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P H Y S I O L O G Y . (Lecture No. 29.)

Flesh foods always contain various organic poisons, the most important of which are uric acid and xanthine bodies. Uric acid is a stimulant, and has a very detrimental effect upon the tissues. It is the deposit of these substances in the tissues and joints that leads to the various kinds of rheumatism, gout, and kindred diseases. The following brief table gives an approximate estimate of the number of grains per pound of some of the common varieties of flesh foods:

	3 1-2
Veal	3 1-3
	6 1-2
Mackerel	2.2
Hospital beef tea	7
Meat Juice	49.7
Meat Extract	63

We are surprised to see the large amount of uric acid that is contained in the so-called meat juices, and meat extracts. In fact, the bulk of the solid constituents of these juices is made up of organic poisons, chiefly uric acid and xantine. This easily accounts for the stimulating effect of these often prescribed "foods," and shows us that they must be very harmful to the system. If a single pound of meat extract contains as much as sixty-three grains of uric acid, it must be a dangerous food, to say the least. When we remember that uric acid is with great difficulty eliminated from the system, we are not surprised at the great frequency of rhemuatism, gout, etc.

In this connection I will give the amount of uric acid contained in the common drinks:

Cocoa	59	Grains to the pound.
Coffee	70	
Tea	175	

We thus see that meat extract contains almost as much uric acid as coffee, and a little more tha cocoa. Tea of course contains a much larger amount. This little table explains very lucidly the reason why flesh foods are so stimulating and irritating to all the tissues of the body,, and they ought to be discarded from the table entirely. We see at once that the only difference between hospital beef tea meat extracts and the stimulating drinks like coffee and tea is in degree. They all belong in the same cupboard --tea is on the highest shelf, and the others are on some of the other shelves. Their effect is identical, only differing in severity. If these substances were only used once or twice, or only for a brief period, they would not have such a profound effect upon the body, but when we take into consideration the fact that they are used day after day, for weeks months and years, we are not at all surprised at the large amount of disease produced by these harmful substances. On accou t of the inability of the body to eliminate uric acid and kindred poisons readily they are retained in the body and deposited in the tissues. Just as soon as they begin to be stored up in the tissues that means that the blood is continually clogged with the poisons, and will contain these poisons in different quantities just as long as they are not properly eliminated. Nature is doing her best to get rid of t e poisons, and consequently is taing them from the tissues, but there is a limit to the excretions, and consequently there is the bringing on of rheumatism and gout.

Now let us turn to the vegetable diet and some of the advantages that accrue from the use of vegetable foods. In the first place let me state what the vegetable foods are: We might describe them as consisting of the fruits nuts and gains, and what are properly called vegetables. Of these four varieties the first three are the most wholesome as well as the most nutritious as a rule. I do not mean that the vegetables ought to be discarded entirely,--potatoes are a very wholesome food, although they are not as easily digested as some of the other forms of starch, yet they form a good food for the healthy person. However, I must say that vegetables like cabbage,turnips, onions, &c., do not form the best food, and we would get along better by eliminating them from the bill of fare. In the first place they contain very little nutriment, as we shall see from tables later on, and in the second place they are digested with great dfficulty. They require a longer time for digestion, and are liable to overtax the digestive organs. Perhaps potatoes are the most wholesome of all the vegetables. I would include not only the common Irish potato, but the sweet potato, which is, if anything, fully as nourishing. I might say in passing that vegetables like the cabbage, lettuce , etc, are more wholesome in their natural state and more easily digested than if they are cooked, so that for a healthy person "slaw" is much more easily digested than is boiled cabbage.

Now some of the advantages of a vegetarian diet: Foods coming from the vegetable kingdom are in the purest forms. The apple is perfect for food as long as it is sound. It is full of life. The skin protects it, and it is maintained in that healthy condition until it is eaten. This is true of almost all foods coming from the vegetable kingdom.. The potato is stored away in the cellar in a living condition, and if properly cared for will grow when planted the next year. The same is true of all the vegetables and all the fruits, and of grain, until it is ground into flour, and even then it does not lose all of its living qualities, although of course it cannot be made to germinate and grow. Th This means that these vegetable food substances are capable of resisting putrefaction and and decay processes, As long as they are alive and properly preserved. They retain this condition, until they are served up on the table. This, you see, is very different from the flesh food, which begins to decay just as soon as life leaves the cells. Some one might ask me this question: "Is the food injured by cooking it." No, I do not think so, although the fresh fruits are believed to be more wholesome when they are perfectly ripe than when they have been preserved for some time. Of course this depends largely upon the methods of preserving. If the fruit is preserved in sugar, so that large quantities of sugar are used, then the fruit loses its delicate flavor and becomes difficult of digestion because of the large amount of sugr present. It is far better to can the fruit using but little sugar, boiling the cans and fruit thoroughly, and them sealing them thoroughly, and then they will keep for years, and the fruit will be in just thesame condition when the can is opened as when it was closed after boiling. Preserving fruit in thtat way does not alter its wholesomeness to ant extent whatever.

Again, fruit is free from disease. Germs that cause disease do not grow and thrive in fruits and vegetable foods. This I believe to be due to the vegetable acids and salts found in the vegetable foods, and that serve as a means of protection. Of course, fruits and all plant foods are subject to decay, and they "rot" as we say, but the germs that bring about this kind of disease are not pathological germs,--they are not disease-producing germs, and that makes a great difference. Take for example, when a man unwisely eats a rotten apple: It doesn't give him tuberculosis or typhoid fever or malaria, --it will merely produce temporary indigestion and possibly a slight fever. But it is not necessary to eat rotten or spoiled food of any kind, for this can be easily distinguished and rejected.

Again, vegetable food is the cheapest food. It is the cheapest not only from a financial standpoint, but from a nutritive standpoint. The common corn, which contains three times as much nourishment as xxxxxxxx does flesh foods, is obtained all the way from two to six cents a pound. Beefsteak would probably cost from ten to eighteen cents a pound. Suppose that the cornmeal costs three cents a pound,--which would be rather high,-- and the meat only costs twelve. You can easily see, then that the corn meal is twelve times as cheap, when you come to take into consideration its nutritive value . Some may doubt whether the cxxxx vegetable foods xxxx contains all the necessary food elements. I am glad to answer that they containx not only all of the food elements, but in the most perfect combination. Flesh foods are made up almost wholely of proteids and fats, and contain little or no starch. The various grains contain all of the three food elements , as well as the various salts tht are necessary to the body. Take oatmeal, or cornmeal, for instance , and we hg an abundance of starch. We also have a quantity of fats and proteids. Indded, the grains, wheat, oats, and corn, each form almost perfect foods as far as the food elements are concerned. Whole-wheat bread may indded be considered the staff of life, for it contains almost exactly the right proportion of starch, proteids and fat.

We must now pass on to the nutritive value of foods, and will first consider some of the most common grains.

Wheat, 87-9 %, corn 84, oats 85, rice 87. Wheat flour contains but 84 per cent, whole wheat bread 82 %, while ordinary white bread contains a little more than two-thirds as much,, or 55%. White bread is poor food. It not only contains a relatively small amount of nourishment, but also contains a very small amount of proteid material. It is interesting to note that the proteid element lies just underneath the outside scale, or bran, as we call it. Now then, in preparing wheat flour, this part is removed from the wheat, and consequently the white bread is almost pure starch, and is but little more nutritious than the ordinary Irish potato. This explains the fact that the growing child fed on white flour does not develop properly, and are liable to such diseases as ricketts, etc. Bear in mind that the proteids are necessary for new tissue formation. Starches are available only for the formation of animal heat, and not for the purpose of forming new cells. Now then, the child needs good nourishing food that can build up the bone and muscle and nerve tissues of the body, and this element is found only to the very slightest extent in white bread, and by no means in sufficient quantity to sustain the demands of the growing child. But legumes are very nourishing; lentils have 84%, peas as high as 90% --depending upon the variety, and beans 87%. The flour made from beans is still more nutritious, and contains 91 per cent of nutrient material,--in other words, it is almost a perfect food.

We will now consider the nutritive values of some of the common fresh fruits: The average apple contains about 14%, the peach 13%, the banana 26, grapes 18, and strawberries only 10%. It is seen that the banana contains the same amount of nourishment as lean beef, chicken, and some other varieties of flesh foods. Of course the nourishment of nutrient matter of the banana is composed chiefly of sugar and starch, and a very little proteid. On the other hand the lean beef consists almost entirely of pure proteids. But we must bear in mind that the flesh of the fruits is not only valuable for the amount of nutriment contained; fruits contain mild acids in abundance, and various salts which are not only wholesome, but are actually required by the body, and which act as a natural stimulus to the digestive processes. Indeed some of the fruits,--for example the pineapple, contains aferment tht actually aids in digestion. Dried fruits are much more nourishing than the fresh fruits, and this is easily explained, because in the drying process the largest part of the watr is evaporated. Dried prunes contain 69 % nourishment, pears and raisins 66%, and dates 67%. All these four varieties are exceedingly wholesome and very nutritious, and my be used in much greater quantities than are usually provided on the bill of fare. Prunes are especially nutritious, and act as a mild laxative, and are thus useful to overcome constipation. Raisins to be wholesome should be stewed and the seeds should be rejected.

We must now pass on to nuts, and we will only mention two of the more common varieties. Walnuts are exceedingly nutritious, containing 88% of actual nutrient material. This is made up of starch, sugar, and a large amount of fats, and some prpteids. Peanuts contain 79 %. The peanut is not really a nut, but nevertheless it answers the purpose of nutsm and is exceedingly wholesome when properly eaten. The only objection to nuts of any kind is tht they are not properly chewed, and are consequently difficult of digestion, and may sometimes even act as irritants. Nuts, to be absorbed into the system, must be thoroughly ground between the teeth and emulsified, and if this is done they are readily digested. Preparing the nuts by grinding them in machines is a splendid way to prepare a wholesome article of food, as well as one that is very nutritious. Hon y contains 79 per cent of nourishment , almost all of it consisting of sugar of both varieties, but chiefly cane sgar. For this reason honey should not be eaten in large quantities, because the cane sugr is diges ted with greater difficulty than is the grape sugr or the s gr found in the ordinary fruits. Honey ca not be taken by some people on account of a somewhat unexplainable idiosyncrasy.

We will now consider a few of the mor common vegeta les, beginning with therusset apple, which contains 24% per cent o nutrition, and the sweet apple27%, we jump down to the beet, with only 11%, tomatoes 7%m lettuce 5%, turnips 5%. It might be argued that such vegetables as cabbage, turnips, etc., although they do not contain very much nourishment, still contain numerous salts which are very wholesome. Yet there is another thing tht we must consider, an tht is that these vegetables contain a large amount of cellulose, or what we ordinarily call woody material, and this of course is indigestible, and tends to prevent the digestion of other foods by entangling them in their fibers, and thus retarding digestion and favoring fermentation.

P H Y S I O L O G Y . (Lecture No. 35.)

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We were speaking this morning about the different kinds of tissue tht were found in the nervous system, and mentioned the nerve cells and the nerve fibers. Now these two together really form but one element, and that complete element we might call a neuron, or we might use the term nerve-cell, in its broadest sense, that is, includ-ing the nerve body, or nerve cell, and including the nerve fiber. The nerve fiber is used for the purpose of carrying the impulses.. The impulses are carried from the nerve cell towards the end of the fiber which passes out. The nerve fiber may be very long as compared with the size of the cell. Inddd it may be several hundred times the bulk of the nerve cell. All nerve fibers are composed of nerve cells, and the nerve cells are held in place by a supporting frame work, this frame work being made up of figrous tissue, loose in structure, together with another kind of nervous tissue, and this is made up of little delicate cells, very small, irregular in shape, with many numerous processes. These are called spider cells, on account of the almost innumerable processes that pass out from the cells. These spider cells are found in the spinal cord, in the cerebellum, or smaller brain, and in the large brain, but they are not found in the nerve trunk, but just in the cerebral centters. These, together with the ordinary connective tissue, serve to hold the nerve-cells proper in place, so that they are properly separa-ted and are not mixed up.

In taking up the study of the nervous system we will first of all study the spinal chord, because that has the simplest structure and is the easier to understand. The spinal chord is contained in the verte-bral column, a column made up of bones called vertebrae, irregular in shape and set end on end ,one above another,. This vertebral column forms a canal. (Diagram.) In this spinal canal is found the spinal chord. The spinal cord is protected by three membranes. The outermost membrane is very dense and firm, and tough and strong. It is so strong that it is almost impossible to tear it. Then comes another membrane which contains a number of spaces filled with lymph,and then comes still another filled with bloodvessels for the nourishment of the cord. These three protective membranes surround the cord everywhere and also surround the brain. They are the same membranes that surround the brain. The spinal cord in the adult is about seventeen to eighteen inches in length, varying a little ,of course, depending upon the height of the individual. The weight of the cord is very slight, weighing only about one and one half ounces. In the adult the spinal cord does not occupy all of the spinal canal by any means--only about two-thirds of it--and ends here at the upper part of the second lumbar vertebrae. The remaining portion of this canal is occupied by the so-called "cauda equina," because it has the appearance of the tail of a horse. It is made up of nerve-fibers ,which, passing down, do not pass out of the canal immediately, but lower down. So we have in the lower part of the cord a large number of thise nerve-fibers which make a sort of a tail, and they pass clear down to the lowest extremity of the vertebral canal. I have a spinal cord here which I have taken great pains in mounting. This cord I removed from a yearling calf , and you see here the lower part where these fibers are lying side by side and this weight is attached to the lower part of the cauda equina. Here is the upper part of the cord where it unites with the medulla oblongata. This is mounted in such a way that we can see the nerves passing out. There are thirty-one pairs of nerves that pass out. These lower nerves do not pass out immediately, but keep bending down till they form a tail or bundle of nerves--fifteen or twenty nerves passing down that way, filling the lower third of the spinal canal.

The spinal cord at first, in very early life, completely fills the canal, but in the process of development the spinal column grows faster than the cord, consequently, at maturity, the cord reaches only to the second lumbar vertebrae.

The spinal cord is divided into four portions, according to the position of the cord. From the spinal cord, nerves are given off at more or oess regular intervals, and these nerves are the spinal nerves--given off from the spinal cord. These nerves are paired--every time one is given off on one side another is given off on the other. There are thirty-one of these pairs--eight cervical, twelve dorsal, five lumbar, five down here in the sacral region, and one below, called the coccygeal nerve. This givesus thirty-one pairs of nerves, making in all sixty-two nerves given off from the spinal cord.

Let us now consider the structure of the spinal cord: We will take a transverse section section, as I have it shown here on the board. (Diagram.) It consists of two symmetrical halves; We have two kinds of matter making up the cord,--we have a peripheral portion, an outer border made up of white matter. By looking at the transverse section we can see an H-shaped portion (Diagram.) And this is the white matter. The cord consists of two semilunar or crescent-shaped bodies of gray matter, and these are joined together by an H-shaped bridge of white matter. This is the gray matter of the cord and outside, forming the periphery is the white matter.

Now let us take up the outline of the cord: This (Diagram.) represents the anterior surface. The anterior surface is characterized by a fissure which passes in about one-third of the cord. That is called the anterior fissure , and here, the innermost membrane of the cord dips down into the bottom of the fissure and then passes out again. This membrane, which is called the pia mater passes around to the posterior where it passes immediately to the gray matter. This posterior fissure is really not a true fissure but is really made up of connective tissue which passes in and forms the dividing line . The anterior fissure is a true fissure and there we have a dipping down of the pia mater. These fissures serve several purposes; they bring the bloodvessels of this membrane down to the gray matter , and so we find the bloodvessels passing in in different ways and thus forming a rich bloodsupply for the nourishment of this gray matter.

Taking up the structure of the cord proper,we will first discuss this particular portion or white matter,as it is called. The white matter is made up almost entirely of nerve-fibers ru ning up and down in the cord forming a connecting link between the brain above and the cord below , some of them even passing out from the cord down to the periphery. There are some nerves that are as much as thirty inches in length; some of them passing up from the skin of the arm to the cord,until they reach the medulla oblongata--the upper and expanded portion of the cord. This "white matter" has its peculiar white color on account of the structure of the nerve-fibers. Each nerve-fiber is made up of an inner core ,and that is the essential portion--it is the inner core that carries the impulses, and this is surrounded by a thick outer layer of "white substance," as it is called, and that is what gives it the peculiar white color to this portion of the cord. This white substance acts,not only as a protective sheathe, and for insulation,but for the nutrition of the inner core. We might liken this to the Atlantic Cable, which is made up of a number of wires,and each one is insulated,and they are rolled and packed together,and then there is an outside sheathe protecting this inner core. In the nerve-fiber these are separated from each other by a small amount of semi-fluid substance,and then these bundles of fibrils are surrounded by a white substance,and that again by connective tissue,so that the nerve-fiber is very well protected and cared for.

Now we have in the white matter tracts or columns, as they are called,. In the lumbar region the grey matter is abundant, and we have a very large H -shaped body; in the dorsal region the gray matter is very much less. Now right here in the front portion we have a column of nerve fibers which come down from the motor areas in the top of the brain; those are motor fibers, and they go to the skeletal muscle-fibers, the muscles of the trunk, arms , shoulders,and the muscles of the lower limbs, and are distributed to each individual muscle-fiber or muscle-cell. That is the way those motor fibers are distributed to the various muscles, and therefore that column of nerve-fibers is called the motor tract or motor column of nerve-fibers, because it contains fibers that go to the muscle. Here is the posterior part,next to the fissure there are two columns, onelying next to the fissure, the other just above it. These are sensory nerve-fibers because they carry impulses of sensation- that is,impulses causing sensation of cold, warmth, or pain or some other sensation, or it may be the sensation of touch, - the tactile sensation. Those fibers then, are called sensory nerve -

Then there is another name for the fibers that we must mention. The motor nerve-fibers are also called efferent, which comes from two Latin words "e" from, and "fero" to bear, or, to bear out, and that is because they bring the impulses from the brain into the periphery. The sensory nerve-fibers are called "afferent" which means to carry to the center,--in other words the sensory nerve-fibers carry various kinds of sensation from the periphery or skin to the brain. For example, supposeI cut my finger here,and there is a sensation of pain--an impulse is sent to the brain. Now if that nerve-fiber is injured or broken, or cut in two ,then I don't feel any pain at all,--in other words,the pain is not down here in the finger,but up in the brain, and I can only feel it by means of these nerves that carry sensation to the brain. You have all had the experience of striking the elbow right in a particular spot and you have a sensation of extreme pain down in the finger. That is the nerve that goes to this finger. Ordinarily this nerve is used to carry sensations from the finger, and consequently, if you stimulate it in its progress--there is a little place where it is exposed, and if you strike it there, it carries the sensation of pain to the brain,and the brain is used to receiving sensations from the fingers through that nerve, and consequently it places it in the finger and not in the elbow

We have two kinds of nerves, motor nerves or efferent nerves, which carry the commands of the will, as it were --that is, if I will to do anything with the muscles,it is by means of these motor nerves that the messages are sent down to stimulate the muscle to action. Then th the sensory nerve-fibers or afferent nerve-fibers by which I can tell what is going on, or I can tell whether the day is warm or cold--or the tactile sense or the sense of touch ,--by feeling of an object,I can tell quite closely what the object is; All those impulses are carried up to the centers through the sensory nerves.

The white matter of the cord, then, is made up of nerve-fibers and a little separating tissue, and, distributed throughout the white matter, we have those two kinds of nerve-fibers. Here we have another tract of motor nerve-fibers, and in this anterio-lateral portion we have some sensory nerve-fibers. We thus have five or six of these tracts passing up and down the cord.

Now let us turn to the gray matter: This is made up largely of nerve-cells varying in size, some of them large, stellar and spindle-shaped cells, and they are in communication with the nerve-fibers. As I have explained, each nerve-cell is in connection with a nerve-fiber, and if it were not for the processes by which it has communication with the nerve-fiber it would have no physiological function whatever. It also consists of a large number of fibers that do not have this "white substance," just the naked axis-cylinders and a very large number of bloodvessels and lymph vessels. The bloodvessels are very much more numerous in the gray matter than in the white, and that is the reason why the gray matter has a different color from the white. The white matter has its color, on account of this white substance which surrounds the nerve-fiber proper, and the gray matter does not have this, and besides, contains a large number of bloodvessels.

Passing up higher, we come to the medulla oblongata, as it is called The medulla is really an expanded portion of the cord. Here we have a redistribution of the gray matter, which begins to pass up to the surface, and is gathered up into little groups here and there. The medulla is only a very short, small body, and then we have the small brain or cerebellum as it is called. The small brain or cerebellum lies immediately under the brain proper or cerebrum. This substance of the brain proper is almost fifty times as heavy as the cord. The bulk of the brain compared with that of the cord is as fifty to one, -perhaps I should say from thirty to fifty. The great bulk of the brain is made up by the cerebrum, and the brain is covered on the outside with gray matter, and on the ~~outside we~~ inside we have fibers. The motor nerve-fibers pass down from the centers in the brain to the cord, and there they communicate with other nerve-cells which pass out of the cord. The weight of the brain is, on the average, from fifty to fifty-five ounces. The rule that a man is wiser because his brain is larger does not apply, because it quality of the brain, and not quantity, that counts,--for example experiments which have been recently made in Chicago upon dogs: some dogs had been kept quiet from birth, and just merely fed and kept in a dark place, and it was found that there was a lack of development of the brain; other dogs of the same breed and the same age were allowed to be out and take exercise, and then at the end of a number of months there was a careful examination made of the brain, and in the case of the first dogs, it was found that there were a smaller number of brain-cells, and especially in that area of the brain which has to do with sight--which is back in the occipital lobe. The dog had no occasion to use its sight for it lived all the time in the dark. We could not distinguish any difference with the naked eye, but it is the microscope that shows us the difference.

We will now have to turn our attention to the nerve-fibers: Nerve fibers serve as a means of carrying impulses or stimuli,. Every single tissue of the body is under the control of the nervous system. Now if it were possible to remove every other portion of the body--every other tissue of the body, and leave the nervous system exactly in place, then we would have a outline of the man or animal that would be almost perfect. That shows the wide distribution of the nerves. Nerve fibers are ~~[illegible]~~ are gathered together in bundles, and those bundles are called nerve trunks, and it is by this term that we speak of the nerve ordinarily. When we speak of the sciati c nerve, we speak of the nerve trunk tht ends in the thigh. I have here a diagram of a small nerve trunk, and here you can see the connective tissue protective sheathe that holds it together,. (Describing diagram.) The bulk of the nerve fiber is for ~~xxx~~ insulation, the essential portion being found in the center. That is the part that carries the impulses. Every nerve in the body is connected with the central nervous system, but no nerve fibr is in direct communication or connection with any other n~~x~~ fiber. Each nerve fiber carries an impulse a certain distance, and then there is a change; there is a little station, as it were, and then it turns it over to another neuron, which carries it onward..

This diagram shows the structure of the retina of the eye--this is the anterior prt, so the rays of light enter on this side and pass to the hind portion of the retina, and there they set up chemico-physiological changes in these nerve cells, and that starts the impulse, and that travels down here, and a new nerve element takes it up and carries it on but still the two nerves do not ~~txxxxxxxxxl~~ join each other, but there is just a contact-union. This second element does not carry it very far: hre is a large ganglion cell which sends branches, and that takes up the impulse and carries it bck to the brain. That gives us a good idea of how the impulse is carried from the periphery ~~ixxxx~~ to the brain substance, where we do our thinking.

Some of the nerve fibers as we have seen hve this white protective sheathe, and others do not. So you see that in a certain way these nerve fibers reinforce the sensation. This is a crude way of explaining wht takes place, but it gives us a good idea. They reinforce the impulse as it were, and then send it on. As in telephoning, we set up a vibration . Light, is a vibration. This is really what takes place, No one can say that such and such a thing is exactly what takes place, wbut there is reason to believe that this is the case. Certain of the changes are chemical changes, and can be observed, and they are not only chemical, but, in a certain way, electrical. We stimulate a nerve fibre, and use a very delicate capillary electrometer, and we can see that something is taking place within the nerve fiber. There is a negative variation, and shows that there is something actually taking place. But more than that, this change is Nature, and we cannot explain it. If we have a stimulus applied to the nerve cell, that stimulus must be of a certain strength, and it must set up chemical changes sufficient to start the nerve impulse. If it is very weak there will be no response at all,m because it is not sufficient to start a contraction of the muscle.

We will now speak of the cranial nerves, so-called, because they come from the brain. There are twelve of these cranial nerves, and these have been known for a great many years. Those nerves go to various parts of the body; some of them are nerves of sensation, some are motor nerves, and some are mixed nerves.

The first of all is the olfactory nerve, or nerve of smell, and this olfactory nerve has no other function in the body except that of smell. It is really an outgrowth of the brain, and passes down and is connected with these little nerveendings right here in the nostrils, and every time we take a whiff or smell and recognize some odor, then those little nerve ending right here in the nostril are stimulated, and the impulse is started and that travels up and back into the brain, an then there are impulses set up in the brain by which we recognize the sensation. If that impulse does not reach to the brain we do not recognize it at all.

The pain is in the head, and the smell is in the head. That is where we recognize them. The first nerve, then, is the olfactory nerve, and it is a nerve of special sensation.

The second nerve is the optic nerve, a d this is the nerve of sight, and has to do with vision. This nerve begins right in the retina in hose large cells, and the sen sation passes back by means of this optic nerve back into the brain and there the impulse is set up by which we recognize the sensation and recognize the object. We can estimate the actual amount of time taken for that impulse to travel back and be recognized..

The next nerve is the motor occuli, which goes to the muscles which controls the eye. The motor occuli is a motor nerve, as the name itself signifies, and is distributed to the muscles of the eye only, and has nothing whatever to do with sensation or vision.

The next nerve is also a motor nerve, called the Pathetic, and this also goes to one of the muscles of the eye. The pathetic is the smallest cranial nerve.

The next nerve is the so-called trifacial nerve,, which is the largest, and is the nerve which gives us so much trouble in neuralgia. It is the largest of the cranial nerves. It is both a motor and a sensory nerve, having to do with motion and also has to do with sensation, and is a nerve of special sensation .
This nerve has two roots, a motor root, and a sensory root, and those two unite and form a large nerve, and this passes out of the cranium, out of the brain cavity, and divides into three large branches, one to the eye, the others to the face, one going to the upper jaw, the other to the lower jaw, cheeks, etc.

The sixth nerve is the abducens or rectus muscle of the eye. It is very small and delicate, and has to do with motion and motion only, going to the rectus muscle of the eye, and is used to abduct the eye, or turn it out.

The next is the ~~auditoryxnervexxorxnervexofxhearingxxx~~ facial nerve, and also has to do with motion only. It is distributed chiefly to the muscles of expression of the face.

The next, the eighth, is the auditory nerve, or nerve of hearing. The auditory nerve is a nerve of special sense only, and has to do only with hearing.

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PHYSIOLOGY. (Lecture No. 36.)

We were studying the cranial nerves last evening, and had reached the ninth nerve, which is the glosso-pharyngeal. It is a motor nerve, going to the glossa or tongue and the pharynx.

The Tenth nerve is the pneumogastric. This nerve has the widest distribution of any of the cranial nerves. It upplies the organs of voice, and organs of respisation, and goes to the lungs, pharynx, aesophagus and stomach. The word literally means the lu ngs and stomach. "Pneumo" coming from a Latin word "pneuma" , air, or lungs, and gastriq referring to the stomach. The pneumogastric nerve is one which carries motor nerves, and nervex fibers of common sensation. It is really a mixed nerve .

The eleventh nerve is the spinal accessory, which goes to some of the muscles of the neck. It is a very small nerve.

The twelfth and last ~~xxx~~ cranial nerve if the hypoglossal, which is a nerve of motion , and extends to a number of muscles, some five or six, controlling the tongue. This nerge, then, has to do with speech.

If we pass right down the cord we find that the spinal nerves are analagous to the cranial nerves. The cranial nerves are all paired, just the same as the spinal nrves, which pass down in pairs to the different parts of the body..

The cranial nerves are distributed chiefly to the head, and are largely nerves of sensation. The spinal nrves are both motor and sensory. The spinal nerves rise from two roots (Diagram) the posterior root and the anterior root, and this posterior root is characterized by a posterior root ganglia, as it is called. The spinal nerves pass out from the gray matter at more or less regular intervals, converging, however, to form a single nerve. So we have the posterior root ganglia, the mass of fibers passing out of the posterior root being connected with the ganglion cells , and then coming down here they unite, to form a single spinal xxxxxx nerve. Now there are thirty-one pairs of nerves which are formed by the union of the two roots. The anterior is made up of efferent fibers passing out to the various muscles of the body, and the organs that are under the control of the central nervous system. The sensory nerve fibers come from the periphery. They bring the sensations of pain, temperature, etc., and they keep the central nervous system in touch with the body and make it acquainted with the changes going on, so that, for instance, the centr al nervous system knows the amount of blood in the heat, or in any of the organs of the body, by means of these nerve fibers; and just as soon as some part of the body needs a little more bloodimpulses are sent out by means of the sensory nerve fibers to the brain, and they set up an irritation which gives an increased blood pressure, so tht they can get more nourishment.

These nerve fibers unite to form a mixed nerve trunk. Here in this trunk we have both sensory and motor nerve fibers. The difference between these is not anatomical; we cannot tell the difference between them, for in appearance the nerve fibers of the anterior portion and the those of the posterior. They are not analagous, but the diffrence is not characteristic. If you were to choose a piece of nerve fiber and ask me to tell to which class it belonged, I could not tell.

Our state of being, whether depressed or active, is almost entirely made up by some of these impulses carried in by these sensory nerve fibers, and thus it depends upon the environment and state of health of the body. If the tissues are diseased they are grumbling

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and growling, and these nerve fibers are brin ing in sensatio s of disease . If the surroundings are pleasurable, then those sensations are carried to the brain.

Now I want to say just a word about nerve degneration. How do we know we have h re in different parts of the cord, different nerve fibers--that we have two tracts of sensory nerve fibers, one on the inside, the column of Gail)?) and one on the outside, the column of Burdick (?), when there is no line of demarkation to distinguish them? Then we have here another tract of motor nerve fibers . The posterior lateral tract is a tract of motor nerve fibers . Most of the other tracts are sensory, some being mixed. Now how are we going to distinguish them? Now suppose we cut the sciatic nerve , right in two. Say a man has had an injury and cut the muscles of his thigh, and it has not been amupated entirely, but just partly cut in two. Now there is going to be death of a portion of that limb, and it will be the periphery, or that part which is away from the source of nourishment. The nerve fiber bears this nourishment to the nerve cell, and just as it is separated it dies and degenerates. Now this is the method used to distinguish these different tracts. Now asuppose we pass a knife in a section of one half of the cord. Now all the nerves which have their nutrient supply from tat secbion of the cord will degenerate. . Take at the end of the spinal cord, and you will find that they have degenerated, showing that the nerve centers are up here in the bain. . Now we can observe, by this method , just where the degeneration takes place. These nerve fibers all degenerate upward. Their nutrient centers lie here in the gray atter of the cord, or else up here in the posterior root ganglia. Some of the nerve fibers passing to the potterior root pass straight up to the brain. (Describing courses of nerve fibers.)

As I said, these nerve always degenerate upward, so by careful examination and study we are able to distinguish them.

The eyes are controlled by the back part of the brain--the occipital lobe, and when we see things by means of the eyes we have activity in the occipital lobe, an that is where we recognize objects. When we have an injury to one of these nerves we have what is called nerve degeneration, but we also have in some cases nerve regeneration. But this never takes place in the central nervous system. If we have an injury to the cord it never recov ers. That is why injuries to the cord are so very serious in nature. But outside of the cord, in the periphery, there is a chance for regeneration and restoration. Of course if there is amputation that settles it,xfmx and there is not only death of the amputated part, but the rest of the nerve atrophies, for it is no longer of use to the body. Now take for instance in the arm, and it may be injured, but not completely severed. ; that end will grow out again, and the lost sensation of the parts to which that nerve was distributed will return under favorable conditions. This fact has only been fknown for a few years. . In case they are severed, there is but a slight chance for recovery. The proper thing to do is to take the two ends and sew them together, or, if they cannot be joined, the next best thing to do is to place a bridge of catgut, and the peripheral end and the sacral end brought together in this way. This serves to gui guide the new growth, as it were. You see there is a lot of muscles and tissues there, and if it is displaced it has a hard time growing out, and it may xxxxxxxxxx be imbedded in the connective tissue, and there woul be no return of sensation or motion. If the cicatricial tissue is formed, that "scar tissue" will prevent the end of the nerve growing out properly and reaching its proper destination. The catgut is absorbed, and the new growth will follow in its path, there being less resistance here; it will follow along in the path of the old nerve fiber and be redistributed. It takes a considerable length of time for this new growth. It is not accomplished in the course of a few weeks, but usually takes from three or four months to a year before the sensation is restored perfectly.

We will now take up the physiology of the nerve cell. We will take up its life history, which, in the complete sense of the word includes the cell-body and the fiber. Tjhere is the protoplasmic and the nerve branch., the principal and more essential being the nerve, That nerve branch may be short, or it may be long. If it is very short, like those of the retina,.....................

(Diagram an description.)

The life of a nerve cell is co-extensive with the life of a body. The most of the nerve cells live as long as the person lives . They do not break down, become lost, and new ones take their place--that does not take place in the nerve cell, and this shows that they have a very high and perfect development. The nerve branch may be very long--it may be fifty or sixty inches in length. The maximum length is usually given as 100 centimeters, or sixty inches. Thus we see that the nerve branch has a very much greater bulk than the nerve body or nerve cell, but it is very delicate on account of its great length. It may be fifteen hundred times greater in bulk than the nerve cell. Growth of the nerve element takes place from the nerve cell. The nerve body is the essential, all-important part, and that is the part that develops first, and these nerve fibers come on later. In the growth of the nerve cell they take up different positions. In the very early life they appear to migrate,--they appear to possess an amoeboid movement, and they travel upwards and take up the position they maintain through lifexx the life of the individual. This movement that takes place in embryonic life continues to maturity to some degree-- till about the age of thirty. Now in case some of those cells are misplaced, through lack of nutrition or from some other cause, and they travel in the wrong dir c- tion, the we have what we call an idiot--and that has been found to be the case in the br ains of idiots, that there has been a general displacement. There are many other causes, but this is one of the cauzses which produces congentlal idiocy. The nerve cells are misplaced, and consequently there is confusion in their organization, and thereiis a lack of intelligence. This growth and development of the ner e cell is one of t e most impirtant developing proce s that takes place in the body. The development of t e muscles is important, as is the development of the bones, but the development of the nervous system is of far greater importance. We find that phose people who have hd no chace in life, the products of the slums, who are brought up under the most unhygie ic conditions as far as food and air is concerned--and do we wonder th at they have depraved minds? Those things are nevessary for the building up of the nervous system. We see the untoward results upon the bones of the body, and if you notice carefully you will notice that there are diseases manifested in many different ways which depend upon this lack. And we find that there are propensities of many differe t kinds that depend upon the physical development of the individual. Notice the child learning to do anything, and it is very imperfect, and on examining the brain we find that there is a physical reason for it. The physical system is incompletely developed. . These nerve branches are notmall formed until about the thirtieth year, and it believed that new br anches have been formed even later than that--that the new b anches go on forming almost as long as life lasts. The extent of new formation after

forming almost as long as life lasts

the thirtieth year is not fully comprehended as yet, but we do know that the organization of the nervous system is by no means complete until the thirtieth year, so we ought not to expect in a child what we would expect of a fullgrown person, because they have not the ability to do it. The child has not got the power of observation or memory of the adult, because that is just undergoing development. The various organs are being formed, and the nerve cells are just passing out their processes. This organization, then, is going on until we reach the prime of life, and then and then only are the different nerve elements in proper connection with each other, so that the individual is capable of what we might call mature action. He is really not capable of putting forth his best mental activity until this organization is complete. The nerve cells are the essential part, and they require the best nourishment, and constant nourishment. Changes are constantly going on in the nerve cells, and if their nourishment is not of the proper kind, if it is not abundant, there is going to be a lack of development and suspended growth of the nerve cell. The nerve cell is affected by these harmful conditions more than any other part of the body, because it is more sensitive. It is the most highly organized, and the most easily affected. Irritants that may get into the blood will produce more harmful effects upon the nerve cells than upon all the other parts of the body put together. Take strychnia, for example, and notice the effect upon the system; or take alcohol. A man does not take very many drinks of whiskey before it has an effect upon his mind. His body is all right, but his mind has no control over it, and he does things that he is not accountablefor. A man who under the influence of liquor commits a murder is not accountable for that crime, but the man who sells that liquor, the saloon-keeper, is, for he keeps on selling the man liquor after he is drunk, and if someone happens to offend him he is just as liable to do him harm as not. The controlling part is all deadened by the drink. The nerve cells, then, are alive just as much as the body as a whole.

Now take a man ninety years of age, and he deteriorates throughout his entire body. All the tissues of the body are affected by the senile changes., In extreme old age the man becomes childish, and the energy xxxxxxx of the brain is below par, and a man loses it, little by little. There are anatomical changes that can be observed under the microscope, the nerve cells are smaller, and the nuclei have become smaller, and they disappear, and he takes on a very yellow color on account of the large amount of pigment formed. These changes come on with advanced age, little by little. In fact, he deteriorates, and that means, a loss of vitality. The full vigor of vitality is lost by extreme old age. The rate of deterioration depends largely upon the exercise that has been given the mind. Take Gladstone, for instance; he was a man of great mental activity, and he preserved his powers by using them. If you want to develop in any one line just work at it and develop it. That is the way the child learns to walk; by tumbling down, and walking on, and tumbling again, etc., until finally he learns to walk. We all had to learn to walk at one time, so that now we can walk without paying any attention to the act of walking. This is one of the greatest laws of nature that we know of; this means growth, and thus we take on the powers of the body. Take this arm here, and we will suppose it was broken, and I had to keep it in a sling for ten or twelve weeks; there would be an actual atrophy of the arm. Nature is economical, and there is a lack of nourishment for that arm because there is no use for it, and if we wished to keep it growing it would be better to give it a slight massage. xxWxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx

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We cannot exercise it, but we can, by maipulating it, bring more blood there, consequently by being promptly massaed we have more blood there, and that furnishes the nourishment upon which it can build itself up. Suppose the arm is inflamed. Inflammation is almost always the result of of disease, and under certain conditions if there is only a slight amount of poison thre we can, by massage, bring the blood in sufficient uantity to wash it away. But if there is very much there it is liable to result in death. This break and the irritation is counteracted by nature, in bring a large amount of blood there. We bruise a part, and then we have a swelling. That is ature trying to epair the damage. Nature is always reparative and restorative, and all we have to do is to find out what Nature is trying to do, and help her on. N ow suppose you strike your eye, and you don't treat it: It will be black and blue; that is because of the clotting of the blood. Now if we are able to give it proper treatment, there will be none of this clotting of the blood, and it will pass right along, abd there will be no discoloration. Heat causes a dilitation of the blood vessels, and encourages the circulation. The blood then circulates faster, and there is no <u>states</u>. The pain of the bruise is caused by the stretching of the nerve when the swelling comes.

Production of the nerve impulse. How is the nerve impulse formed? I might say that it is caused by chemico-physiological changes taking place in the nerve cell. All the time changes are going on in the nerve cell. There is activity, metabolism there, there is building up, anabolism, and breaking down, metabolism, as long as there is life. Now that building up is for two purposes; one for the growth of the cell, the other for formation of material. The process is just about the same as the process tat takes place in the gland. Take for example the parotid gland in the mouth, and this process is going on all the time;

the cells are never at rest. When they are not pouring their secretion out into the blood they are taking it out from the blood material from which to form the saliva. Now in the glands of the stomach the cells are all the time taking up materials from which they can manufacture hydrochloric acid and pepsin. Now that is their function, and duty, and just as fast as they manufacture it they pour it out into the stomach. Nerve cells do not secrete, but they do their work, just the same, and part of that work is to take material from the blood from which they manufacture a substance which, at the right time, they set off by an impulse, just as we set off a little pile of gunpowder, and they explode as it were, and that starts a series of changes, and that starts the impulse travelling down the nerve fiber.

This gray matter contains a very large number of blood vessels, and the white matter, on the other hand, contains very few. These cells that we have been speaking of take up materials from the blood and form substances which are easily broken down, and the impulse acts as a mechanical stimulus, and it finds a substance which is all ready to be touched off, and it explodes it.

We cannot understand all of this thorouhly, but the chemical change may be demonstrated; we know that when the nerve cell has been doing very hard work it becomes acid. It is normally alkaline, but as it works it becomes less and less so. Then there are electrical changes when the impulses are passing. Now the impulse passes into the cord, and into the cell, setting free the energy, and that energy which is set free escapes from the cell in the form of a nerve impulse, and that just travels down the nerve fiber to the muscle, and sets free the energy in the muscle, and that energy causes the muscle to contract, and then you have a response. The first impulse is reflex, and may originate in the mind or in the body. If you touch your finger to the stove you do not stop to think about removing it, but just take it off that stove at once. If you h ad to wait to think about it you would be severely burned. But you have the power to start these impulses at will, without waiting to thinkmabout it.

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P H Y S I O L O G Y. (Lecture No. 38.)

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The nerve impulses are carried by the nerve fibers. They are started in the nerve cells by chemico-physiological action. The presence of these impulses may be easily demonstrated by the aid of proper electrical apparatus. The experiment is made in this wise: A delicate ~~skm~~ capillary electrometer is connected with the nerve trunk; then when this same nerve is stimulated by an electrical current an impulse is started which travels in both directions. As soon as it reaches the point where the electrometer is attached, it produces a negative variation which lasts for ~~aboutxaaaxaaaaadxxxx~~ but an instant. Nerve impulses travel very rapidly. It has been estimated in the case of a frog's nerves that they travel at the rate of about 33 yards per second, and in man a little more than thirty-seven yards. Nerve impulses are never started in the nerve fibers, but always originate in the cells. They are started in different ways, as by the action of the will, or reflexly, or mechanically, by electrical and other stimuli. The primary elements are the nerve cells, and in the development of the organism they are formed first, and the nerve processes, both axis cylinder and protoplasmic, are developed later. This growth, as we have learned, continues until the age of puberty, and it is believed to continue until maturity, or about the age of thirty. This continuous increase in the number of processes causes the nervous system to undergo a very complex and perfect organization. The more perfect the organization, the more perfect the anatomical distribution of both nerve fibers and nerve processes, consequently the finer the quality of the brain, and the better the work that may be expected. A little thought will make it very evident that the child, or youth does not possess the same powers of intellect, memory, etc., as the adult, and this is because the organization is less perfect, and the anatomical ~~development~~, conditions are still being developed.

Nutrition is one of the most important properties possessed by the nerve cells. Each nervecell develops not only its own nutrition, but the nutrition of its nerve fiber and nerve processes. There is a constant metabolism going on in the neve cell; there is a building up process by which the cell is restored and its energies repaired, and hand in hand with this constructive process the destructive, breaking down process is going on, and the old, worn-out material is broken down into waste substances and gotten rid of as rapidly as possible. But the metabolism does not end here. It is necessary for the numerous substances to be built up into more complex forms, so that later in ~~thexxx~~ they are broken down and made to serve as energy for the starting of impulses. Indeed, these processes are the most numerous and the most characteristic of the nerve cells. Growth of the nerve cell depends largely upon functional activity. As soon as there is disuse there is a lack of functional activity,, and there is a lack of proper nourishment, just as in other parts of the body, and the cell shrinks. This process which the cell undergoes is what is called "atrophy", which comes from the greek a privitive,, signifying a lack, of nourishment. If the nerve cell is not kept active in starting impulses it is no longer of use to the body; it is unable to supply its demands, and it atrophies and degenerates. In this connection it would be well to say a few words about irritants: Irritants are substances which, when brought into contact with the nerve cells stimulate them and excite them into greater activity, and this abnormal state of irritability is followed by a state in which the cells are worn-out by the excitement, and become very much depressed and benumbed . Many of the irritants coming into contact with the cels paralyze them almost intstantly, and the cells do not fully recover from their effect for a long time. Strichnia is one of the most virulent poisons that can be brought into contact with the nerve cells. It arouses their irritability to such a degree that the stimuli enter the cord, and diffuse over the gray matter, and nerve imuplses are sent out which cause chronic convulsions, or what are commonly known as convulsions. Amputation of a limb of course destroys the nerve elements to a ~~maxxxxx~~ greater or less degree ; however some of the fibers or fingers grow and form a knot of fibrous tissue which becomes very painful, and is known as neuromala(?) These of course are found near the stump, and must frequently be removed by the surgeon in order to get relief. At other times these nerve fibers die and degenerate, and give no further trouble. It is interesting to note in this connection that the nerve cells which are in direct communication with the degenerated nerve elements undergo atrophic changes, and instances have been known in which these elements undergo what ~~xk~~ might be called a secondary degeneration.

The sense of fatigue is both physiological and ~~psych~~ histological. We need not describe the physiological sensations, because they are obvious to all. The brain feels weary after it has performed a severe task and the nerve cells are tired. Rest comes with a change of employment, showing that new nerve cells are now brought into activity. Indeed, this is the most satisfactory kind of rest that we can take--that is, a change of environment and a change of employment. Absolute rest is demoralizing, and is unnatural and unphysiological. The nerve cells are the most delicate and susceptible of all the elements of the body.

They are easily wearied, and demand rest. If proper rest is not urnished the nerve cells may uiergo atrophy and become starved , and then such diseases as nervous prostration, hysteria, etc., ensue. Nerve tissues suppliy food to most of the other tissues of the body. This is due to two facts: First, their wide distribution, and second on account of their intimate connection with all the pther tissues of the body, and are the means by which these elements are brought into hrmonious play.

The histological s nse of fatigue forms the most interesting of studies. The following experiment hs been performed recently by one of our most eminent physicians and scientists: The nerve ce ls of a ganglia in a frog were stimulated by means of an electric current of known strength. After the stimulation for a space of from one to two hours it was found tat these same nerve cells had lost from 15 to 20% of their bulk. In other words, they had shrunken. Still further stimulation produced a still further change, even to the loss of forty per cent. Other exp riments of this ature hve been made. The n rve cells of the common barnyard fowl have been examined by means of the microscope. The fowls killed in the morning were found to have round, full nerve cells, which appeared normal in every respect, while the ganglion cells of the fowls that were killed at night afer a day of ordiary work were found to have undergone a considerable degree of shrinkage. This is most noticeable in the case of the nucleus, which is considerabl reduced in size. The nerve cell was also reduced in size, and contained vacuoles, which are normally not found inmthese cells. Further experiments have been performed to find out how long it would take these nerve cells to regain their normal condition. It was found tht where the nerve cells had been stimulated for a period of six to eight hours, it required all the way from eighteen to twenty-four hours for the cells to recover their normal size. In the case of birds, the cells were found to be in a normal condition in the morning, and shrunken in size in the evening. These experiments are interesting because of the light that they throw upon the anatomical changes that accompany the conditions of fatigue. Similar experiments have been made upon the dog.

Degeneration and Regeneration of the fibers. This subject has been studied more perfectly with the motor nerve fibers, or medulated nerve fibers. A noted physiologist, Dr. Waller, of England, was the first to discover the degeneration of nerve fibers and he seized upon this means to show the position of the nerve tracts in the white mattr of the cord. Degeneration always takes place from the cord towards the end of the fiber. This cut-off portion of the fiber degenerates and dies because it is the lowest trophic center. (?) Prof. Waller experimented upon the cord, and showed that when a semi-section was made that certain nerve tracts degenerated downwardm and others degenerated throughout the cord. In this way he was enabled to mark out with a considerable degree of accuracy the columns of nerve fibers which run up and down the cord. He showed that the nerve fibers which degenerate upward had their centers either at the medulla or in the higher centers of the brain. Regeneration never takes place in the cord. When a nerve fiber in the cord has once degenerated and died, it is never replaced by any other nerve fibers. This is not true of the fibers outside of the cord. When a nerve fiber has been injured, as by being cut in two or lacerated to such an extent that degeneration takes place, the regeneration of the nerve trunk may under favorable conditions take place in the course ofa few months. The conditions favorable for this new growth or formation of nerve fiber are both numerous and varied. First of all the nerve fiber must have a chance to grow down into the old channel, otherwise the inflammatory tissue formed will prevent the proper distribution of the nerve. When a nerve trunk, as for example the sciatic, is cut in two, the following process takes place. First the peripheral end begins to degenerate, and in the course of three or four months breaks up into particles which are afterwards absorbed. The sacral end also degegerates, butonly slightly, and then if the conditions are favorable begins to grow down towards the periphery. There are many devices which have been used to guide the newly-formed nerve. The bone tube has been used with a considerable degree of success, as has a simple bundle of catgut. This latter is perhaps the most efficient as well as the most simple and easily prepared. In doing the operation the bundeeof catgut is placed as a bridgebetween the cut ends, and both ends are fastened t o the bundle. Now during the inflammatory process hat takes place for a few days after the operation this bundle of catgut threads remains in place and thus forms a pathway through which the new fibers may grow without meeting much resistance. Wherever there is inflammation takes place the e is more or less formation of new connective tissue. If there is a wound, a cut, or a deep burn, this new formation of tissue is called scar tissue, and this is a second grade tissue. At first it is of a bright red color, due to its great vascularity, but in the course of time the ti ssue begins to contract and shrink, and finally we have a white scar. This is due to the great contraction that takes place, thus occluding most of the blood vessels. Now it is very evident that if such inflammatory changes were allowed to take place in the vicinity of the nerve trunk, and a considerable quantity of this dense firm scar tissue formed, it would make an almost impassable block for the developing nerve, and the nerve would consequently perhaps never reach its proper destination. In a series of 56 ~~persons~~ operat~~ed~~ions ~~upon~~ performed by Prof. H uber of the Univer ity of Michiganm almost all were suffessful, and the dogs recovered both motion and sensation. In most cases perfectly. The length of time require d for the regeneration of the nerve trunk of course depends upon the distance through which it must grow, also upon the conditions favoring its growth.

We must bear in mind that in order fot the muscle to contract it must be connected with the nerves, and consequently thenerves must be distributed to all the mus le fibers of the muscle, and new nerve-endings must be formed.

Reflex action. The spinal cord is an aggregate of reflex centers. The reflex action is the simplest and most frequent reaction of the nervous system. It may be defined as an unconscious response to stimuli. Of course it is di ficult to draw any hard and fast lines between voluntary and reflex movements, nevertheless many of the reflexes are typical, and there is no danger of confusion with the voluntary movements. Reflex actions depend upon the anatomical structure more than upon physiological conditions. we might take as a typical example the so-called "knee-jerk," or knee-kick. This may be easily demonstrated in the following way: The person is ma e to sit in a chair and throw one leg over the other in a loose, relaxed condition. The operator stands on the right side, and by meansof the fingers taps lightly and quickly upon the tendon just below the patella. The repponse is a kick of the foot. This reflex is sometimes termed the patellar reflex. The mechanism is as follows: Striking the tendon starts an impulse, whith travels up the nerve to the cord, and starts impulses in the bray matter. These impulses travel down to the muscles of the thigh and cause them to contract, thus throwing the foot out. The patellar reflex is important in the diagnosis of certain diseases, for example, locomotor ataxia. Here there is a lowered condition throghgut the nervous system, particularly of the cord. Certain elements in the cord begin to cxxxxxxx atrophy, and finally we get a more or less complete degeneration. In propprtion of this degeneration the reflexes of the lower limbs are interfered with as are various movements, such as walking, etc. Such a patient will usually have no patellar reflex at all, and striking the tendon will give xxxxxxxxresponse. At other times there is a hyper sensitiveness of the reflex xxxxxxx centers, and tapping upon the tendon produces a very much exaggerated response.

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P H Y S I O L O G Y . (Lecture No. 39. Aug. 22) [1×88?]

We will take up this morning the subject of reflexes. The reflex is an unconscious response to a stimulus. Suppxxxxxxxxxx In other words, a reflex is the change of an afferent impulse into an efferent impulse. Suppo e we take an impulse (Diagram), and here we have the impulse travelling up; we have here a nerve cell with a nucleus, and then here is the impulse travelling down again. It was formerly believed that that was the condition obtaining in the cord. We know now that the process is more complex than that, and the impulse is possibly something like this: (Diagram.) That the nerve impulse travelling out from the center--they have numerous protoplasmic branches passing out, and then at the posterior root ganglia we have the fiber going in from the periphery, going into the cells, and then entering the cord, and then from there on by means of a.....fiber.......they come in contact with the second element . Here (diagram) is a section of the cord. Here is the peripheral nerve from the outside, and again we have the peripheral nerve that goes back to the outside.

Now there is a stimulus where the nerve is, just below the outside surface, and this nerve comes here and acting reflexly with the nerve-ending in the skin, and then this comes down here and ends. (Diagram.) Now then, there is a stimulus right here; suppose the finger is burned, o or at least becomes very hot, and the impulse travels up to the center, and a new impulse is started over the second element, and it starts that to contracting, and as the result that finger is removed from the cause of the pain. Now that is the simplest impulse or reaction conceivable. Usually we find in the cord much more complexity, but such reflexes as these are found in the cord. A reflex, then, is the conversion of an afferent impulse into an efferent or motor impulse.

One impulse travels up and brings, as it were, knowledge, and then on account of that knowledge another impule is started bck to the periphery a d there is a rsponse, and that response, if it is a pure reflex, is unconsious. We know what takes place, but we do not direct it. The reflex takes place very rapidly. In the case of the "knee-jerk" that we demonstrated it requires about 3-100ths of a second. In the case of the eye it requires about 4-100ths of a second, for the response. These measurements have been made very carefully.

We will now have some experiments with our frog, to illustrate this property, and in order that it may be purely reflex, and that we may be sure of it, it is necessary to destroy the brain, or else to cut off the communication between the cord and the brain. (Operation.) Now you see he is perfectly limp. The only difference between that frog and the ordinary frog is that the communication between the cord and the brain is cut off.. I did that last evening, so that the frog might recover from the shock a little. I have here, for the performance of the experiment, water, with which to wash the limbs of the frog after each experiment, one bottle of 1/4 % acetic acid, then 1-3%, another with 1-2%, another with 3-4%, and another with 2%. Then we have some glacial acetic acid, so that if we have not got a strong enough solution we can readily make it.

Now there are several principles that we are to illustrate by means of the reflexes of this frog. Now if the communications between the brain and the cord were not cut, the movements that we would get might be reflex, or again they might not be, and we would not be able to distinguish between them, consequently we sever the connection between the cord and the brain. The voluntary movements always originate in the brain and never in the cord, so that we know that whatever movement we may

and never in the cord...

get will be purely reflex. Now then, the response to stimulus always depends upon the kind of a stimulus. The response, if is a movement or contraction of a muscle,--the strength of that contraction depends within certain limits upon the strength of the stimulus. We apply a stronger stimulus, and we two things; a quicker, and a stronger, response. .

I will first apply the very weakest solution,--1-4%, acetic acid, which is the acid we find in vinegar. We will make this experiment by simply placing a leg in the solution. We will introduce the foot gradually, so that we may know just about what is required to produce the response. The amount of surface covered by the stimulus also has an effect upon the response, as well as the strength of the stimulus, so in order to get a response with 1-4th solution it is necessary to immerse the whole foot. After a while it gets accustomed to it, and then there is no respose.

Now we will try the 1-3 % solution, and with this we get a little quicker response. It did not take place any sooner, but we get a stronger response. We must not apply these stimuli too rapidly, but wait until the normal condit on is restored somewhat each time. It takes a certain time to start the impulse, and make it strong enough to cause the contraction. Each time we must e careful to rinse the acid from the limb, so that he will not become accustomed to its presence, and fail to respond. Just as soon a the stimulus is applied impulses are travelling up,--they are slight, and not sufficient to cause ~~cxxtxxxx txx~~ a new impulse. Now after a while, these keep travelling up, and they will all be added together, and those taken together are sufficient to start the new impulse, and that starts the contraction. These experiments prove this to be true. Take for example a rabbit, and remove a portion of the skull by trephining, and stimulate the motor area of the lower limbs, and find out the strength of the aststimulus that will give a response. Now by adding these stimuli together we get the effect.

Now we will take a stronger solution, 1-2 % and see what we get. This gives quite a vigorous response. The frog got quite excited over that. Now we will take the three-fourths solution, andwillagain take the same limb and the response is both quicker and stronger. .. If I had taken the other limb, that has not bee experimented upon, the response would have been much quicker and stronger, even, than this., because this has been doing work all the time, and consequently it is tired, and does not respond so promptly.

Now a still stronger stimulus--1 %. That was very irritating, and I must hasten to washnthis off or it will interfe e with out other experiments. Now about 1 1-2%. The difference is veryslight.

Now we have seen the response that we get; now we want to try to show that there was a purpose in t e response; in other wor s, that the response was purposeful. The leg
is taken away from the irritating substance, and it tries to rub it off. Now we can show tat even more perfectly by taking a little filter paper and placing it on the flanks of the frog. I take here a small piece of filter paper, and dip it into the solution. I will not be able to get a response with the most dolute sol tion,, as the ater causes it to wash away rapidly, so I will have to use a stronger solution. I will begin with the 3-4% or 2-3%. I will place this on the right flank, and see whether we get any response at all or not. If the skin were dry we would have a better chace for getting the response, for then the solution would not be so diluted. We will find that if we hold the

limb that has been irritated, that the other limb will act. This illustrates the act that if we keep on irritating we must increa e the strength of the irritant to produce the effect. This is irritated u til it is worn out, and if I should put on a stronger stimulus it would be just simply paralyzed. I might possibl get a response, but would probably paralyze this little delicate nerve ending.

Now if you take a frog that has been lying in a spring allwinter, and the response will be very poor. I have had frogs for demonstration that would not give a single response. On the other hand, take the frog in the fall, after a season's activity, and the response is much more powerful. . In the spring the system is in a lower state of activity, and consequently the irritability is very much lower.. There is a very marked difference between such a frog and the frog in the Fall.

We will now consider the spontaneous or automatic reactions. Such changes are set up inside the body by conditions in the body. That is not exactly true to a certain extent, but it is more than that, but there are changes in the brain and in the mind. Voluntary movements are caused in the body. Just as soon as you hax voluntary movement, s the word itself signifies,, there is an action or influence of the will and the voluntary movements are distinguished from the reflex movements in these different ways; First, you cannot predict the movement of a voluntary movement. If the r sponse is to be influenced by the will , you cannot predict it. But you sti mulate the right leg, and the right leg acts; but if this is to be influenced by the will, no man can predict what is going to happen. The reflex comes within a certain time. The response is immediate. It may be in the course of a few minutes, but practically it is immediate. But when we have the influence of the will to depen x upon the response may be immediate, or it may come in the course of a month or a year. To show that voluntary movement of any sort is can not be predicted, but may come at any time after the stimulus has been started; A person visits a lecture and he hears certain things, and these start a train of thought in his mind,, and there is some question comes up in his mind. It may be two or three years afterward he may be talking with that speaker--with the man who gave that lecture, and when speakig with him tht same question comes up in his mind, and he asks him about it. There is a response to that stimulus three or four years afterward. That would not be posible in a reflex movement, which is always immediate if it takes place at all, and not a long time afterwards.

spontaneous movements are numerous, as well as those resulting from the action of the will. Movements, then, taking place in the body which are due to changes in the body, but not influenced by the will are spontaneous or automatic movements. Some of these are spxxxxxxxxxxx continuous, taking place as long as life lasts. The ciliary movements ar continuous, and going on all the time. Again, the movement of the heart is a continuous movement. The heart is beating all the time. There is a period of rest, and a period of bxxxxxx activity, so that the heart is said to be beating all the time, and in that way the movements are continuous. The heart beats, and beats rythmatically. There is a certain definite rythm . This movement of the heart and the cilia is something we may easily observe, but there is another movement going on in the body all the time that is less readily understood, and that is this: We speak of skeletal tone, and arterial tone. Arterial tone always exists in the xxxxxxxxxxxxxxxxxxx blood vessels as long as life lasts. There is a certain elasticity there in life, and after death that elasticity is lost. That is arterial tone, and it is under the control of the nerves of the spinal cord. But sever those nerves, and the arterial tone is lost and the blood-vessels are dilated. The impulses are continually passing from the cord down to the arteries, and if they are cut this stimulation ceases.

Again, we have skeletal tone. The muscles of the body are all the time under constriction. Noti ce the difference between the muscles of a healthy man, and those of a man sick in bed. Take it in the case of the athelete, and his muscles are like iron, even although they are a semi- fluid substance; they are under constriction, and the skeletal tone is high. The skeletal tone depends upon the vigor of the body. As long as life lasts there is some tone in the body, but when death comes the muscles become perfectly flaccid. So you see the muscles are all the time in a state of contraction, and we can readily rec ognize when a person is ill, even t ough he may be able to be walking around by looking in his face and seeing the amount of tone present; this is easily recog ized, and is determined by the state of the vitality of theo body. Muscle-tone results from the impulses that are being borne to and from the cord, and these are reflex. We do not have to think about it in order to have muscle tone. When we go to bed at night our muscles are not perfectly relaxed. You can notice the differ nce in the position of a person who is sick, and a person who is not. This is due to what we call the muscle tone. The impulses that come down from the centers keep up and maintain the muscle tone, and so impulses are all the time passing in and starting other impulses, not sufficient to cause an actual contraction, but just sufficient to keep the body in a state of health. Our tissues are un er tha t same influence, the only difference being in degree, but it is more characteristic in the arteries and skele tal muscles, and that is the reason we term it the sketal and arterial tone.

PHYSIOLOGY. (Lecture No. 40.)

August 23, '98.

We have thus far been discussing some of the general properties of the nervous system and some of the general phenomena of the nerve cells. Now we must pass on to the physiology of the nervous system, and we will take up first of all the nervous mechanism of the respiration. Respiration was the first of all the subjects taken up for consideration in our course, so we will now consider the nerves that have to do with this important function of the body.

To but a slight extent, respiration is under the control of the will, and hence we say that respiration is both a voluntary and an involuntary movement. Natural breathing is always involuntary, and is reflex, or automatic. The respiratory muscles are of the striped variety. They are voluntarymuscles, nevertheless we do not have full control of the respiration. We can breathe deeper, and we can breathe more rapidly, or we can breath more slowly, or shallowly,--but we cannot commit suicide by holding the breathe. Thus we see that our control of respiration is limited. There are certain sets of muscles that bring about respiration and respiratory movements. First of all the diaphragm, a dome-shaped muscle, standing by itself, forming the median partition between the thoracic cavity above, and the abdomen below. Then the intercostal muscles, lying between the ribs both externally and internally and other muscles, the pectoris muscle, and other muscles. The diaphragm is supplied by thephrenic nerve. The phrenic nerve is made up of two sets of nerve fibers. These two sets of fibers come from the spinal nerves, one from the fourth and the other from the fifth certical.. The phrenic nerve is properly a spinal nerve, receiving no fibers at all from the cranial nerves. The two phrenic nerves, the one on the right and the other coming down on the left, side, supply the diaphragm. We find that we ca stimulate either one of these nerves by stripp ing it,-- pass the fingers over it quickly and it will cause a contraction of the diaphragm. If one of these phrenic nerves be damaged, you have paralysi of that side of the diaphragm, so that the diaphragm will act imperfectly. It will only contract partially. That experiment in itself shows us that the phrenic nerves supply motor impulses, or motion, to the diaphragm. The intercostal muscles are supplied by the intercostal nerves, which are smal branches of the dorsal spinal nerves.

The nervous mechanism governing the respiratory muscles is what we call self-governing mechanism. The chief centers lie in the medulla, in that portion of the central nervous system that unites the cord to the brain. Subordinate centers are distributed throughout the cerebral spinal nerves, and are found higher up in the brain,. Just as son as we disturb the cord or the medulla respiration ceases. This shows us that the respiratory centers from which those impulses are constantly emanating lie in the medulla. The medulla is the lowest portion of the brain. It is interesting to note that this is bi-lateral, there being two distinct lobes, the right and left, connected by a bridge of fiber. Although they are connected, they act more or less independently, and, they act synchronously. Should we disturb one side, there would be a corresponding cessation of respiration on that side, but should one of the pneumogastric nerves be disturbed, lower down, then there would be little effect, the function being taken up by the corresponding nerve, and the respiratory acts are little affected. So this shows that they act in harmony; if the left nerve trunk is disturbed the right takes up its function and carries on the impulses. We have two nerves, one to the right, the other to the left, lung, and then we have a bridge connecting those two centers, in the medulla. Cut off the left pneumogastric, and the impulses will go over that bridge and pass down the right nerve and thus be distributed to the lungs, and there will be but very little effect upon the respiration.

Again, each bilateral half has two distinct portions, or we might say ea ch half is really a double center, and we find that we have impulses which go down and bring about contraction of the respiratory muscles--of the inspiratory muscles, and others will go down and bring about contraction of the expiratory muscles, so that we have what is called a double respiratory center, . We thus see that the nervous mechanism of the respiration is not as simple as we might at first apprehend. These two center which are apparantly one -two on one side and two on the other side, we shall call the inspiratory and the expiratory centers . Stimulation of the inspiratory cent ers brings about a contraction of the inspiratory muscles--of the diaphragm, and also of the intercostal muscles, so that there is a raising of the ribs. It not only causes a contraction of those muscles, but causes an increase of the insporatory rate. The same is true of the expiratory center. I stimulate the expiratory centers, and we can contract the respiratory muscles, and decrease the respiratory rate . A powerful stimulus will cause, when applie to the inspiratory nxxxxx center, xxxxxx an arrest of the respiratory a ct in the inspiratory phase, and a strong stimulant applied to the expiratory center will cause an arrest of the respiratory movement in the expiratory phase. The inspiratory center must, then, must be regarded as an exhilaratory center, because when it is stimu lated it causes an increase of the respiratory rate, on the other hand theexpiratory center mush be regarded asan ixxxxxx inhibitory center, for that decreases the rate.

If we consider them both together, the nerve as a whole, we get an exhilatory effect, because those nerves are more irritable, and consequently respond more read ily. We will not have time to discuss the subordinate xxxxxxxxx centers, but must now speak of the rythmic movement of the res piratory centers.

Respiratdon takes place ordinarily in a delicate rythmical way. There is a rythm about respiration and inspiration, each phase being of equal length. The rythm, rate, and force, are all to be consi ered to each phase. The phases are equal, consequently if this is true there must be a periodical discharge of impulses from the nerve cells of the centers--and this is true. Those discharg s are not brought about by the act on of the will--respiration c ontinues right on, whether we pay any attention to it or not, but it is due to the stimulating effect of the blood. I will ex lain how it is that the blood stimulates these centers and causes a periodic discharge to take place. Rythm, rate, and force, may all be affected by the will,, for instance, increased blood temp erature causes an increased rate of in p iration. Consequently in sickness, when we have a high temperature, we naturally have an increase of the pulse, and also an increase in the rate of respiration, and that is true with scarcely an exception. On the other hand, a lowering of the blood-tempe ature caused a decrease in the rate of in spiration.

That illustrates the economy of nature. Wherever we hve a high temperature of the blood, we hve something wrong with the blood. It means that mtabolism is going on very activaly, and it means too that there is not the proper elimination of the poisons of the body, that they are heaping up, causing this rise of temperature, consequently the respiratory muscles try to overcome this ~~xxx~~ defect by supplying an abundance of oxygen, so that they my be gotten rid of in this manner. When the blood is normal we have a decrease of respiration when there i a decrease of the blood-temperature. We mustnotice th at in disease, this change of the respiratory rate is synchronous with the change in the pulse and with the change in the temperature. The impulses passing up from the various tissues are constantly acting; such impulses are constantly being brought into these centers, and may be looked upon as possessing a certain kind of intelligence; they are constantly in communication with the lungs ; they act as a central station, just as over at the railroad station where the switches are controlled by means of wires and signals, and the man who sits there knows the condition of every switch, and can control every switch. In the same way these centers that lie way up here in the medulla are in constant and continuous communication with both lungs, and readily recognize the condition of the lungs whatever it may be. .

Now suppose e section one of the vegus nerves, a branch of the tenth or penumogastric nerve; we cut one of those two, and wht is its effect upon the respiration? If one of the nerves is injured that does not mean that respiration is going to stop, at all. The effect will be very slight, only that the respiratory movmments become a little less frequent Now suppose we cut both the vagi nerves--the effect is a marked decrease in the frequency, together with a marked increase in the depth of the inspiration. What does that show? It shows that the vagus nnerves have an inhibitory effect upon the heart; that by means of those vagus nerves the heart is controlled, so that it does not beat too fast. There is a retarding effect, if you please, upon the heart.

Now suppose we stimulate the heart by cutting this nerve; we get a corresponding increase in the rate, just as if we had stimulated the center in the medulla. The heart beats faster. This leads us to believe that the pneumogastric centers are constantly carrying impulses to the heart, and are thus controlling the heart.

The vagus nerve supplies both the respiration and the circulation; the same nerve is distributed both to the lungs and the heart, and consequently we would expect that they would act in harmony --and they do. The xxx afferent impulses that come up to the respiratory centers are carried chiefly by the pneumogastric nerve. Other nerves also carry some of the impulses, but the pneumogastric is the most important.

In what different ways may this center in the medulla be stimulated? I said a few moments ago that the stimuli that come to this center bring about a discharge of impulses acting through the blood, chiefly. It is by means of the respiration that the blood is purified. Do you wonder, then, that the conditions of the blood regulate the respiration; that just as soon as the blood becomes more venous that there is an increase in the respiratory rate, also in the depth--for example, here is a person starts to take a rapid run or vigorous exercise--there is a marked increase in the respiration. Running causes a greater contraction of the muscles, and there is increased work. There is a large amount of carbonic acid gas produced that may be increased five-fold by vigorous exercise. This means that the blood becomes impure; that it becomes venous, and the presence of this great amount of carbonic acid gas stimulates the respiratory centers, and the lungs not only breathe faster, but deeper. We see what a wonerful provisxxion of nature it is; a change in the condition of the blood changs the rate and depth of respiration, and if we continue the exercise for a while the r spiration will be equal to the demands of the body, and the poisons are eliminated as fast as they are produced, and then we do not have that "tired feeling." Tat tired feeling is due to the heaping-up of poisons in the body, more than to actual w eariness of the muscles themselves. Now then, if those poisons be eliminated and gotten rid of from the body, then this feeling of weariness passes off. When one practices on the track and makes a habit of taking vigorous exercise, after a while they get what we call the "second wind," and do not feel as weary as before. That second wind means tat there is a compensation or balance between the respiration and the demand of the muscles, which are getting the amount of oxygen they need for their work, and the carbonic acid gas is being eliminated. Suffocation means a heaping-up of poisons. A person who is suffocating becomes filled with poisons, and it stimulates respiration. Strangulation stimulates the respiration and the lungs try to bring more oxygen. So we might say that the respiratory centers of the lungs are under the direct control ofthe ~~lungsx~~ blood. The blood passes throu h those centers, directs the impulses, and controlls the centers. When the blood passing through the centers is normal, and contains only a normal amount of carbonic acid gas, then the respiration goes on naturally without change. When the blod becomes more venous, more impure, then there is a change i the respiration; it becomes deeper and more frequent in order to purify the blood. When the blood returns to its arterial condition then the respiratory rate decreases,.

Some one may ask the question, then, Do not the afferent fibers have any effect? Yes, they do, but their effect is merely subordinate. The blood determines the rate and depth of the respiration more than any other agent. It is practically the determining factor, and these xx other elements have a secondary effect. we do find that breathing certain substances cause a stimulation of the circulation. The blood may be perfectly pur e and normal in its composition, but beathing certain gases into the cixxxxxxxxxx lungs causes a stimulation of the centers and an increase in the rate.

The principal nerves tht control the lungs are the pneumogastric, and they carry exxxxxxxx exhilaratory and inhibitory impulses down tb the lungs., and have a double effect upon the lungs. The efferent impulses tht come from those inspiratory centers that increase the respiration in rate and depth, also hve an effect upon the bronchi. They are called bronchi dilator fibers, also, because they cause dilation of the bronchi. We have sev ral effects taking place when an inspiratory impulse reaches the lungs. First of all th re is an increase in the rate; sedondly there is an increase in the depth, thirdly there is a dilitation of the bronchii, all working harmoniously together, and al causing the same effect. T his incr ased depth depends in reality upon the dilation of the bronchi. We have bronchi dilator, and bronchi-constrictor fibrs. When an impulse travels down to the lung it also has three effects,--decreased rate, decreased depth,--and that depends upon the effect of those bronchi-constrictor fibers' because there is an ef ect upon the bronchial tubes ; so we hve two kinds of nerve fibers going to the lungs, the inspiratory,and the expiratory nerve fibers.

We must now pass on to the nervous mechanism of the heart. I have said that it was impossible to hold the breath long enough to commit suicide. The holding of the breath causes a heaping -up of poisons and carbonic acid gas and other poisons remaining in the blood, and they are not gotten rid of by the lungs. These have a stupifying or paralyzing effect, and if we can hold the breath long enough, we will become unconscious, but then we cannot control those functions any longer, and we begin to breathe again, and consequently there is no chance for fatal results from holding the breath; you can only hold it long enough to become unconscious. This is a powerful excitant and stimulaht to the heart But we have no instances on record where a person was able to hold his breath for a s ufficient length of time to cause death. In orderx to produce sleep a splendid thing is to take deep breaths. They are soothing or sedative in their action.

We have no control over the heart, practically. There are instances where it was supposed that the person had a slight control over this organ, and could at will increase or decrease the rate of hxxaxx beating, but such instances are very rare, and I do not know how authentic they are. The heart is an automatic organ to a certain extent. It is also supplied with nerves from the central system, of which the principal is the pneumogastric. This nerve is one of the mo t important which go to the lungs and stomach; it is the most widely distributed of all the twelve cranial nrves. The heart has a double nerve supply, a and also has what we call ganglia, which are located in the substance of the heart itself--right in the muscle of the heart itself. So then it has an internal supply and an external supply. Its automatic activity is due to thxxxx this internal supply--to the ganglia which lie in its substance. These are very small--mostly microscopic,--and are distributed throu hout the substance of the heart, but are found more abundantly in the little septum which divides the ventricles and the auricles .

It appears from experimentation that the heart possesses spontaneity and contracts spontaneously on account of these ganglia, which send impulses to the muscles, and thus cause contraction of the muscles.

Cardiac muscle, the muscle of the heart, is peculiar kind of muscle, and is found nowhere else in the body, and with this anatomical peculiarity we must expect physiological peculiarities. The heart differs from all the organs of the body. The heart has a great deal to do with the originating of its own impulses and contractions. The contraction of the ventricle is apparently not a tetanic or compound contraction, but a simple one. We remember that the compound contraction is one where the impulses continue to pass into the muscle and maintain it at a certain degree of contraction. The contraction of the muscles of the body, with scarcely an exception, is tetanic, but the heart contracts with a simple muscular contraction that is prolonged a little. (Diagram.) The heart is supplied by two nerves, the same as the lungs--by both pneumogastrics. If we stimulate a vegus nerve we find that the heart goes slower. Cut a vegus nerve and stimulate the end connected with the heart, and a very slight stimulus will cause a slowing of the heart, and an increased stimulus will even cause the heart to cease beating entirely. What does that show us? That shows us that the vegus nerves carry inhibitory impulses to the heart. We cut both vagi, and the heart begins to beat rapidly, because the retarding influence is removed. So the nervous mechanism of the heart is something like that of the lungs, which also have inhibitory impulses coming to them to slow them up, so that we have a reserve force there, ready for any emergency that might come.

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PHYSIOLOGY. (Lecture No. 41.4?.)

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If we stimulate a skeletal muscle the resp onse is proportionate to the stimulus--the stron er the stimulus the stronger the response, and vice versa. But not so with the heart. If we g t any contraction at all from the heart muscle we get the maximum, no matter what the stimulus may be. Just as soon as the stimulus is able to bring about a contraction, it is the most powerful that the heart is able to produce This is, I think, not thoroughly understood; but I think it is a wise provision of ature to prevent overwork of the heart. Many stimuli may reach the heart at the same time, but no matter how many there my be, the response is just the same. If the heart beat were very much stronger with the increased strength of the stimulus, then there would be a great danger to the life of the individual. It is believedthat each beat of the heart is the maximum beat of which the heart is capable at that time. So we see that this rythm, this continuous rythm, is a property not only of the nerves of the heart, but of the heart muscle. The heart is up - plied by two pneumo gastric nerves, which carry impulses to the heart the same as to the lungs. This is a very complex nerve, made up of a number of fibers. It is made up of first, what we call inhibitory, and secondly, exhilatatory exhilatatory or augmentor, nerve fibers. These terms are really self explanatory,--inhibitory, tending to stop, and exhilatatory, to increase or to strengthen--causing to move more rapidly.

Let us consider the anatomy of the nerve for a moment. We find on passing back to the brain that there are two origins for this nerve; that some of the fibers come from the second and third spinal nerves and a third from the medulla.(?) Here we have a mixed nerve. It is even possible to stimulate those two roots directly, and then we get the effects directly. If we take a nerve fiber direct from the medulla, we get inhibition; it causes the heart to beat slower, and if those stimuli are increased very much it may even stop the beating of the heart entirely. That leads us to say that those nerve fibers are inhibitory. On the other hand if these two nerve fibers coming from the cranial centers are stimulated, if the stimulus is small, we have a corresponding increase in the rate; if the stimulus be large, we have an xxxx corresponding increase in the beat of the heart. Those nxxxxxfxxxxxx experiments performed upon the nerve fibers at the beginning, upon the muxe nerve, shows u that it is a mixed nerve, and that it contains both of these classes of fibers. The inhibitory nerve fi bers act directly from the medulla, from a double center in the medulla called the cardiac inhibitory center, meaning heart-retarding. Th cardie-inhibitory centers, then, are in the medulla. . These are found deep down in the neck, right at the base of the skull where they come together to join, after coming out. After they pass out and join they lie between the carotid artery and vein. So in performing the experiments on blood pressure, with the dog, we have to dissect the nerve and put it aside, for we are liable to do injury to the nervem although even if the nerve be cut it does not make so very much difference. Nature has so provided that if the nerve be cut that there is still a chance to regulate the heart through the nervous system. There is a slight effect upon the lungs, but after a while all the duties are taken up by the remaining nerve. This pneumogastric nerve xxxxxx is both a reflex and a motor nerve. That is, it is both sensory and motor. Let me explain; If we study the nerve carefully we will observe th t the pneumogastriccarries impulses to the brain as well as from the brain, mmdxjustxthexsamexaxthx thex xxx and in a certain way the heart reguates itself; and the same is true of the lungs. The lungs also send impulses to the medulla all of the time. Now then, the state of the blood affects the cardio-inhibitory centers just the same as the pulmonary centers of the lungs, both directly and indirectly, and we find that when there is a decrease of the oxygen of the blood,--when the blood becomes clogged with the poisons and wastes of the body, it acts as a poison. It paralyzes the cardio-inhibitory xxxxxx center, and consequently the inhibitory impulses are entirely shut off, allowing the heart to beat more rapidly. In this case the venous blood has a paralyzing effect. In the case of the pulmonary centers it has an irritating effect. Sending the impulses down causes impulses to come down and inspiration to take place, increasing the rate of inspiration, as well as the depth of expiration.

But the mechanism of theheart is very different from that of the lungs. The heart is an organ that could be very easily overworked if nature did not specially guard over it. There is really a special guard set over the heart to protect it from over work, and that guard is the cardio-inhibitory center, which is all the time holding the heart bask and preventing overwork. The heart is such a powerful organ that otherwise it could be easily overworked, and possibly ruptured. It is a sort of bag, containing the blood, and it would be very easy to increase that blood pressure too much, and people have dropped dead suddenly just from the bursting of one of the walls of the heart and allowing the blood to flow into the thoracic cavity. But this is rare, because of the cardio-inhibitory center. That is heart failure, but what is commonly known as heart failure is failure in the valves of the heart. When we come to consider the mechanism we will see that ature has so provided it that the organ itself shall determine the amount of work that it shall do. In other words, we do not have an arbitrary center up here in the medulla, to say just how much work it shall do, without any attention to the condition of the organ. we may find it in the arrangements made by man, but not by nature. We find in nature that the organs or elements which are doing the work determine how much work they are able to do, and it is not regulated arbitrarily by those outside who have no sympathy with those tissues. Although we have a center up here in the brain, that work depends upon the impulses sent out by that same nerve. The vagus nerves carry those impulses. Some of the impulses are of a certain nature, and others are of another nature, and they are all looked over carefully, and the size of the heart and the strength of the heart and all those things are taken into consideration in sending down impulses to the heart So then, every time the heart beats that beat is the maximum strength of the heart at that particular time. The inhibitory centers are all the time holding it back a little bit, so that the heart is able to beat a little faster and a little stronger at some times than at others, and if it were not for this fact there would be danger to life. It is believed tat during the natural life these impulses are all the time being sent to the heart, although they vary in number depending upon the judgement of the system, and the whole system, as well as the heart. The heart is connectedwith every other prt of the body. A blow upon the abdomen, for instance, hs a direct influence upon the heart. A blow upon the abdomen has more than once killed a person. We have authentic records of persons having been killed by a kick in the abdomen. A blow upon the abdomen causes faintness if it is not very strong. what is the effect? It is a reflex impulse travelling to the heart and strengthen the cardio inhibitory centers so much that the heart is entirely stopped. I do not know of any other way to explain it than as a protective measure of nature that has been stimulated too much. This nerve, way down here in the abdomen, when stimulated, is able to stop the heart. Not directly, for it doesn't go to the heart at all, but it goes up to the brain and is in connection with a center right here in the medulla. There are other means of producing exactly the same resultd, showing that the nerve controlling the heart is in direct communication with all the organs and tissues of the body, because the heart is the primary cause of the circulation of the blood and consequently the system as a whole is in very close communication with the heart-center, because the heart must make known just howmuch blood it needs, and then the work of the heart is very closely determined. Now then, other impulses come up there from the nerve cells and nerve tissues to this nerve center to make known whether they have an abundance of blood or not, and how much they need. Now when those two conditions are just about balanced that means a healthful state of the blood and the body; but on the other hand if the blood is clogged with poisons, the healthy blood may be doing its work, nevertheless it is clogged up and it must do more than the ordinary amount of work to get rid of these poisons. The healthy blood is more easily distributed to all the parts of the body than is the impure blood.

There is not a single organ of the bddy that is not at all times working harder than the heart. There is not a single organ in the body that has the same structure as the heart, or anything like it. Heart muscle is peculiar to the heart, and is capable of doing a large amount of work. When we think of its beating seventy-two times per mintue, we see that it must have the best of nourishment at all times ixxxxxxxx because if it does not have that that weakness is felt throuhout the whole body.

We must now pass on to what we call the vaso-motor centers. We might speak of the effects of drugs, first, however. Many different drugs are given to produce different effects upon the heart, and of these we might mention digitalis and atropine or atropia. Atropine when applied to the heart prevents inhibition. Atropine paralyzes the inhibitory centers found directly in the heart. We may apply it directly to the heart, or to the nerve itself, to paralyze the inhibitory nrve, and thussinhibition of the heart is prevented, and in that way the heart beats faster. . This safety-valve that nature has provid d us is set aside and trampled upon. It paralyzes the inhibitory centers, ri ht down here in the heart itself, and consequently inhibition is no longer possible as soon as atropine is applied. No matter what impulses may be sent down, they cannot act because of the paralysis of the endings of the nerve. This is a dangerous drug to use.

Muscarine(?)is a great antagonist of atropinr. It stimulates the xxxxxxxx inhibitory centers, and stops the heart's beating. Painting a frogs heart with a dilute solution of atropine sets it to beating rapidly by paralyzing the centers, so tht the impulses cannot reach the heart at all, and the heart goes on beating rapidly, and is not regulated in any way in its work. Muscarine stimulates instead of paralyzing the cardio-inhibitory center. Under the atropine stimulus it works more rapidly, but the muscarine ~~paralyzes the in~~ stimulates inhibitory cen er so that it must stop its action.

Painting a frog's heart with atropine, with a camel's hair brush, will start it to beating rapidly. Again, painting it with muscarine will cause it to slow up. But these are both unnatural and unphysiological. Natu e has provided the best means known of regulating the heart. Man understands the heart less perfectly, and uses some drug to regulate it. Digitalis is considered as a heart stimulus. The primary effect is stimulation, but if you stimulate for any length of time there is a depression just as soon as the effect of the drug passes off and then the heart is weakened and then it will require still stronger doses to produce the required effect. The effect of stimulating these inhibitory centers, then, is to strengthen the heart by saving it. The more inhibitory impulses, the less the heart beats, and consequently the strength of the heart is saved. On the other hand, paralysis of those inhibitory centers causes the heart to beat more rapidly and afterward there is a period of depression, and the heart is weakened.

Now then, the vaso motor centers. This mans the motor nerves of the vessels, and these work in harmony with the nerves of the heart, and these are distributed chiefly to the muscular parts of the arteries, which is ~~Thaxxxxx~~ relatively more abundant in the larger than in the smaller; in the smaller thay are more . The vaso motor centers hare found up in the medulla, alongside of the cardio inhibitory centers, and there is a communication between them. The vasomotor centers are of two kinds, vaso dilator, and vaso constrictor. Those which cause the vessels to enlarge, and those which cause the contraction. So we have then, going to the bloodvessels, two sets of nerve fibers the same as to the heart, and let us see how they act in connection with the heart. Suppose we have inhibition of the heart. If the heart beats slowly, if the inhibitory impulses are increased, then there is a lowering of the blood pressure because of the slow beating of the heart, but there is a reciprocal action on the part of the blood vessels. The system requires its nourishment just the same as before, and if the blood pressure were allowed to become lower then there would be insufficient nourishment supplied to all the parts of the body, so the blood vessels narrow and contract , and consequently keep up the blood pressure If the blood vessels become smaller then the blood pressure remains the same. It requires less blood to maintain the same pressure. On the other hand if the heart has a stronger beat,--if it is beating more rapidly, then there will soon be a great increase of blood pressure,, and there would be danger. But we have the dilator nerves, and there is a dilation of the blood vessels, and the blood pressure remains the same We can remove from an animal one-half of its blood, and the pressure remains the same. We can inject half the amount of blood an animal has, without increase of the blood pressure. We see they act in harmony. When the heart is beating more rapidly and stronger, there is a tendency to increase the blood pressure, but the vaso-dilator nerve fibers recognize what is going on,--it may be that some drug has been taken, so that they proceed at once to dilate the blood vessels. It is a most wonderful mechanism that controlls all the blood vessels, and there is an intimate connection between them because they act together, and the blood vessels may really be considered as outgrowths of the heart. We see that the blood circulates in closed tubes everywhere, so that the blood vessels are really an extension of the heart, and this shows us that there must be a very intimate connection between their nerve supplies. Now suppose the constrictor nerve fibers should act sometime instead of the dilators, some time when the heart is beating strongly;

You are going to have a rupture of the heart or something of the kind, very shortly, just from that singl irregularity. Nature has balanaced these mechanisms very finely, so that there is no possibility of a mistake. You raise the temperature of the body three or four degrees, and you have to g o to bed. It just prostrates you. We have ill health and sickness just as soon as this fine balance is disturbed.

The nerve upply of the digestive organs. The nerve apply of the digestive organs controlls all the digestive movements. Peristalsis, for instance, is controlled by the nrves, as are the ovements of the secretory glands. Take for instance the sub maxilary gland, and we have what is called the chorda tympani , which comes from the fifth cranial neve. We find that this small gland also has a double nerve supply, which might be likened to that of the heart. The chorda tympani is a motor nerve, but also has sympathetic fiber coming up from the neck. So we have two kinds ofnerves going to the gland, joining after entering the gland, but before entering the gland we can stimulate them separately, very easily. By stimulating the corda tympani we have two results--first, a diltion of the vessels of the gland, and an increase of the activity of the gland. The gland goes into functional activity. Now let us see how those two act reciprocally with each other; If the gland is to be active functioally, it must have some material upon which it can work, and consequently there is an abundance of blood there. Not only is the gland set in a state of functional activity by the stimulating of the corda tympani, but the blood vessels ofthe gland are wi ely dilated, and consequently there is a large amount of blood there and we have an abundant flow of saliva. That is what takes place when you take food into the mouth when it is dry, and by making the teeth go. This causes a flow of saliva, reflexly.

The salivary glands of the mouth, on the other hand, are a little different in constitution. If stimulated there is no effect upon the blood vessels,--if anything, they constrict, consequently the secretion of the gland is less abundant while this nerve is being stimulated, and the secretion is less watery, and thicker. So we have the two nerves regulated by centers in the brain, which are in communication with the gland, and know just when they are in a state of health, just how much work they can do, and consequently the impulses that come down there set the gland to work are many or few in number, and the activity of the gland is lessened or increased.

The effect of chewing gum? Chewing-gum is not food at all, but nevertheless it starts these glands into functional activity, and starts these reflex impulses. These impulses go to the brain and say that there is a chewing going on in the mouth, and that there is food there, and the evidence is all weighed up there, and the impulse goes back down to start the secretion of the saliva, and the saliva is secreted in abundance,--but it is wasted, because nature has so provided it that the act of thorough mastication brings more saliva, because as the food becomes finer, it requires more moisture in order to thoroughly saturate it.. So that really chewing gum is a fraud played upon nature. The same mechanism is true of the stomach itself; the nerve fibers go there to the gastric glands and cause them to act, and their action brings the secretion. When we take food into the mouth it has a reflex action in the stomach, so that it goes right to secreting in order to be ready for the food. The nerve fibers of the stomach are mostly sympathetic, and they act from the solar plexus, or great abdominal brain, a large nerve ganglion' the nerve fibers of which all together make up the solar plexus, and they send fibers to the intestines to regulte their activities. When food en ers the stomach an impulse is started, and there is a secretion of the gastric juice, and the sa e is true of the intestinal canal, and all of the digestive tract. The secretory ctivity depen s upon the nerve impulses. Food does not start the secretion di ectly, but through the nervous system, and there is not a single tissue in the body that acts but acts through the nervous system. . You ca not make them act directly. You cannot do it physiologically, but it is only through the nerves that you govern the body, and thus we see the importance of having good strong healthy vigorous nerves, so as to properly rgulte all the functio s of the body.

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