and these fibres are called

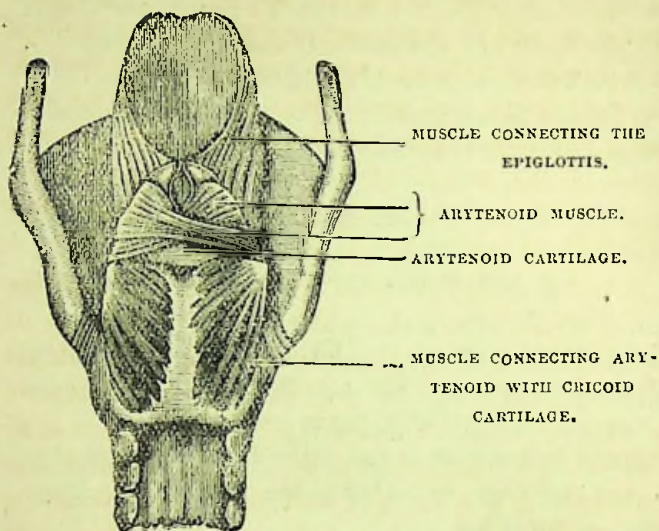


Fig. 71—Back view of Voice Box showing local muscles.

### The Vocal Cords.

Most of the muscles that are in the larynx are connected with the arytenoid cartilages as the above picture will show. The duty of these muscles is to move the vocal cords near to or farther from each other and also to make them tense or to keep them in a relaxed condition. When they are near together, the air in passing through the slit (of which you have learned in Chap. XIV.) between them causes them to vibrate. These vibrations produce a noise and we speak. When they

are farther off from each other, no sound is produced but we can take in more air into the lungs. During normal breathing the air passes through the slit between the vocal cords and now if we want to speak we have only to bring into action some of those small muscles shown in the picture and this will cause the cords to be stretched to such a degree that the appropriate sound will be produced.

Sound is always produced as the result of air striking against certain obstruction which stand in its way. If there is no obstruction placed in the course of the air current, no sound will be produced. Those who have the experience of deserts will tell you how there is no noise in those great sandy plains. The scorching sun beating on the vast ocean of sand that meets the blue sky in the dim distance ; not a bit of tree or no relic of vegetation is visible. Is there no wind there ? Yes, the hot dry wind blows there all day long ; still what a gloomy calmness overshadows the dreary desert place ! It is because the winds have no obstruction to strike against any tree, hut, hill or any standing object and they sweep over the flat land without causing any noise.

By offering appropriate reistance, it is possible to produce different kinds of noises. It is on this plan that the different wind instruments of music are constructed. In the human instrument of voice, the resistance to the air is changed by the action of muscles. If we want to speak we bid certain obedient muscles to stretch the cords. When they are tight, the air hits

them and causes them to vibrate and sound is the result. Here the note emitted varies according to the laws of stringed instruments. The tenser the cords are, the higher will be the note given out. If, however, we do not want to speak, the vocal cords hang loosely and the air passes easily in and out between them without causing a sound.

The three pictures ( Fig. 72 ) show the vocal cords in different conditions. The first A, shows how the the larynx would look during the singing of a high note. The view is obtained by means of proper adjustments of mirror and light. Note that the vocal cords are closely approximated to each other and that their margins are very sharp and tense. The second, B, shows its appearance during quick breathing. The third, C, indicates the position of the vocal cords when a deep breath is taken or when a deep note is sung.

So much for the arrangements for the production of voice. But who is to give the command to the various muscles in order that the particular muscle may contract to produce the desired note. That power is

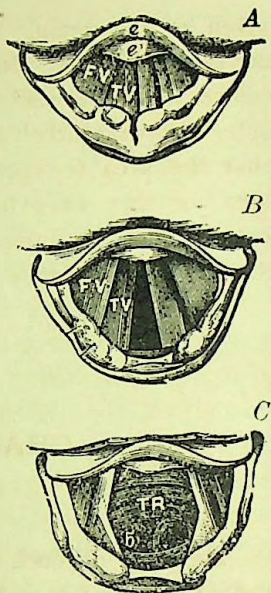


Fig. 72 - Appearance of of the vocal cords in different conditions

e e'—epiglottis  
T. V.—true vocal cord.  
F. V.—false vocal cord

given to the brain. We have told you in the chapter on cerebrum how Mr. Broca has located the speech centre in the lower portion of the frontal lobe of left side. But recently Marcy and others have found out that the area for speech is not limited to such a small area for they have found patients whose Broca's convolution has been injured and still they have maintained the power of speech.

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## CHAPTER XXIV.

### *Touch.*

The sense of touch is associated with the skin. But does the skin feel nothing else but the ordinary touch, say, of the finger or the prick of the pin. Heat, cold, pressure, pain etc are all felt through the medium of the skin. The function of the skin as a sense organ is therefore not limited to the ordinary sensation of touch but it includes a group of sensation which are collectively called cutaneous sensations. There are special organs in the skin which mediate these different cutaneous sensations.

I ask you to see again Figure 51 given on page 176. In that section of the skin you will see that beneath the scaly layer called the *Epidermis* which is composed of epithelial cells only, there is a deeper layer. This is called the skin proper or the *dermis*. The dermis or the

true skin is thrown up into numerous folds and presents a very wavy outline. The elevations of the dermis are called the *papillæ* or the hillocks of the skin. Like the *papillæ* in the tongue, these *papillæ* also contain the ramifications of very fine nerves that enter into its substance. Here however in the skin the nerve fibres do not end abruptly but they are swollen into somewhat oval structures. These may be best called

### The Tactile Corpuscles.

There are various kinds of tactile corpuscles. The different kinds of these cells are affected by different sorts of sensation.

Fig. 73 shows some of the tactile corpuscles. These are called Pacinian bodies after the name of the gentleman who described them. The cone shaped projections shown in the figure are the elevations in the dermis referred to in the previous paragraph.

In the skin these tactile corpuscles are separated from each other by some distance which is very variable. In the tip of the tongue where these bodies are most numerous, the distance between two adjacent tactile corpuscles is  $\frac{1}{24}$  inch only; whereas in the tip of the fingers it is only  $\frac{1}{12}$  inch. In the forearm, the tactile corpuscles are situated  $1\frac{1}{2}$  inch apart while in the leg they are  $2\frac{1}{2}$  inch apart. Each touch body can carry the sensation of touch from one point only. If one has to feel two points on the surface of the skin two touch bodies ought to be stimulated. So if you place the two points of a compass one inch apart on the skin of your forearm and shut your

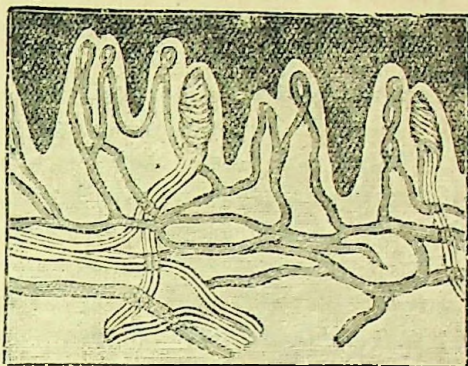


Fig. 73. Diagram of Feeling cells in the Skin.  
( *Pacinian Bodies* )

eyes, you won't be able to distinguish two points. But if you feel the two points through the skin at your finger tips you will be easily able to recognise the presence of two points.

In respect of distance between two points the tip of the tongue has the greatest judgment. So acute is the judgment made by the tip of the tongue that distances between two points will be found to be increasing when the two points of the compass are successively brought from the cheeks, to the lips, then to the tips of the tongue. Our estimate of the size of a cavity in a tooth is, therefore, usually exaggerated, when based on sensations derived from the tongue alone.

Heat sensations are best felt by the cheek or the elbow, for the heat spots are very abundant in these

regions. The washer-woman therefore generally holds her iron to these places when forming a judgment of its temperature.

Pain sensations are most acute over the cornea or the pupil of the eye. This is well borne out by everyday experience. A tiny moat causes how much smarting in the eye—that any body who has ever been caught by a dust-storm can express to you best.

The acuity or sharpness of cutaneous sensation is generally a matter of practice. The blind people who have been taught to read from raised types have a more developed touch sensation than you or an ordinary individual possesses. If you were to try to read from those raised letters you won't be able to distinguish a single letter while these people have trained their finger tips so much as to read with the perfect ease from such arrangement.

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## CHAPTER XXV.

*Hearing*

*or*

*The Far*

The ear is the organ by which we can hear. What is called the ear by common people has very little if anything to do with the appreciation of sound. It is merely an expanded piece of cartilage situated near

the orifice of the ears much as a sort of adornment to the human face. It is called the *Pinna*.

The ear has been divided by the the anatomists into three parts :—

**The outer Ear.**

**The middle Ear.**

**The inner Ear.**

The *outer ear* consists of the part that we see, namely the *Pinna* and a canal leading inwards. It is into this canal that water sometimes gets in when you dip your heads under water. The expanded part of the outer ear, called the *Pinna*, aids to a slight extent only in collecting the sounds and sending it to the *Meatus*. In man they have but very little function. Some of the lower animals as for instance the horses, the dogs, etc., can collect the sound-waves better by pricking up their ears towards the direction whence the sounds proceed.

The canal that leads from the *pinna* is the **auditory canal**. It is about an inch and a quarter long. You can get your little finger down this canal until it reaches some yellow wax. The orifice of the canal is guarded by small delicate hairs. The wax is secreted by glands that line the lower portion of the canal and they evidently protect what is beyond it.

Let us imagine that we are hearing somebody talking to us. The words as they fall out of his lips are thrown like stones on a pool of water. Many of you, when you were young, had thrown stones at some ducks in a pond. You must have noticed the ripples that are

produced in the water by the falling of the stones. Similar invisible waves are produced in the air as anybody speaks. These waves are the *sound waves*; the sound waves enter through the auditory canal pass through the wax and strike against a thin elastic partition, set at the far end of the canal. This partition is called the Ear drum or

### The Tympanic Membrane

It separates the outer ear from the middle ear. As the sound waves strike against the Tympanum or the ear drum, corresponding vibrations are also produced in it. These vibrations are then transmitted by certain structures of the middle ear further on to the internal ear.

The middle ear is a tiny cavity situated in the interior of the temporal bone. It communicates with the pharynx or the throat-chamber through the ear-pipe or Eustachian tube. Thus the pressure inside the middle ear is always kept at atmospheric pressure. This equality of pressure both on the inner and the outer side of the Tympanic membrane ensures its proper vibration. If you suddenly rise up in a balloon, you feel somewhat deaf. This is because the pressure outside has fallen while the pressure in the middle ear has maintained its previous condition. You are then to swallow: this makes the middle ear to communicate with the throat chamber and your deafness passes off. In abscesses of middle ear, deficiency in hearing is a marked feature.

The structures which transmit the vibrations through the middle ear are the three ear bones. They are called

The Hammer (*Malleus*).

The Incus (*Anvil*).

The Stapes (*Stirrup*).

SEMICIRCULAR CANALS.

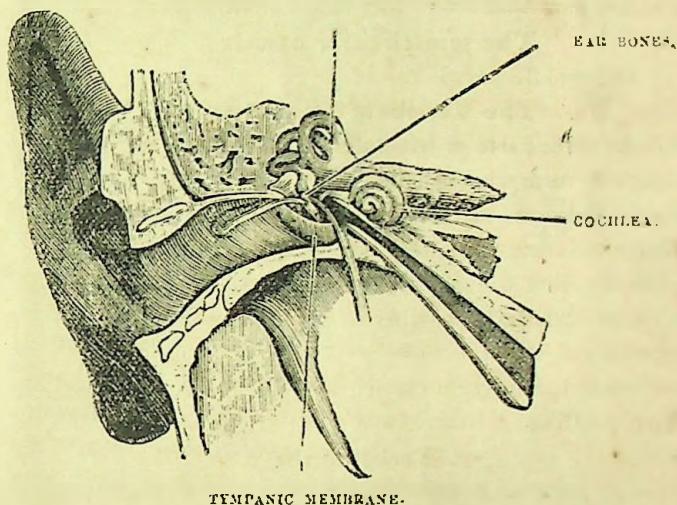


Fig. 74—Diagrammatic view of the Right ear.

The hammer leans close and tight against the membrane and when it shakes, the hammer shakes too.

The anvil is connected with the hammer whose vibrations are transmitted to the next bone, the stirrup.

By the transmission through the ear-bones the vibrations are rendered sharper and more effective. The vibrations have now reached the inner ear.

The **inner ear** consists of three parts, a central part which has nothing characteristic, a part something like a shell and the other part something like a bow of ribbon in in three loops.

One part is called

**The Cochlea ( Ear Shell )**

and the part that looks like loops of ribbon is called

**The semicircular canals.**

The middle part is called

**The Vestibule ( Reception Hall )**

All the three parts of the internal ear which are of bony structure form what is called the *osseous labyrinth*, and inside the osseous labyrinth is a fine bag of the same shape and size which is made of a thin membrane. This is called the *membranous labyrinth*. The word labyrinth is used, possibly to signify the complexity of structure.

Inside the internal ear is a fluid clear like water. This is called

**Peri-lymph.**

The whole of the internal ear is so small that the perilymph inside it, is not more than a single drop.

We have left the sound vibrations with the stirrup bone. The stirrup bone vibrates and transmits its vibrations to the oval hole called *Fenestra Ovalis* which is closed by a membrane to which the base of the stirrup is attached, and from this the vibrations are carried to the reception-hall or *vestibule* of the Internal ear.

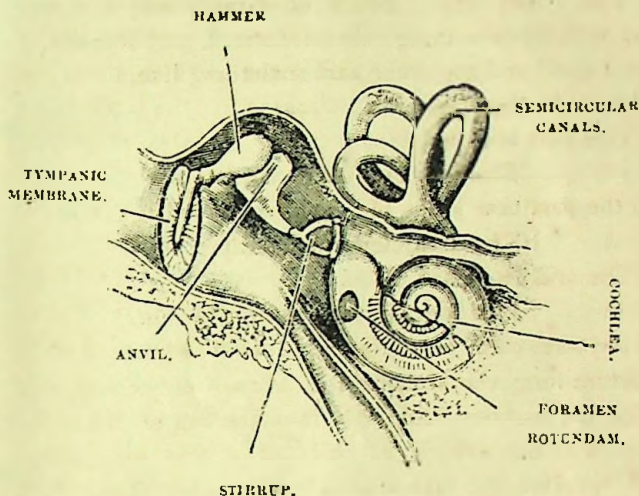


Fig. 75—Highly Magnified view of the middle and internal ear.

We know that the internal ear consists of an irregular bony cavity divided into three parts, the first portion known as *Vestibule* which situated in the inner side of Tympanic membrane and between *cochlea* and *semicircular canals* is an oval-shaped cavity.

The second portion called the semicircular canals (3 in number) have nothing to do with hearing; so we shall leave them for the present.

Lining the vestibule and the semi-circular canals is the closed membranous sac of identical shape with them, but much smaller in dimension. The fluid which it

contains, is called the Endo-lymph, and the fluid surrounding its outerwall is termed as Peri-lymph. The Canal of corti also contains the endolymph.

This third portion called *Cochlea* is the real organ for the reception of sound. The Cochlea resembles somewhat the shell of a land-snail and it consists of a winding hollow tube  $1\frac{1}{2}$  inch in length arranged spirally with a two and a half turns from the base to the cone. The tube itself is however divided off by a cartilagenous partition called *lamina spiralis* into an upper and a lower division. The lamina spiralis being bifurcated afterwards, divide the cochlea into three canals, the middle of them being known as the *Canal of Corti*.

The vibrations transmitted by the stirrup is taken up by the perilymph of the vestibule. Then they are taken up along the perilymph of the semicircular canals.

They are next taken up by the endolymph of the canal of corti. The endolymph vibrations affect the nerve terminals of the **Auditory Nerve** or the eighth cranial nerve which is distributed more or less to the vestibule and cochlea and which carries the sensation of sound to the brain where it is interpreted.

In the internal ear or labyrinth analysis of sound takes place; but how that happens is yet a matter of diffidence. According to some, there are some very minute microscopical *Hair cells* made of columnar epithelium which are supported on the *Rods of Corti*

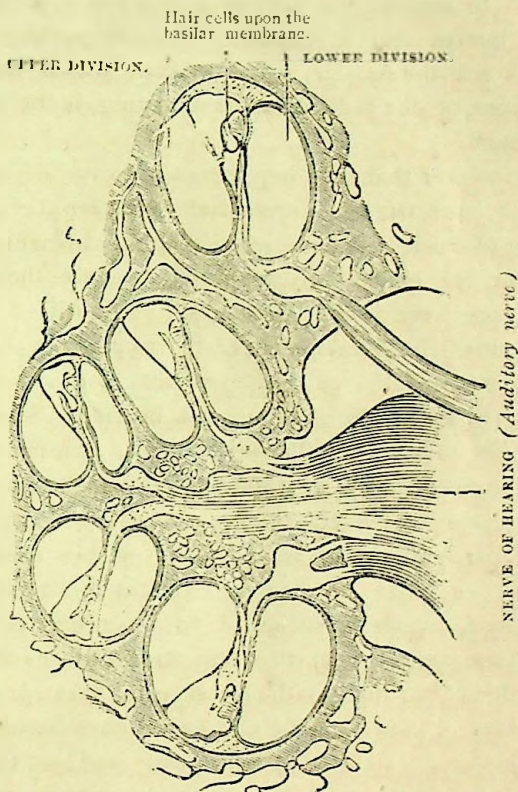


Fig. 76 - Section of Cochlea very much magnified.

(After Gray.)

and which like the strings of a piano vibrate in response to the particular note which reaches the ear. This is a matter of sympathetic vibration. Others do not find sufficient number of hair cells to be present

so as to account for the very numerous notes which the human ear is capable of distinguishing. They think that the *basilar membrane* on which the lower portions of the rods of corti are resting, is the analyser of sound.

However that may be, we can always develop our ear by practice to differentiate between the various notes of music. Those who from the beginning have an ear for music, are supposed to have their sound analyser very well developed; but still a certain amount of the development rests on practice.

We have told you just now that the semi-circular canals have nothing to do with hearing. The 3 semi-circular canals, each about  $\frac{1}{16}$ th of an inch in diameter, are placed almost at right angles to each other; they open into the vestibule through a common opening. The perilymph that is contained within them move when we move our head. The movement of the fluid it is said, causes a sensation to be generated in the auditory nerves, and this sensation tells us about the position of our body with reference to space. Animals deprived of their semi-circular canals have been found to be unable to balance themselves; and so these canals have been credited with the function of balancing or the equilibrium of the body.

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## CHAPTER XXVI.

*Sight*

or

*The Eye*

The eye is a wonderful organ; the mechanism by which we are able to see is simply a fascinating story. You must have patience to learn about it thoroughly.

The eye brows, the eye lashes and the eyelids are the external appendages of the eye. They have a protective function for the ball of the eye. The *eyelids* are composed of muscular fibres covered by skin externally and a very thin membrane internally which is called

**The Conjunctiva.**

The muscle which forms the substance of the eyelids is the muscle which we have talked of in a previous chapter. It is called the *orbicularis oculi* muscle. The *conjunctiva* is an exceedingly thin membrane. It not only covers the inner side of both the eyelids but also the white of the eye-ball. A little abrasion will cause it at once to swell up and be irritated.

At the junction of the two membranes is a row of hairs commonly known as eye-lashes, which protect the eye like a screen from the entrance of foreign bodies. At the base of these eye-lashes there appear also the openings of very little glands which secrete an oily material to lubricate the edges of the lids and lashes.

A stoppage and inflammation of one or more of these glands is recognised as *stye*.

Besides the external appendages that protect the eye there is a mass of fat in the socket of the eye in which the eye is embedded. This mass of fat is an additional source of protection for the eye; specially it protects the eye from being smashed up by blows.

The surface of the eye, so delicate it is, that it requires constant washing and cleansing. For this purpose there is

## MUSCLE RAISING UPPER LID

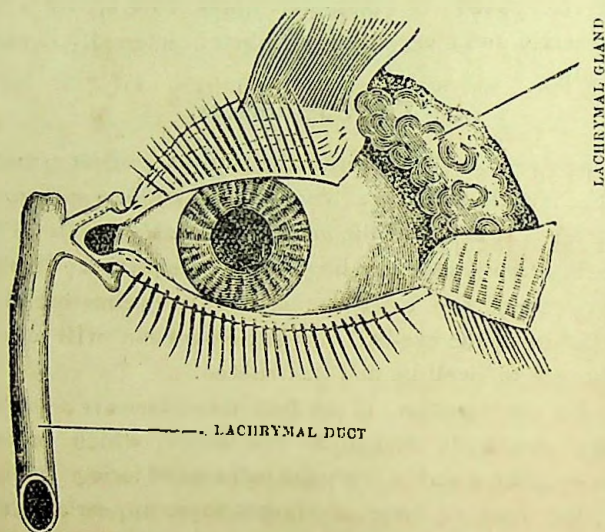


Fig. 77 - Diagram showing the lachrymal gland and lachrymal duct.

### The Lachrymal glands.

It is situated in the cavity containing the eye-ball which is known as *orbit*, at its outside corner i.e., on the side farthest from the nose. This lachrymal or tear-gland is constantly taking in some of the constituents of the blood and working them up into tears. Ordinarily only that amount of tear is produced which is just sufficient to keep the eye moist. But when you feel very sad or emotional, under the influence of certain nerve-impulse a large amount of tear is got up by the lachrymal gland and the surplus flows out over the eyelids running down the cheeks. But sufficient quantity of tear flows into the inner corner of the eye to be carried away by

### Naso-lachrymal duct.

which is the main pipe of this gland falling into the cavity of the nose. Hence persons afflicted with great sorrow, are always found to blow out their noses just to get rid of the tear that have been running in

But it is not enough that the eyeball should rest on a soft cushion and be kept clean by the tears. It must be used to see the various objects of the world from which we have to learn so much. To enable it to move conveniently in all directions there are no less than six muscles in each.

Four Straight ones ( Recti muscles ) called the *superior, Inferior, External* and *Internal recti muscles*.

Two Slanting ones ( Oblique muscles ) called the *Superior* and *Inferior oblique muscles*.

With the help of the following diagram you will be able to see how these six muscles act and pull the eye to different directions.

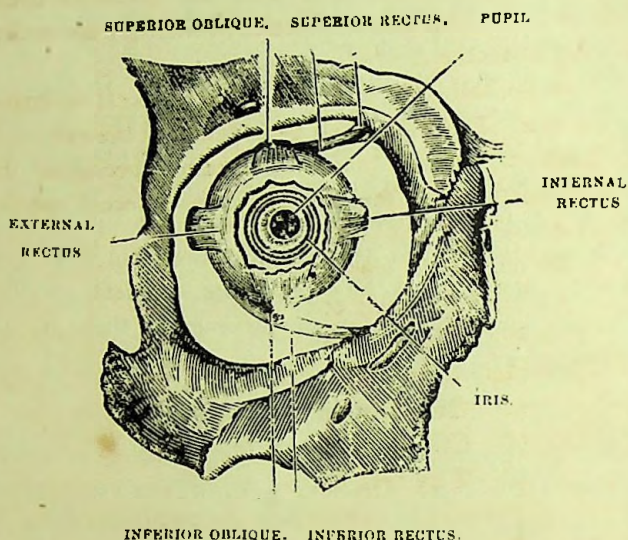


Fig 78—Showing the External muscles of the Eye.

The action of these muscles is very complicated. You can best understand how accurate must be the pull of the different muscles in order to enable you to carry your eyes from letter to letter and from line to line as in reading the pages of this book. How artful is the mechanism that controls the movements of these muscles and that mechanism is of course lodged in the brain. You must thank the Creator who has endowed you with such an intelligent and wonderful apparatus.

When your brain is injured, the control over your eyes is lost and the eye is deviated to one side or the other. Persons with squint eyes have not a well-balanced muscular control over their eyes and therefore their eyes seem to look in one direction while they are really looking at another.

Now I shall tell you about the *tunics* or coats of the eye. There are in all three tunics of the eye.

Each of these tunics is again specialised in certain portions of the eye to form different special structures.

In the outer tunic we have—

- (a) **Sclerotic coat**
- (b) **The cornea**

The middle tunic consists of—

- (a) **Choroid**
- (b) **Ciliary body**
- (c) **The Iris**

in the middle of which is the pupil.

The inner coat which is

A nerve network is called the **Retina**

The **outer tunic** composed of firm dense fibrous tissues and fine elastic fibers forms the white hard covering for the eye that protects the other more delicate coats inside. This coating covers five-sixths of the outer surface of the eye-ball, being thicker behind than the front and is continued in the rear as the optic nerve or nerve of sight. To this coat are attached the various muscles which move the ball. In the front of the eye where you see the black thing,

this coat loses its white colour and becomes exceedingly transparent like a piece of glass. It is here called the *cornea* as distinguished from the sclerotic. The cornea being transparent, the black colour of the next coat is seen in the centre of each eye.

The middle coat is a pigmented coat lining  $\frac{5}{6}$ ths of the eye-ball, internal to the sclerotic. In different individuals the colour of the pigment varies from black to grey, to green or bluish or even to reddish. Just where the white coat stops short in front of the eye, the middle coat is a little folded up inwards to form the hairy coat or the *Ciliary processes* and then just behind the cornea it is projected as a contractile circular screen called the *Iris* in front the Lens. It is something like the diaphragm of a photographic camera. The round hole which is left inside the iris is called the *Pupil*. The pupil corresponds with the aperture of the camera. The size of the pupil is variable. In the dark the pupil is dilated to take in as many rays of light as possible, while in the bright sun it is very constricted and small just to cut off the extra rays of light and save the delicate structures inside from being scorched by the sun. The size of the pupil is altered by the contraction of muscles in the *Iris* or the diaphragm of the eye. You may notice the effect of light on the pupil by placing your hand over the eye of some of your friend say for two minutes. On taking up your hand you will see that his pupil has grown bigger than it was previously ; but soon however on being exposed to the bright daylight, it will contract and regain its previous size.

Behind and touching the iris is the

### Lens (*Crystalline lens*)

of the eye. To give a common place metaphor, it is both like the jelly and the onion. In structure it resembles the jelly but instead of being all run together like the jelly, it is placed in layers like an onion. It is  $\frac{1}{8}$ rd inch in diameter and convex both behind and in front. This lens is suspended from the ciliary body by means of fine ligaments. The ligament of the lens can be made to lax or tense by the action of a muscle called the *Ciliary muscle* composed of involuntary fibers arising at the junction of the cornea and sclerotic. We shall later on see how important this muscle is in our act of vision.

In front of the iris, in the space between it and the cornea is a fluid called the

### Aqueous Humour.

Behind the iris and the crystalline lens is a bigger compartment formed by a very thin transparent membrane filled with a sort of semi-solid glossy matter called the

### Vitreous Humour.

The rays of light enter by the pupil, pass through the crystalline lens and the vitreous humour and ultimately reach the sensitive portion of the eye. This sensitive portion is composed of a network of nerves. This forms the third coat and it is called

### The Retina.

The Retina forming the inner tunic is situated at

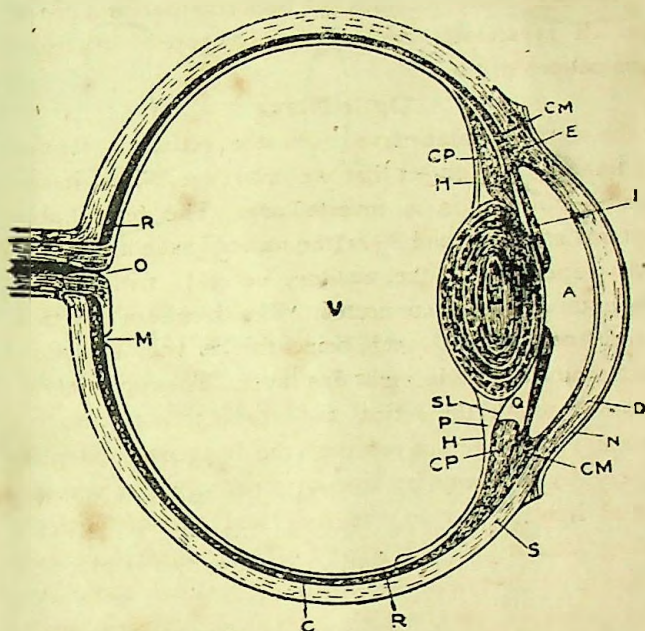
the back of the eyeball and capping all round the Vitreous Humour occupies the back compartment of the eye. It is almost exclusively composed of nerve terminations of the

### Optic Nerve

or the second cranial nerve. On the retina is formed the image of any object that we may see. The image formed, however is an inverted one. The retina also contains some *rods* and *cones* (the names I have mentioned when speaking of the auditory nerves) with which the optic nerve is connected. The thickness of retina varies from  $\frac{1}{60}$  to  $\frac{1}{200}$  inch, being thicker behind than in front, and it contains eight fine layers. The optic nerve passes through the retina and spreads out on its surface. The retina receives the images of external objects by means of its layers. Probably the perception of light is due to the rods and that of distinguishing colour to the cones. The central point of retina is called *macula Lutea* or yellow spot, the most sensitive part, which helps one to see small objects distinctly when they are directly turned towards it.

The diagram at page 288 shows how an inverted image of an ordinary tumbler is formed after passing through the crystalline lens. Then how is it that we normally see things in proper position as they are? We do not mind what sort of image may be formed in our retina; it is with the perception of the object that we are concerned. Judging from this view, we may say that we rather see with our brains than with our eyes

Fig. 79—Vertical Section of the Eye.



**DIAGRAM OF HUMAN EYE IN SECTION.**

- |      |                             |      |                             |
|------|-----------------------------|------|-----------------------------|
| S.   | Sclerotic.                  | M.   | Macula Lutea.               |
| D.   | Cornea.                     | O.   | Optic Disc                  |
| N.   | Epithelial Layer of Cornea. | S.L. | Suspensory Ligament of Lens |
| C.   | Choroid.                    | H.   | Hyaloid Membrane.           |
| I.   | Iris.                       | P.   | Canal of Petit.             |
| C.P. | Ciliary Processes.          | V.   | Vitreous Humour.            |
| C.M. | Ciliary Muscle.             | Q.   | Posterior Chamber.          |
| E.   | Canal of Schlemm.           | A.   | Anterior Chamber.           |
| R.   | Retina.                     | L.   | Crystalline Lens.           |

which are merely sub-stations where impulses from outside are collected and transformed so that they may be appreciated by the brain.

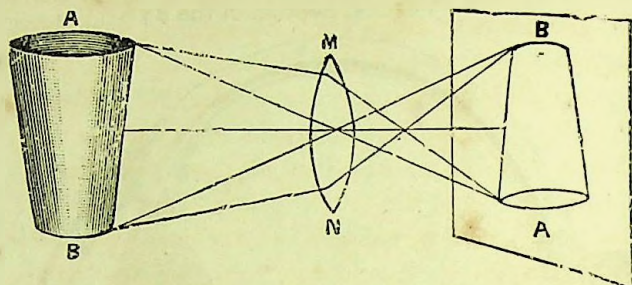


Fig. 30—Showing how an inverted image is formed by rays of light passing through a convex lens.

A. B.—a tumbler. M. N.—convex lens. B. A.—inverted image of the tumbler received on a screen.

You know that if you place a candle in front of a convex lens and try to obtain its shadow on a screen on the opposite side you get an inverted image of it formed. This image is distinct if the screen is placed at some particular distance from the lens but gets blurred if either the screen or the candle be removed from its proper position. Now in the case of your eye the crystalline lens is a double convex lens and the retina is the screen on which shadows of external objects are to be distinctly focussed. The external objects are at different distances apart from the lens. Then how is it that we are able to see objects with almost equal distinctness be they placed near to or far from us? For this purpose there is a mechanism of *Accommodation* which is constantly at work. This accommodation is accomplished not by moving the lens as in the camera or microscope,

but by changing its convexity. Our human lens is made up of elastic fibers, and its anterior surface is kept flattened by the tension of the elastic suspensory ligament. It can contract and expand the convexity of the lens and thus, changes in its curvature are produced. These are automatically done in the human eye which is now seeing some printed matter and at other times looking out through the window into the streets. The ciliary muscle by regulating the ciliary processes on which the suspensory ligament is dependent, forms the chief mechanism of accommodation. When it contracts, the ligaments of the lens relax and the lens becomes more convex, and *vice versa*.

Those who are long-sighted or short-sighted have a short and a long eyeball respectively. So these persons, if they do not wear glasses, have to accommodate more than ordinary man has to do under the same circumstances, in order to overcome the difference in length of their eyeball. This puts an extra strain over their eyes. Such eye strain often results in very bad types of headache. Headache in young persons, therefore, often point to some defect in their eyes and in fact many a defect of the eye has been found out simply due to the headache of eye strain.

Short-sighted persons have a long eyeball and so the rays of light do not form an image on the retina but in front of the retina. Hence by the use of concave glasses such a defect may be easily corrected.

In long-sighted persons the reverse is the case. The length of the eyeball becomes short and the rays

of light instead of crossing on the retina cross behind it. So the image formed is a blurred one as in the previous case.

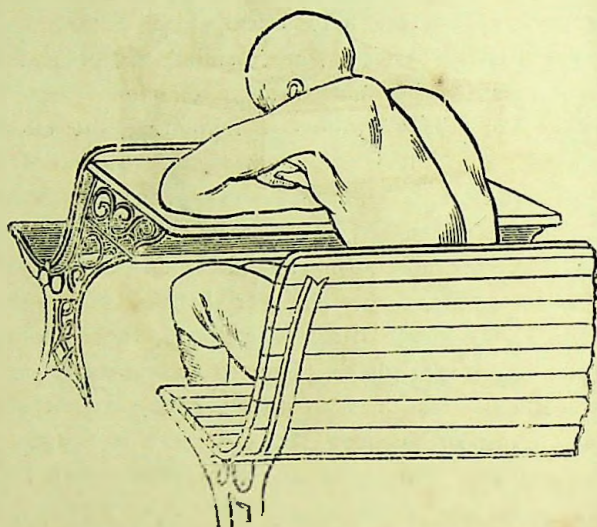


Fig. 81—Diagram of faulty position during Reading.

Most of the cases of defects of the eye among our student community are due to faulty positions of the eye in reading and writing. Figs. 81 will show you how much you have to twist and bend the rays of light before they can reach the retina if you sit in a faulty position and how easy it becomes when you sit up straight with the book just in front of you, (Fig. 82).

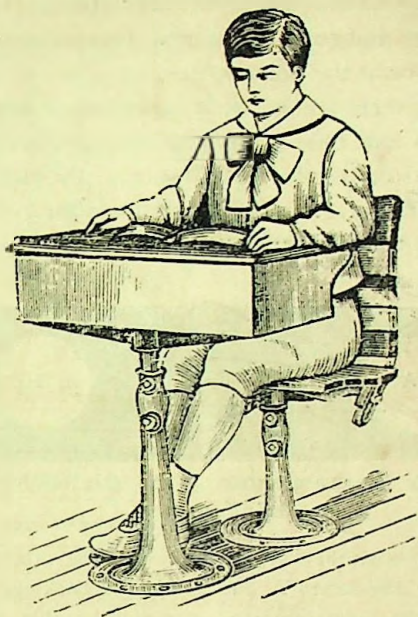


Fig.—82—Diagram of correct position for reading.

But sometimes boys and girls have been found to lean over and over again in spite of being told not to do so. In those cases the cause of the bending of the head must be sought for in some defect of the eye.

We have told you so much about the eye and its wonderful mechanism for seeing objects. The retina, we have said, is the sensitive part of the eye. In the retina are to be found 8 or 9 layers of structures,—the layer of rods and cones, the layer of nerve cells,

nerve fibres etc., etc. Of all these layers, the layer of rods and cones is the real receptive organ for the eye. For at the point where the optic nerve enters the eyeball, there are no rods or cones; now if any image falls on this point you cannot see anything. This point is called the blind spot. By the help of the following diagram you will be able to verify the existence of the blind spot.



Fig. 83—Diagram showing the existence of the blind spot.

**Direction**—Shut the left eye and with the other eye look attentively on the letter A and move the book away from or towards you. At a certain distance you won't be able to see the letter B. In that position the image of the letter B falls on the blind spot and so it causes no sensation in your optic nerve.

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# APPENDIX—A

## Endocrine Organs and Incretion

Secretions are classified in two groups, the external secretions being those that are poured out upon the cutaneous or mucous surface. Examples of external secretion are the saliva poured into the mouth ; perspiration poured out upon the surface of the outer skin ; gastric juice poured out in the stomach ; bile from the liver into the intestines etc. There are certain organs within our body which secrete only inside themselves,—Thyroid, the Suprarenals etc. This class of secretions have been denominated as *Internal Secretions* or in short *Incretions* ( to distinguish “excretion” from other glands ). There are on the other hand, certain other group of organs which perform double functions—that of internal and external secretions. For example, the Pancreas prepares the well-known Pancreatic juice which is no less than external secretion poured out into the duodenum as an important digestive factor ; it also prepares an internal secretion from within the cluster of epithelial cells known in medical parlance as the *Islets of Langerhans*. This internal discharge is absorbed back into the blood to exert fundamental influence on the assimilation of sugars in the body. The Liver prepares an external secretion—the bile which is poured out into the intestines to exert a contributive influence on digestion ; it also prepares several substances that are absorbed back into the blood for nitrogenous metabolism, destruction of toxins etc.

The history of internal secretions opened its first page from the year 1849, when A. A. Berthold of Gottingen showed by convincing experiments, how blood through special organ of the body underwent some special changes in composition and physical property by virtue of which it could regulate the entire organism. Berthold can really be ascribed to as the discoverer of the internal secretion of the body and the medical men of the present day give him the credit of being the pioneer in putting up experimental evidences with respect to incertions. But the doctrine had not had a veracious scientific footing until the year 1889, when in 1st June at a conference of the Society de Biologie, Paris, Brown Sequard, then on the wrong side of 70, delineated in a confirmed and vivid way the experiments which he performed upon himself by subcutaneous injections of testicular extract, resulting in a mental buoyancy, physical strength, recuperation of cerebral activity etc. His explanations found an easy conviction in the minds of medical erudites of England and France, which no doubt laid the foundation stone of the theory of the internal secretion of endocrine organs and contributed to the first application of a new method of treatment now known as organo-therapy.

The name internal secretion or *Secretion Interne* was first adopted by Claude-Bernard. The organs which secrete the incertions are called the *Endocrine organs*. To give a clear definition of these glands, we should put it thus :—Organs of the body that yeild

to the blood, in addition to the common metabolites resulting from the general life processes of cells, certain specific products that influence even the remotest part of the body and to a great extent regulate one's personality, are designated *Endocrine Organs* and the specific chemical substances thus generated known as *Internal secretions*. These organs are sometimes termed "Ductless Glands" to distinguish them from glands whose products issue forth through channels or ducts lined by epithelial cells.

The principal endocrine organs are the Thyroid, the Parathyroid, the Thymus, the Suprarenal glands, the Gonads, the Pituitary gland (*Hypophysis cerebri*), the Pineal gland (*Epiphysis cerebri*): and the insular tissue of the Pancreas (Islands of Langerhans), the Spleen, the Liver, the Kidneys, (as some Aopine) also the salivary glands, the prostate and the bone marrow, in females the Breast (Mammary glands), the Ovary and the Placenta, perform their endocrine functions *pari passu* with their other physiological activities.

Analogous to the idea that the Endocrine products emerges into and are carried by the blood or lymph to distant parts, regulating the activity of the cells there, the term *Hormone* (which means 'I arouse') was suggested for these incretions by Bayliss and Starling. But apart from acting as excitants or depressants of the distant cells as they are supposed to be, these secretions are positively known to perform the function of *neutralizing poisonous substances* circulated in the

blood. As such, the term "Hormone" has acquired for itself a more limited connotation.

The growing knowledge about the Hormones have brought home to our mind more than ever the truth that our physiological processes are being mediated through two distinct agencies : (1) The agency of the Nervous system and (2) that of the Internal Secretions. And the last is the better, more desirable and prolific one, as much as it does not tire out the organ they act upon and preserve the slow but sure continuity of its secretion.

The ways and means in and by which the specific products of the endocrine organs influence the rest of the body are gradually being found out, though the domain of internal secretions remains much yet to be explored, with of course greater possibilities before it. We shall now try to describe in brief the position, structure and special functions of each of these wonderful glands one by one.

First of all, let us take out

### The Thyroid Gland.

This organ consists of two maroon coloured small masses situated astride the neck, above the wind-pipe partially covering it and close to the voice-box or larynx. The two main masses are bridged over by a narrow isthmus made of the same tissue, the whole structure having a weight of about 30 to 35 grams. The gland is covered by a capsule to keep it in position. When examined under microscope, it shows closed

spherules lined by a single layer of epithelial cells enclosing a gelatinous substance generally known as *colloid* containing a high percentage of Iodine. This Iodine is the active agent of this gland.

The Thyroid is chiefly the gland of energy-production. It elaborates an incretion which increases the metabolic or the combustion rate of the system and thus brings about growth and generation of energy. Besides the action as an energiser, it is a growth catalyzer and has a remarkable power of differentiating tissues, *i.e.*, of speeding the activity of the cell—greatly of the eyes, skin, hair, nail, teeth etc. The thyroid is indispensable for normal growth and development of organism. In cases of morbidity or atrophy of the gland, such as occurs in *cretinism* of children, the failure of physical and mental growth is remarkable.

The internal secretion of the Thyroid has an anti-toxic property, *i. e.* of preventing the inevitable results of poisoning. It insures resistance against poisons including microbes, bacteria etc. which cause and spread infectious diseases, and is a nice antiseptic agent for the blood. It has been found out as a result of extensive experiment that thyroidless animals are more susceptible to infection. It is also established that Thyroid incretion goes a great way in the regulation of mental activity (exerting influence over the sympathetic nervous system and cerebrum), the body temperature and respiratory process (intake of Oxygen and output of Carbon dioxide).

### Para-thyroids.

Are generally four in number and are in close apposition with the thyroid. They are often embedded in the masses of the Thyroid, only distinguishable by a separate capsule made of connective tissues. The physiology of the Parathyroids has not yet been fully determined and its precise functions are still a matter of controversy. This much has been proved that it regulates the calcium (lime) metabolism of the body and maintains excitability of nerves and muscles. Certain experiments point to its antitoxic function like the thyroid apparatus, chiefly neutralizing amino-acids and certain agents of bacterial growth in the bowels.

### The Pituitary Body.

The Pituitary Body consists of a lump of tissue made mostly of columnar and granular epithelial cells, about the size of a pea, lying at the base of the brain in the *Sella Turcica* or the Turkish saddle—a very small cup-shaped depression in the Sphenoid bone. It is so small in structure that so long it escaped the attention of scientists.

The gland is mainly made up of two parts—the anterior lobe and the posterior lobe. The removal of the anterior lobe is always attended with fatal results. Its chief blood-supply is from the Internal Carotids and the nerve supply presumably from the sympathetic. The only demonstrable function attributed to the Anterior lobe is to exert a profound influence on the growth, development

and nutrition of skeleton and to some extent the cartilage, tendon and ligament. The incretion from the Posterior lobe—the so-called "Pituitarin" maintains the tonicity of the tissues and smooth involuntary muscle-fibers of blood-vessels and all contractile organs (excepting the kidneys) of the body, such as uterus, bladder, intestines stomach, spleen etc. It controls the salt-content of the blood and maintains normal blood pressure. It is also said to be an indirect agent in stimulating the growth of nerve-cells and sex-cells.

### The Adrenal glands.

These bodies I have touched upon in a previous chapter. As has been already stated they are situated just above the kidneys like two helmets, the posterior ends touching the diaphragm, and usually two in number. They are yellowish of colour, the right being triangular in shape and the left almond shaped of about  $1\frac{1}{2}$  inches in length and  $\frac{3}{4}$  of an inch in breadth, both weighing from 5 to 7 grams. These glands are richly supplied with blood as it has a tremendous importance in the human economy. In higher vertebrate animals, each adrenal shows a distinct division into two parts :

(a) *The Cortex* (upper portion)—derived from germinal epithelium from which testes grow in male and ovary in female.

(b) *The Medulla* or *core* (inside portion)—is made up of exactly such cells as are found to give rise to the nerve-cells and sympathetic ganglia.

Adrenals derive its blood-supply mostly from the

abdominal aorta and renal arteries. The nerve-supply is chiefly from the sympathetic.

Each division of the glands has its distinct incretion. The nature and precise functions of the cortex are not definitely known. But it has been concluded that it plays an important part in the development of sexual organs and certain psychic growths. The medullary secretion of the Adrenals are something like an emergency-store for the sympathetic nervous system. Pain, anger, fear, or any sort of excitement calls forth a good deal of secretion from the medulla which then influences almost all the organs of the human body through the sympathetic nerve-fibers. What takes place is the with the pouring forth of the "adrenalin" (as the incretion is named) into the blood, the whole system is practically bucked up into activity, so that the heart beats more rapidly, the blood pressure goes high, eyes see more clearly, ears hear more distinctly, respiration-rate runs up, body temperature is increased, muscular efforts are revived or enhanced, and so on.

### Pineal gland.

The Pineal gland is almost oval in shape, hidden away in the base of brain (projecting from the roof of the 3rd ventricle) in a tiny cave, behind and above its larger colleague—the Pituitary. The Pineal is larger in children than in adults and in female than in males. The Pineal is most useful in the time of adolescence in bringing about a marked growth in physique,

mentality and sexuality. Experiments have been performed in little boys (within the age of 15) with backward growth by feeding them with pineal gland continuedly for a few months, attended with exceedingly satisfactory results. Just when the puberty sets in, the sex-organs is suddenly matured, body and pubic hairs are grown, a change in voice is marked, thought and speech are developed, shyness, formality, excitability, amativeness and other new traits begin to manifest; these are normal functions of the secretion of the Pineal. The Pineal is almost dormant during the middle and later part of one's life.

### The Thymus gland

The Thymus is an organ of 2 lobes, subdivided into many lobules, composed of a cortex and medulla (like the Adrenals). It is situated inside the chest astride the lower end of the wind-pipe or trachea, overlapping the large blood-vessels near the base of the heart. The cortex shows almost like a lymph-gland and when examined under a microscope exhibits a good many number of lymphocytes. The medulla is made up of a cell-network, in the meshes of which are found large number of peculiar cells called the *Hassall's corpuscles*, which are said to elaborate the internal secretion. The Thymus is larger in infancy and undergoes emaciation with the advance of age. The normal functions of the thymus is not much clearly defined except that it is the gland of childhood which keeps the children childish.

### The Pancreatic gland

You have learnt something of this gland in our previous talk about the digestive tracts. You know that this gland is situated below the stomach near the Solar Plexus and is solely concerned in the carbohydrate metabolism of the body. It is an organ with both external and internal secretion, both of which are so inter-dependent that one cannot act without the other. The excretion called "the Pancreatic juice" falls in the 12 inch pipe Duodenum through a duct; while the secretion called the "Insulin" generated from the specialised cells in the innermost region of Pancreas—called the Islands of Langerhans—is poured forth into the general circulation to control the sugar metabolism of our system. It is needless to say that the saliva and Pancreatic juice are instrumental in digesting the carbohydrate portion of our food and changing it into glucose to be deposited in the liver as glycogen. The liver goes on giving out to the blood in the form of glucose certain amount of its glycogen according to the needs of the tissues of the body. Now, what the "Insulin" does, is that it acts as a brake to or controls the generation of glycogen (Glycogenesis), the storing up of it in the Liver and its elaboration to the blood in the form of glucose. In cases of the deficiency of insulin (as is found in *Diabetes Mellitus*), glycogen is produced and stored up in greater quantities and a higher percentage of glycogen being split up into glucose is given out to the tissues that are unable to utilize all of it. Necessarily the surplus comes out

in the urine through the kidneys, with the salient symptoms of progressive loss of weight, thirst, asthenia, hunger and dry itchy skin.

## The Gonads

### (The Sex Glands)

The Gonads signifying the testes in the male and ovary in the female in addition to giving out their external secretion in the form of *spermatozoa* and *ovum* respectively, elaborate an incretion from a specialised tiny gland called the *Interstitial gland* composed of a peculiar group of cells (now known as "Leydig cells"). The functions of these cells have been studied for years in series of eunuchs or individuals from whom the testes were cut off. In male, if castration preceded their puberty, the following signs were noted :—

- (a) That generative organs do not grow.
- (b) Moustache and beard do not appear on the face.
- (c) Voice remains high-pitched as in children.
- (d) Muscles get flabby and weak.
- (e) Mental condition remains dull, indifference and lassitude supervening in every work.

The individual shows one of feminine type.

In female, whose ovaries with the Interstitial glands were cut off, signs just reverse to those of the normal female, were noticeable. Such as—

- (a) The pelvis do not grow.

- ( b ) Breasts do not develop.
- ( c ) Hairs come out on the face like males.
- ( d ) Voice gets low-pitched and hoarse.
- ( e ) Psychic conditions get sub-normal, the woman having become stunt-headed, dunce and inert in every respect.

The woman shows one of male type.

From all these observations it is now deduced that the Interstitial gland in the female ovary and male testes play a very prominent role in the evolution of primary and secondary sex-character ; or in popular language one might say that the absence of the Interstitial and its incretion means absence of manly man and womanly woman.

Now, I shall point you to the following chart which, I think will be of great help in remembering the principal endocrine organs, their incretions and normal functions :—

<i>Name</i>	<i>Secretion</i>	<i>Normal Function</i>
1. Thyroid	Thyroxin	Energy production, control of the growth of specialised organs, tissues, brain etc.
2. Parathyroids ( Unknown )		Control of the calcium salt and regulation of the nerve excitability.

<i>Name</i>	<i>Secretion</i>	<i>Normal Function</i>
3. Pituitary		
Anterior	( Unknown )	} Growth of skeleton and support of tissues.
Posterior	Pituitarin	
4. Adrenals		
Cortex	( Unknown )	} General growth of body and development of sexual organs.
Medulla	Adrenalin	
5. Pineal		
	( Unknown )	} Regulation of sexual character before puberty, growth of muscles and mentality.
6. Thymus		
	( Unknown )	} Gland of childhood.
7. Pancreas		
	Insulin	} Control of glycogenesis and blood sugar.
8. Gonads		
Testes ( male )	} known, but not named	} Direct regulator of primary and secondary sex-traits.
Ovary ( female )		

## APPENDIX B.

What becomes when the Endocrine organs increte  
below Normal ( Hypofunction ).

<i>Names of glands.</i>	<i>Hair</i>	<i>Skin and face</i>	<i>Stature and skeleton</i>	<i>Mentality and nerves</i>	<i>Sexual organs.</i>	<i>Gastro-intestinal tract and teeth.</i>	<i>Heart and lungs,</i>	<i>Metabolism etc.</i>
<b>Thyroid</b>	Scanty growth, brittle, dry, dry of outer eye-brows thin	Thick, rough scanty dry skin.	Thin small stunted unsymmetrical, with thick club-like fingers.	Dullness, imbecility, lassitude, submission, lack of initiative.	Lowered activity, In females amenorrhoea.	Delayed dentition, Habitual constipation, ill formed teeth	Low blood pressure, slow heart action.	Low body-temperature, great carbohydrate tolerance, often obesity.
<b>Para-Thyroid</b>	*	*	*	Possibility of Tetany, spasm of muscle, too sensitive to outer agents.	*	Defective teeth, often bowel complaints	*	*

<b>Pituitary</b> (Combined)	Scanty growth	Soft white delicate, dryness of skin after puberty.	Small stature, short bones, tapering fingers,	Headache, drowsiness, indifference, retarded mentality, cowardice.	Small sex organs, lack of sexual desire, amenorrhoea.	Often a little low blood pressure, slow pulse, easily fatigued.	Low metabolism, obesity near the breast or girdle, increased carbohydrate tolerance.
<b>Adrenals</b> (Cortex and medulla)	Scanty growth	Often dark colour, more often near the genital organs and nipple.		Lack of interest and courage, idle habit, peevishness.	Poorly developed.	Low blood pressure, shallow breathing.	Defective carbohydrate metabolism, loss of weight.
<b>Ovaries</b>	Absence or scantiness of hair in armpit and on pubis.	Face often devoid of feminine charm.	Tall slender skeleton with rough hands,		Undeveloped sex-organs, irregular menstruation.	High blood pressure.	Low metabolism, often unsymmetrical obesity.
<b>Testes.</b>	Lack of pubic hair, beard and mustache but long hair on the head.	Thin, fairly white skin, womanish face.	Tall thin type with tender, flabby arms and legs, weary steps.	Slow mentality, lack of incentive, courage and strength.	Small undeveloped organs.		

## What becomes when the Endocrine Organs increte above Normal ( Hyperfunction )

<i>Names of glands.</i>	<i>Hair</i>	<i>Skin and face.</i>	<i>Stature and skeleton</i>	<i>Mentality and nerves</i>	<i>Sexual organs</i>	<i>Gastro-intestinal tract and teeth</i>	<i>Heart and Lungs</i>	<i>Metabolism etc.</i>
<b>Thyroid</b>	Rich growth fine texture and lustre	Soft, very often white moist skin, increased perspiration	Slender bones tapering fingers.	Anxiety, restlessness, eruptions, insomnia irritability, tremor	Lowered sexual activity.	Constipation and some times violent diarrhoea, indigestion, acidity, vomiting, pearly teeth	Irregular heart action, palpitation depression of blood pressure, rapid breathing.	Increased metabolism, lowered carbohydrate tolerance (glycosuria) loss of weight.
<b>Para-thyroid</b>	*	+	Calcification increased.	*	*	*	Blood pressure greatly increased.	Calcium contents of blood and tissues rising to a high level
<b>Pituitary</b>	Heavy growth specially on chest, eyebrows, extremities	Thick lips, high or thickened nose, large tongue, tough skin, lower jaw well marked	Large skeleton (giantism) thick large fingers, enlarged feet.	Dull mentality, easily discouraged, occasional stupor with headache	Large sexual organs. In females amenorrhoea or sterility. sexual appetite soon wanes.	Teeth widely spaced.	voice changes to heavy tone, blood pressure rises, heart action increases followed by insufficiency	Increased metabolism, carbohydrate tolerance decreased, followed by glycosuria.

Ovaries	Early growth of hair on the pubis and arm pit		Rapid development of large firm skeleton	Untimely ripeness of brain and mind, precocity.	Precocious development and desire. Early menorrhagia.	Early dentition.	Low blood pressure.	*
Testes	Ditto and also plenty beard and moustache		Ditto	Ditto	Ditto	Ditto	Often low blood pressure.	*
Thymus	Scanty beard and moustache. In female no hairs in pubis and armpit.	Very often white delicate skin.	Either tall or short features markedly of opposite sex.		Sex organs often undeveloped	Some teeth large (often middle incisors)	Asthmatic tendency irregular heart, difficult respiration.	*
Pineal	Extensive development.		Increased height.		Enlarged sex-organs, early puberty.	Tendency to intestinal disorders.		Fat-increase, great carbonate tolerance.

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## **HEALTH AND HAPPINESS**

Edited by Dr. K. C. Bose, M. B.

The paper will teach you, rather *talk* to you like a friend, about all interesting topics of health, strength and social hygiene. It will keep you fit up to 80 and make for you a happy family and cheerful home. A monument of useful informations. Circulated throughout India and abroad. Specially published for the educated laymen and students, also contains useful papers for practitioners. Best medium for advertisement. Specimen free. Write or remit to

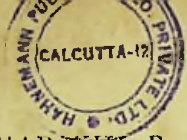
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