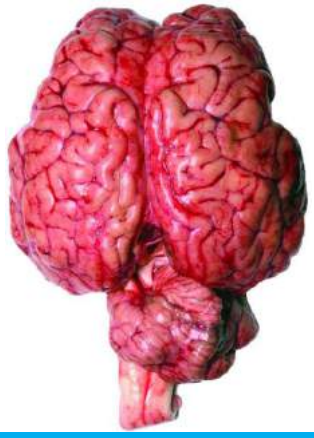

Chapter

5

Co ordination - The linking system

Sharpening of a pencil, grasping a door knob, walking or running, driving, and a few physical actions, all involve well coordinated movements made with well balanced postures. In fact, whenever we move the three basic functions, such as movement, balance, and coordination they work together to perform purposeful motions of body parts. This is actually quite a feat, because moving is a complex process for the body.

Even standing upright is a difficult challenge of balancing on just two feet with a narrow base. Yet, it is common for us not only to stand upright easily and apparently, effortlessly, but also while keeping our balance to perform many other functions.

- *What other functions do you think needed in coordination and balance?*

All our functions are carried out by an effort of several systems working together. For example, while movement, we hardly ever use just the skeletal system or muscular system alone, several other systems also have their own roles to play. Even within the muscular system, several muscles work in a sequence or at once.

- *What triggers movement of the muscles?*

It is a kind of pathway involving the way that our organs, tissues and cells work. All of them pick up signals of change from their surroundings and respond to them. This process triggers different functions in our body as well as by our body. For example, it is natural to move to a side of the road when we hear or see a car approaching.

Responding to stimuli

- *What helps us to respond to such signals?*
- *Why does the living body respond to such signals?*

We can think of a response as an effect of a change in the environment of the organism or signals of change or 'stimuli'.All living organisms respond to stimuli. The cat may be running because it saw a mouse. Plants grow towards the sunshine. We start sweating when it is hot and humid.

The ability to react to particular stimulus in a particular situation must be of great importance in ensuring the survival of the organism.

There is a sequence of events that brings about responses. They start from detecting changes in environment (both external and internal) or stimuli, transmission of the information, processing of the same. Finally the response will detect and execute the appropriate action.

Let us do the following activity to find more about response to stimuli.

Activity-1

Holding a falling stick

Take a long scale or stick at least around ½ meter. Keep your fingers in holding position as shown in fig-1 . Ask your friend to hold the stick / scale near the end and let the other end be suspended between your fingers.

fig-1: Holding stic

Let there be a very small gap around a centimeter between your thumb and stick/scale and the stick/scale and fore finger. Now let your friend allow it to fall. Try to hold it.

- *Could you hold it exactly at the point where it was suspended between your fingers?*
- Mark the point where you caught the stick.
- *How far up was this point from the end suspended between your fingers?*
- *Why did this happen?*
- *How fast do you think the process was?*

Responses are brought about by rapid changes in some muscles and such changes are usually related to changing stimuli. Rapidity of response indicates an efficient communication system linking those parts that pick up stimuli to those that trigger a response.

- *What makes this kind of communication possible?*

Integrating pathways - Nervous coordination

fig-2: Galen

The Greeks believed that all functions of the body were controlled by the brain since damage to that organ produced remarkable changes in behavior. They had very little idea on how such control could be exercised though Galen, a Greek physiologist (A.D. 129-200) made one notable observation. One of his patients, having suffered a blow on the neck when falling from his chariot, complained of loss of feeling in the arm while still retaining normal muscular control of its moment. Galen concluded that nerves were of two kinds – those of sensation and those of action. According to him the blow in the neck had damaged the nerves of sensation but had not affected it's action.

- *Why do you think Galen Drew such a conclusion?*

The functioning of nerves as integrating systems was little known till late 18th century. Then, physiologists began to study the mechanism of nerve functioning and found how signals were transmitted by making the connection between recent work on electricity and the propositions on working of the nervous system made till then.

Now we know more about how nerves from different sections of the brain and spinal cord control responses of different areas of the body. We also know the probable pathways that transmit information but we still know very little about the working mechanisms of the nerve cell.

Structure of nerve cell

Activity-2

Observe the permanent slide of nerve cell or neuron under microscope and try to find out its parts, compare with the following diagram.

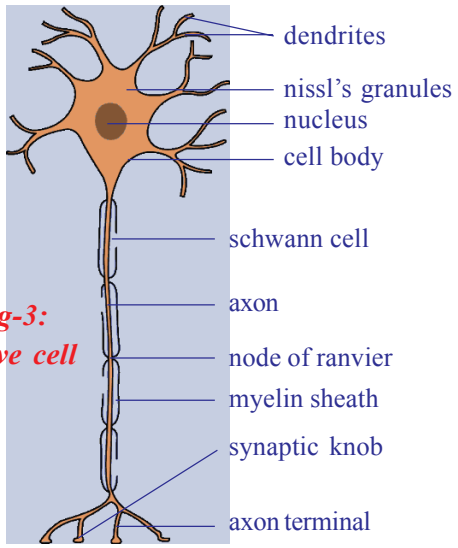

fig-3: Nerve cell

Each nerve cell consists of a cell body with a prominent nucleus. There are fine projections mainly of two types extending from the cell body of the nerve cell. The small projections are dendrites while a long one that extends to different parts of our body. The axon is surrounded by a specialized insulatory sheath called myelin sheath.This sheath is interrupted at regular intervals called nodes of ranvier.The myelin sheath is made up of schwann cells and chiefly consists of fatty material. Axons not having the sheath are non-myelinated fibers. The

covering also forms a partition between adjacent axons. The nerve cell body lies either in our brain or spinal cord or very close to the spinal cord in a region called dorsal or ventral root ganglion. In the brain or spinal cord, it is difficult to make out the difference between dendrites and axons on the basis of their length, often, the presence of the sheath helps us to find out but several axons here do not have the sheath.

We know that the nerve cell is the structural and functional unit of nervous system. Our nervous system consists of around about 10 billion of them, which communicate with each other in a specific manner. Dendrites of one nerve cell connect to the other or to the axons of the other nerve cell through connections called as a 'synapse'.

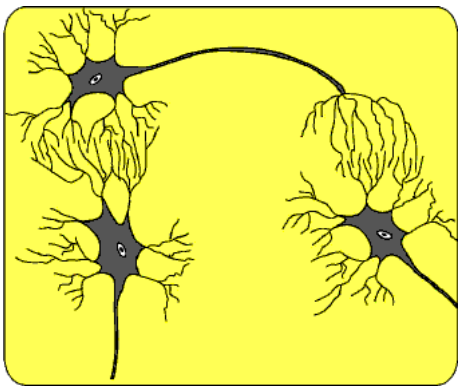

fig-4: Synapse

Synapse is the functional region of contact between two neurons, where information from one neuron is transmitted or relayed to another neuron. Though these are regions of minute gaps and essentially neurons do not have any protoplasmic connection between them yet information is passed from one nerve cell to the other through these gaps either in the form of chemical or electrical signals or both. These synapses are mainly found on the brain, spinal cord and around the spinal cord. Beyond these areas the axon carries the signals to respective areas in our body.

Pathways: From stimulus to response

In the holding stick activity you observed that there is coordination between eye and finger. Different pathways are taken by nerves to bring about this coordinated activity.

On the basis of pathways followed, nerves are classified mainly into three different types.

Afferent neurons:

Afferent (or ferrying towards) which carry messages towards the central nervous system (spinal cord or brain) from nerve endings on the muscles of different sense organs that sense the change in surroundings are called stimulus detectors. These are also called 'sensory' nerves.

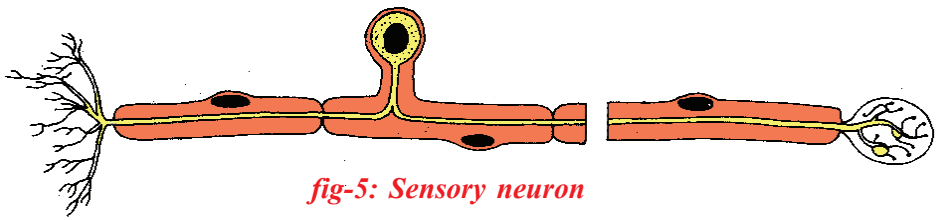

fig-5: Sensory neuron

Efferent neuron:

Efferent (or ferrying away) which carry messages from the central nervous system to parts that shall carry out the response or the effectors (nerve endings). They are also called 'motor' nerves.

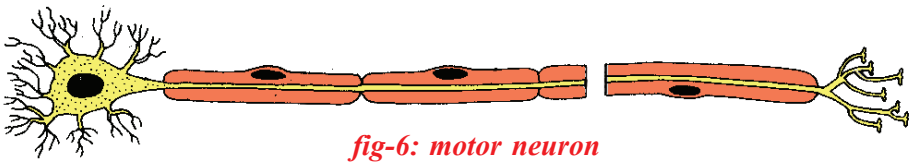

fig-6: motor neuron

Association nerves:

Association nerves, which link together the afferent and efferent nerves.

- *Which organ of your body was the detector and which the effector in Activity-1?*
- *What do you think that the information carried on the afferent and efferent nerves?*

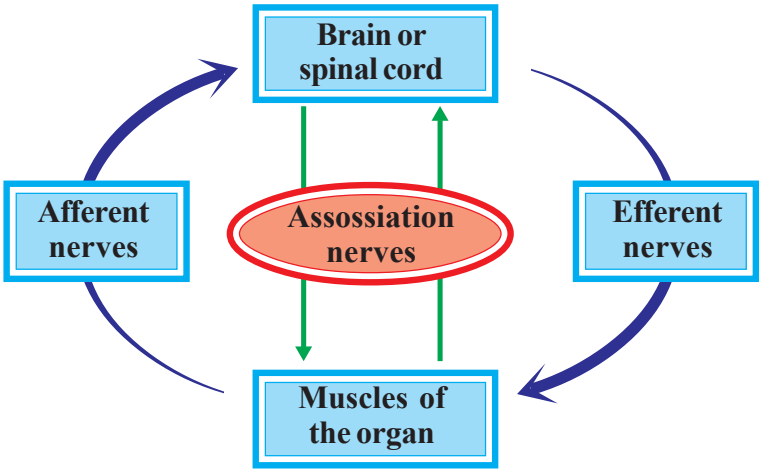

fig-7: Different nerve pathways

Activity-1 showed a response on which you had some control or it was voluntary (recall the use of the voluntary and involuntary muscles that you studied in class 9th.). We know that our body would also need to respond to certain situations on which we may not have a control. Such responses are called reflexes.A simple activity shall help us to understand this better.

Activity-3

fig-8: Knee jerk

Knee jerk reflex

Cross the legs, in a seated position, so that the lower half of the uppermost leg hangs freely over the other. Strike the area below the knee cap sharply, while firmly grasping the front part of the thigh with the other hand. Note the changes in shape of the thigh muscles.

Note that although we are fully conscious, we cannot prevent the thigh muscles from contracting. Such a response

is said to be involuntary. Now the same thigh muscle can operate in a voluntary manner, as when we kick a football.

Do you think most of the functions in our body go about in an involuntary manner? Why /Why not?

Do you know ?

The existence of the knee jerk was first noted in 1875. At first it was doubted whether a nervous reflex was involved at all. But it was discovered that if, in an anaesthetized monkey where spinal nerves supplying the limb were cut, the knee jerk reaction would not occur. Clearly a nerve pathway was involved.

During actions which are involuntary and have to be carried out in very short intervals of time, the pathway that nerves follow is a short one; it does not go up to the brain while voluntary pathways are usually longer passing through the brain. Now let us see what pathways actually are.

The reflex arc

Not until the end of the nineteenth century the reflex was understood in terms of pathways. Picking up information of a stimulus to generate a response involves a pathway from detectors to brain or spinal cord or a set of nerve cell heads near spinal cord to the effectors. Such a single pathway going upto the spinal cord from detectors and returning to effectors is a reflex arc.

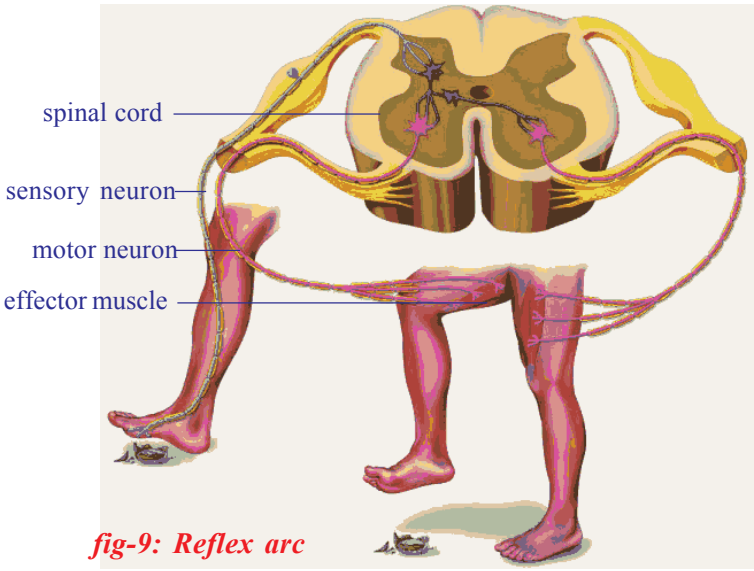

fig-9: Reflex arc

If you accidentally touch a very sharp surface with your feet, several such arcs would operate to cause the muscles of the leg to withdraw the feet. Observe the fig-9, how our leg muscle responds when we step on a sharp edged object.

- *What other effectors would act under these circumstances?*
- *What does this tell us about the association of nerves?*

In fact, you must have experienced, what happens when you do things consciously and otherwise. Say for example, when you are performing an action such as running upstairs. If you start to think about where your feet are going you often stumble. The interesting thing is that the same effectors

in the leg muscles can be made to perform very special movement under the control of the conscious mind (voluntarily). Hence in a football game, the muscles of the leg operate both by reflexes and voluntarily. Most actions of our body are actually controlled together by voluntary and involuntary pathways.

Do you know ?

Nerve transmission from stimulus to a response can occur at a maximum speed of about 100 meters per second.

- Think of any action and try to make a sketch of the reflex arc.

The voluntary and involuntary actions in our body are controlled by nervous system as a whole. We may study our nervous system on the basis of areas from which nerves originate and then spread out to the whole body as mainly two divisions one is the central nervous system (CNS) and the other is peripheral nervous system (PNS)

Central Nervous System (CNS)

Central nervous system includes brain and spinal cord. It coordinates all neural functions.

Brain

Proportionate to the body size, the human brain is the largest of all animals. The brain is present in the hard bony box like structure called cranium. It is covered by three layers called the meninges. The meninges are continuous and cover the spinal cord as well. The space between the inner layers is filled with fluid called cerebro-spinal fluid. It serves as a shock-absorbing medium and protects the brain against shocks/jerks along with the meninges and cranium. Mainly the nerve cell bodies together with capillaries form a mass called grey matter while the myelinated axons or those covered by fatty sheaths form white matter. The grey matter is usually present on the periphery while white matter is present towards the center. This is mainly due to the fact that there is a small area from where the myelinated axons leave the brain. As we

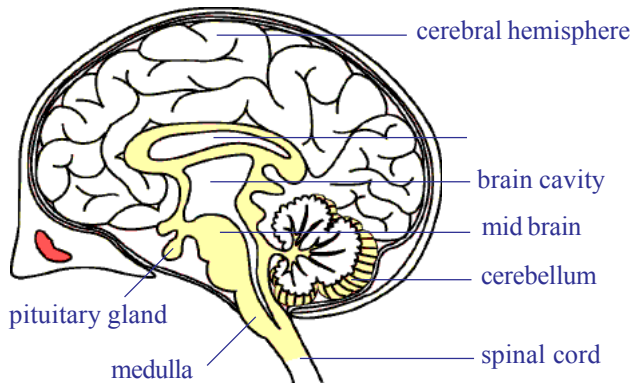

fig-10: Brain

have already studied, the function of the brain as a control center was known nearly 2000 years back by Greek physiologists.

Brain has the following divisions –

1. Forebrain – cerebrum, diencephalon
2. Midbrain – optic lobes
3. Hindbrain – cerebellum, medulla.

Table-1: Functions of the various parts of the brain

Part of the brain	Functions
Cerebrum	i) Seat of mental abilities, controls thinking, memory, reasoning, perception, emotions and speech. ii) Interprets sensations and responds to cold, heat, pain and pressure.
Diencephalon	i) Relay centre for sensory impulses, such as pain, temperature and light. ii) Reflex centre for muscular activities. iii) Centre for certain emotions such as anger. iv) Centre for water balance, blood pressure, body temperature, sleep and hunger. v) The hypothalamus controls the pituitary gland, which functions as the master gland.
Midbrain	It relays motor impulses from the cerebral cortex to the spinal cord and relays sensory impulses from the spinal cord to the thalamus, reflexes for sight and hearing.
Cerebellum	i) Maintains posture, equilibrium and muscle tone. ii) Coordinates voluntary movements initiated by cerebrum.
Medulla oblongata	i) Contains centre for cardiac, respiratory and vasomotor activities. (**Vasomotor** refers to actions upon a blood vessel which alter its diameter) ii) Coordinates reflexes like swallowing, coughing, sneezing and vomiting.

Do you know ?

The brain weighs approximately 400g. Through the brain comprises little more than 2% the body's weight, it uses 20% of the whole body energy.

fig-11: Spinal cord

Spinal Cord

Spinal cord extends from the back of the hind brain(Medulla oblongata) to the back of the stomach or lumbar region, through the neural canal of the vertebral column. It is almost cylindrical in shape. Unlike the brain, the white matter is towards periphery while grey matter is towards the center of the spinal cord. The myelinated axons leave the spinal cord from both sides of the vertebral column. See fig-11.

The role of the spinal cord in nervous control was studied largely by the experimentalists of the sixteenth and seventeenth centuries. They found that the Greeks concept of control by the brain was erroneous. Animals were shown to have the ability to respond to stimuli even when the brain was removed. 'Leonardo da Vinci' (1452-1519) and 'Stephen Hales' (1677-1771) both recorded the survival frogs those brain had been destroyed. The animal still produced muscular moments if its skin was pinched or pricked. Both observers further recorded that the animal died as soon as spinal cord was damaged by pushing a needle down it.

fig-12: Leonardo da vinci

Such evidence suggested that the spinal cord was not simply a trunk road for instructions from the brain, but might be a control center in its own right.

- *According to you what would be the function of the spinal cord?*
- *Are all functions of our body under direct control of the brain and spinal cord? Why do you think so?*

Do you know ?

Scientists have been able to trace out the nerves that originate from brain called cranial nerves and those that originate from spinal cord called spinal nerves. There are 12 pairs of cranial nerves which arise from the brain. There are 31 pairs of spinal nerves.

Peripheral nervous system

Figure-13 shows you that nerves attached to the spinal cord have two types of connections or roots – One to the back or dorsal side and other to front or the ventral side of cord. The experimental work of two men, Charles

Bell in Scotland and Francois Magendie in France, in the early nineteenth century, showed that these roots have different functions. If the dorsal roots of an experimental animal were cut the animal made no obvious reaction. If, however, the ventral roots were even lightly touched, the muscles to which the nerve was connected switched violently. The ventral root evidently controlled muscular activity, the dorsal root did not.

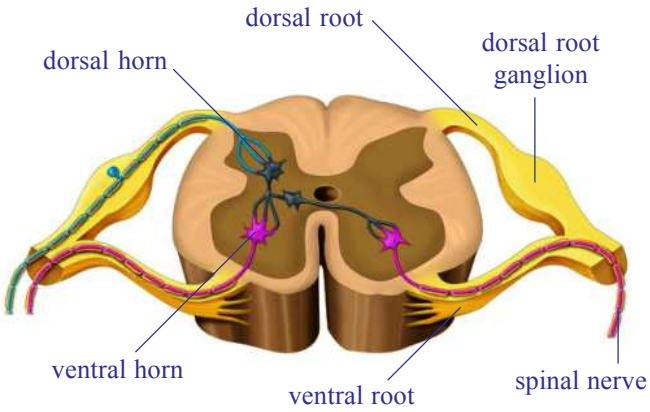

fig-13: Periperal nerves system

In 1822 they suggested that dorsal root carried messages of sensation inwards while the ventral pathway carried outwards the instruction for muscular contraction.

- *Which root according to you gets signals from afferent nerves?*

The peripheral nervous system (PNS) is a vast system of the dorsal and ventral root nerve cell heads and the network of spinal and cranial nerves that are linked to the brain and the spinal cord on one end and muscles on the other.

- *What do you think the end of these nerves act at the muscular end?*

The PNS can either involuntarily control several functions of regions like our internal organs, blood vessels, smooth and cardiac muscles.So it is called autonomous nervous system. It has voluntary control of muscles of some areas of skin and the skeletal muscle.

We can take up an example to see how certain involuntary function controlled by autonmous nervous system takes place in our body. A very evident observation is the reduction and expansion of the pupil of our eye.

When we enter a dark room we cannot see anything immediately. Slowly we are able to see the things around us in the room. This is because of increase in diameter of pupil, which allows more light in. When we come out of the dark room into broad day light the diameter of the pupil decreases allowing less light to enter into the eyes. Both these functions occur under the influence of the autonomous nervous system.

Several functions in our body are controlled by nerves while many of them and others are controlled by other ways as well. You might have heard about people having diabetes and know that they have to take tablets or insulin injections when the level of sugar in their blood rises.Let's find

out what insulin is and how we came to know about it. This would also give us an idea of controls other than nerves in our body.

Do you know ?

Research in the past two decades has brought out an interesting fact. Other than central nervous system and peripheral nervous system, there is a system of neurons present in our digestive tract that can function even independently of either CNS or PNS. It has been nick named as a small brain and the system is called as enteric nervous system.

Coordination without nerves

The Story of insulin

In 1868 Paul Langerhans, Professor of Pathology at the University of Freiburg in Germany, working on the structure of the pancreas, noted certain patches of cells quite different in appearance from the normal tissue cells of the organ and richly supplied with blood vessels. They are known Islets of Langerhans (Islets stands for islands), but their function remained unknown. Many others interested in the function of pancreas and found that its removal from the body of an experimental animal would lead to the development of diseases similar to a well-known human ailment 'sugar diabetes'. This is a condition in which the amount of free sugar in the blood and in the urine is abnormally high. It's a cause in man was unknown but evidence pointed to the pancreas as a possible role.

fig-14: Paul Langerhans

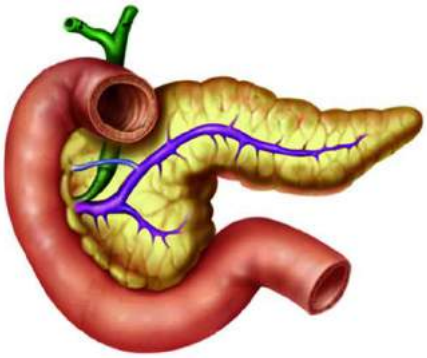

fig-15: Pancreas

The next stage was reached when it was found that tying up the pancreatic duct that emerged from the duodenum(a part of the small intestine) would cause the pancreas to degenerate but the Islets of Langerhans would remain normal. Moreover, an animal so treated would not develop diabetes. This was really a strong evidence that the level of blood sugar is linked with the islet cells. By 1912, workers were convinced that the islets produced a

secretion which directly liberated into the blood. In Latin 'insula' means an island. The name insulin was coined for the secretion, even though it had not been isolated.

Ten years later in Toronto, Banting, Best, and Macleod finally succeeded in extracting insulin from degenerate animal pancreases whose ducts to the intestine had been tied. When given by intravenous injection to a dog with no pancreas, this substance kept it alive and healthy with a low level of blood sugar. Insulin is now produced in large quantities for the treatment of human sufferers from sugar diabetes, to whom it is administered by injection into the skin.

Insulin thus is a chemical that acts as it reaches blood from the cells that produce it.

Other chemical co-ordinators

The evidence that events occurring in one part of the body could be affected and indeed controlled by substances circulating in the blood was now overwhelming. In 1905 the English physiologist Starling had coined the term hormone (Greek, hormao – to impel) for such secretions. The glands secreting hormones were termed ductless glands, since they have no tube or duct to carry away their products, which pass straight into the blood. In this way they different from glands such as the liver and pancreas, whose secretions pass down ducts which are connected to other organs.

The human body contains many other ductless glands (endocrine glands).Glands do not produce their hormones at a steady rate. The adrenal gland, for example, normally has a low output.

fig-16: Cock fight

What will you do if a dog is after you? What will be your first reaction? Have you ever observed any change in your body when you are afraid?

Nobody wants to fight with a dog. The first thing we do is running away from the place.

Try to note the body language of humans / animals when they are fighting / scared.

If we observe our body, when we are afraid, the rate of heart beat increases; the breath rate will be faster; blood pressure increases; the hair on the body becomes erect and we get goose bumps. The other things we might not observe are pupil dilation, skin becomes more sensitive, and rarely the bladder and the rectum may be emptied. We come to normal state only after we reach a safe spot.

We have already studied about nerve co-ordination, where nerves carry stimuli from sense organs to central nervous system and orders to effectors organs-the muscles. But, in the above situation the action of the nervous system is limited. All the changes in the body are carried out under the influence of a chemical called 'Adrenalin' hormone, released by Adrenal gland which is an endocrine gland. The various actions of the body are controlled by hormones and co-ordinated by nervous system. So in this type of conditions nervous system and endocrine system work together to bring about control and co-ordination.

Ask your teacher why Adrenalin hormone is also called fight or flight hormone.

The whole system of ductless glands is called the endocrine system. Information about a few of the endocrine glands is given in the accompanying table.

Try to make a list of functions that you think are controlled both by the nervous and the endocrine system.

Feedback mechanism

Recall the fight or flight behavior of cat and dog. The amount of adrenalin hormone increases in the blood sharply in a frightening situation, getting anger or excited.

- *Have ever observed the duration of anger?*
- *Why does anger come down?*
- *What may happen if anger persists for a longer period?*

Anger is always short lived factor. You know that increased levels of adrenalin are responsible for anger. When the levels of adrenalin in the blood come down slowly we come to normal state. If the adrenalin levels persist for a longer period of time, regular metabolic activities are disturbed.

Increase in adrenalin levels leads to anger, decrease in adrenalin levels leads to normal position.

- *What will happen if it is continued for longer periods of time?*

Similarly the sugar levels in the blood rise than normal level, they are detected by the cells of pancreas, which respond by producing more insulin into the blood. If the sugar levels come back to normal level secretion of insulin is automatically reduced.

So it is necessary that the hormones are secreted by the glands in our body in precise quantities which are required for the normal functioning

Table-2: Endocrine glands

Name of the gland	Location	Hormone secreted	Response of body to hormone
Pituitary	Floor of brain	1. Somatotrophin	Growth of bones
		2. Thyrotrophin	Activity of thyroid gland
		3. Gonadotrophin	Activity of ovary and testis
		4. Andrenocorticotrophic hormone	Stimulates secretion from andrenal cortex
		5. Luteinising hormone	In males - secretion of testosterone.
			In female - Ovulation, development of corpus luteum and secretion of progesterone.
		6. Follicle stimulating hormone	In male - spermatogenesis
			In female - growth of graafian follicles, estrogen secretion, milk production and secretion.
Thyroid	Neck	Thyroxine	General growth rate and metabolic activity
Ovary	Lower abdomen	Estrogen	Growth of the uterus and skeleton of the pelvis Control of the 28 days menstrual cycle in females.
Testis	Scrotal sac	Testosterone	Growth of hair on face, muscular development, deepening of voice, normal sexual behavior and development of male sex organs.
Adrenal	Attached to kidneys	Adrenalin	Increase in heart-beat rate. Rise in blood sugar. Dilation of the coronary artery. Dilation of the pupil of the eye. .

of the body. This means that there should be some mechanism to regulate the production and release of hormones in the body.

The timing and amount of hormones released by endocrine glands is controlled by the feedback mechanism, which is inbuilt in our body. None of the systems, whether nervous or chemical are totally exclusive of each other.

Autonomus nervous system

You know that medulla oblongata is the region that regulates heartbeat, breathing etc. the system that helps to bring about such activities of internal organs is called autonomous nervous system. Normally such involuntary activities take place by the coordinated efforts of the medulla oblongata and autonomous nervous system.

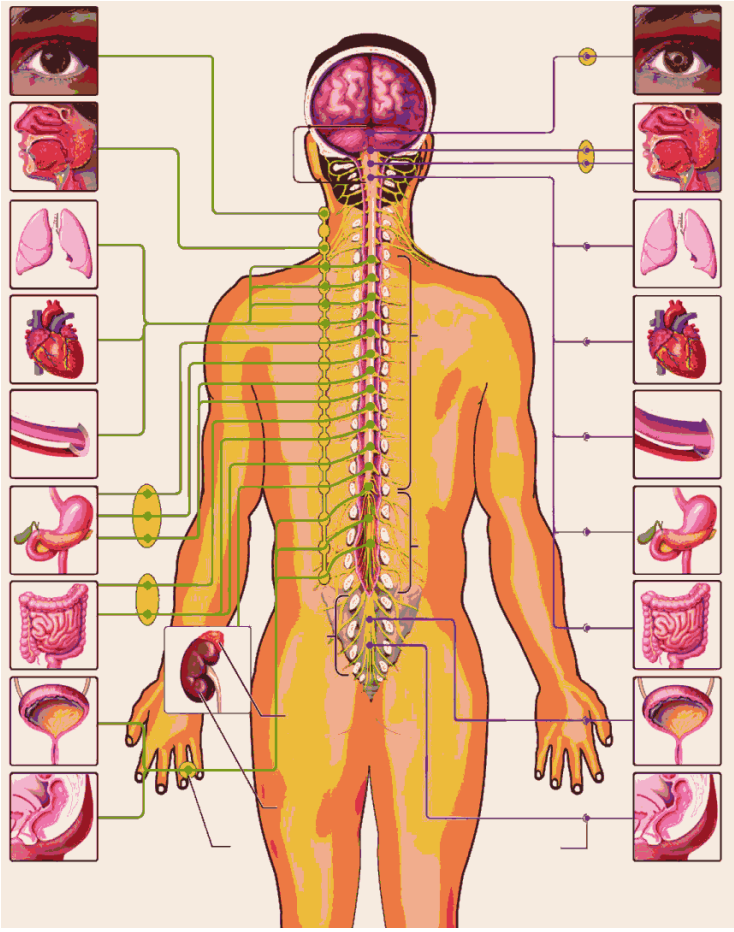

fig-17: Autonomous nervous system

Now let us see how the autonomous nervous system influences the life activities. Observe the fig-17 and record your observations.

- *To which organs of the body do the nerves go from the ganglions near the vertebral column?*

- *What are the organs that receives nerves starting from the brain?*
- *Which are the organs whose activities are influenced by the sympathetic system?*
- *Which are the organs whose activities are influenced by the para sympathetic system?*
- *What do you understand about the functions of para sympathetic system?*
- *What you understand about the functions of sympathetic system?*

Ganglia near the vertebral column are connected to the spinal cord by nerves. The sympathetic system is formed by the chain of ganglia on either sides of the vertebral column and the associated nerves. The para sympathetic system is formed by the nerves arising from the ganglia of the brain and the posterior part of the spinal cord. These together constitute the autonomous nervous system. It is the part of the peripheral nervous system consisting of twelve pairs of cranial nerves and thirty one pairs of spinal nerves.

Control mechanisms in plants

How do plants respond to stimuli?

So far we have studied how control mechanisms work in our body. Do plants also have control systems? Let us find out by doing a small activity.

Activity-4

Touch the leaves of Mimosa pudica (athipathi, touch me not) plant and observe the response of leaves. Are they folding? If so in which direction?

Try to give examples of situations where you may see plants responding to a certain stimulus.

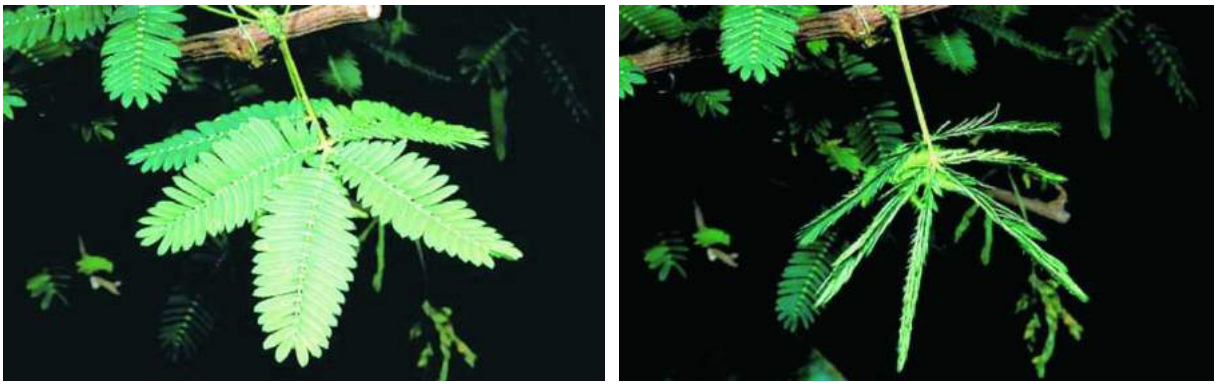

fig-18: Mimosa pudica

Do you know ?

Mimosa pudica leaves have pad like swellings at the base. They are called pulvini. Here cells contain lot of water and large intercellular spaces. Due to water pressure pulvini hold the leaf erect. Touch me not plant shows nastic movement by touch. This is called thigmonasty. When we touch the leaves, an electrical impulse is generated. This impulse acts on plant hormone. Because of this hormone water in the pulvini cells which are closer to the leaf vein migrate to other side of the cells.Then pulvini loss its firmness hence leaves become fold. After 20 to 30 minutes water comes back pulvini attains firmness and leaves become erect.

You might have observed the tendrils of plants growing towards a support. Can you imagine how is it happening? Would you think it is responding to a stimulus?

Both plants and animals react to various stimuli around them. But the method of responding to stimuli is not similar in plants and animals. Higher animals respond to stimuli because they have a nervous system and an endocrine system. Plants do not have a well-defined nervous or endocrine system. They do have some mechanism of control by means of some chemicals or hormones.

Plants can sense the presence of stimuli like light, heat, water, touch, pressure, chemicals, gravity etc. The hormones present in the plants called phytohormones (phyto means plant) control responses towards the stimuli mentioned above. Phytohormones coordinate the activities of the plant usually by controlling one or the other aspect of the growth of the plant. So plant hormones are also called growth substances. Some major plant hormones and their action are given in the following table.

Table-3: Major plant hormones and their action

Hormones	Uses
Abscisic acid	closing of stomata; seed dormancy
Auxins	cell elongation and differentiation of shoots and roots
Cytokinins	promote cell division, promotion of sprouting of lateral buds, delaying the ageing in leaves, opening of stomata.
Ethylene	ripening of fruit
Gibberellins	germination of seeds and sprouting of buds; elongation of stems; stimulation of flowering; development of fruit, breaking the dormancy in seeds and buds.

Discuss with your teacher about seed dormancy.

Activity-5

Take a glass jar and fill with soil. Sow a bean seed near the wall of the jar. This helps you to observe how root and shoot are growing. After 4 - 5 days you will notice seed germinatation. Keep the jar under the sun. Observe how root and shoot grows. Then tilt the glass jar and keep the plant horizontally. Observe the direction of root and shoot growth for more than a week.

- *Does the shoot take a horizontal tilt after a week?*
- *Which side of the shoot may have grown more and which side less to bring about this effect?*

Observe the plant growing towards light and how auxins acts on bending of stem to show a response to the sunlight.

More auxin collects on the light illuminated side of the stem. So cells on that side grow faster. On opposite side cells grow slow to make the stem bend.

Collect bending and straight portions of tender stem. Take transverse sections of both stems, observe them under microscope.

fig-19: Bending towards sun

- *Do you find any difference in the shape of epidermal cells?*

Charles Darwin and his son Francis Darwin performed some experiments on phototropism. They covered the terminal portion of the tip of stem(coleoptile) with a cylinder of metal foil. Exposed the plant to light coming from the side. The characteristic bending of the seedling did not occur. If, light was permitted to penetrate the cylinder bending occurred normally. They stated that when seedlings are freely exposed to a lateral light some 'influence' is transmitted from upper to the lower part causing the material to bend.

In 1926, the Dutch plant physiologist F.W. Went succeeded in separating this 'influence' from the plant that produced it. Went cut off coleoptile tips from oat seedlings. He placed the tips on a slice of agar and left them for about an hour. He then cut the agar into small blocks and placed a block on one side each stump of the decapitated plants. They were kept in the dark during the entire experiment. Within one hour he observed a distinct bending away from the side on which the agar block was placed.

Agar block that had not been in contact with coleoptile tip produced either no bending or only a slight bending toward the side on which the block had been placed.

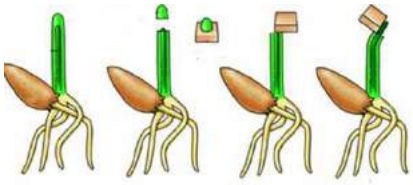

fig-20: Went experiment

Went interpreted these experiments as showing that the coleoptile tip exerted its effect by means of chemical stimulus rather than a physical stimulus such as an electrical impulse. This chemical stimulus came to be known as auxin. In this way the first plant hormone auxin (greek word auxein means to increase) was discovered by Went.

Tropic and nastic movements in plants

The above experiments show that movement of individual parts of plants is possible when they are subjected to external stimuli. This type of response is called tropism or tropic movement. Sometimes the direction of stimuli determines direction of movement, sometimes the direction of movement may not be determined by direction of stimuli. This type of response is called nastic movement.

Let us observe the growth of a creeper plant near window. The shoots of creeper bend towards sunlight. Such type of response of a plant to light is called photo tropism (photo means light, tropism means movement).

We know that roots always grow downwards. This means that plant respond positively for gravitational force. This is called geotropism.

If we observe plant which grow near a rock or wall side. You notice that all roots are growing in one direction, away from the rock or wall where water is available in the soil. This type of response to water is called hydrotropism.

A very interesting thing in plants is movement of tendrils. All plants show positive response to phototropism. But in creepers like cucumber, bitter guard, the stem is weak and thin. Hence plant cannot grow erect. Tendrils play a vital role to make the plant erect. Tendrils are thin thread like growths on the leaves or stems of climbing plant. They grow towards support and wind around them. This type of response to make contact or touch is called thigmo tropism.

If you taste the carpel of a flower it is sweet. Let us recall butterflies fluttering on flowers for this nectar. Ripen stigma secretes sugary substance. This chemical substance stimulates the pollen grain which falls on the stigma. Pollen grain responds to this stimulus as pollen tubes grow to reach the ovule for fertilization. This type of response to chemicals is called chemo tropism. Unequal distribution of auxins affects the root and the stem growth. High concentration of auxin stimulates stem growth and inhibit root growth.

fig-21: Tendrils

Key words

Response, stimuli, neuron, axon, synapse, afferent or sensory nerves, efferent or motor nerves, association nerves, central nervous system, brain, spinal cord, cerebrospinal fluid, peripheral nervous system, insulin, endocrine glands, hormones, feedback mechanism, plant hormones, tropic movements, nastic movements.

What we have learnt

- Nervous system and endocrine system are the two systems that control and coordinate various functions in the body.
- The responses of the nervous system can be classified as reflex, voluntary and involuntary actions.
- The human nervous system is studied under two divisions: The central nervous system and the peripheral nervous system.
- The central nervous system consists of brain and the spinal cord while the peripheral nervous system is further divided into somatic nervous system and autonomus nervous system.
- The autonomus nervous system has two parts – sympathetic and parasympathetic, which cause physical reactions opposite to each other.
- Nerve cell is the structural and functional unit of nervous system.
- Synapse is a gap across where signals are transmitted from one neuron to the other.
- Hormones produced in one body would move to another part to achieve the desired effect.
- A feedback mechanism regulates the action of the hormones.
- Directional movements in plants in response to specific stimuli like light, chemicals etc. are called tropic movements.
- Plant hormones are usually growth effectors or inhibitors. Some growth effectors are Auxins and Gibberellins while growth inhibitors are Abscisic acid.

Improve your learning

1. Fill in the missing sections in the following flow chart.(AS1)

Step on a sharp edged object		Brain analyse information and send commands		

2. Do you think body's team work maintains functioning of our body? Justify your answer with an example.(AS1)
3. Give an example of coordination in your body where both hormonal and nervous controls function together.(AS1)
4. Consider that you are passing by a garbage disposal area and you immediately cover your nose. Arrange the events below in a logical order by marking them from 1 to 5 to trace the events that happen in the nervous system from detection of foul smell (stimulus generation) to covering your nose (response).(AS1)
   (i) At the end of the axon, electrical impulse releases chemicals

(ii) Stimulus received on the dendritic cells of a neuron sets off chemical reaction that creates an electrical impulse

(iii) Electrical impulse transmitted through cell body and axon

(iv) The chemicals cross the synapse and reach the next neuron. Similarly, the electrical impulse crosses several neurons

(v) Finally, the impulse is delivered from neuron to the gland that helps in recognition of the foul smell and muscle cells that help in covering the nose

5. What is a synapse? How it is useful in transfer information?(AS1)
6. Distinguish between(AS1)

a) Stimulus and Response b) Afferent and Efferent nerves

c) Central nervous system and peripheral nervous system d) Receptor and effector

6. How does Phototropism occur in plants?(AS1)
7. Give an example and explain how plants may immediately respond to a stimulus.(AS1)
8. Suggest an experiment to show how roots grow away from light in most plants.(AS1)
9. Give an example to show how hormones can influence visible changes in your body.(AS1)
10. How does a neuron differ from an ordinary cell in structure? Write notes.(AS1)
11. Is the structure of neuron suitable for transmission of impuleses? Analyse.(AS1)
12. Man is the most intelligent animal. What could be the fact that helped us to reach such a conclutssion?(AS1)
13. The axon of nerve cell in hand is sherter than the axon of nerve cell in leg. Do you support this statement? Why?(AS1)
14. Organs respond to the external stimulus by a fraction of second. How do you feel about such controlling mechanism of human body?(AS1)
15. State whether the following actions are voluntary action, reflex action or conditioned reflex.(AS1)

i) Blinking ii) Cleaning the table iii) Playing on the key board

iv) Salivating when food is put in the mouth. v) We close our ears when we hear un bearble sound

16. What will happen to the potted plant kept near window in the room?(AS2)
17. What happens if all functions of the human body is controlled only by brain?(AS2)
18. If you visit a doctor what doubts you would like to clarify about pancreas?(AS2)
19. Take a small potted plant. Cover base portion of the plant tightly and hang the part upside down. Observe the plant for a week. Based on your observation how can you support phototropism.(AS3)
20. Take a cock feather touch smoothly at different parts of your body. Findout which portion of the body has high sensation. Is this similar during sleeping?(AS3)
21. What procedure you follow to understand the effect of plant growth hormones (in agar medium) in the terminal portion of the tip of stem (coleoptile)?(AS3)
22. Collect information on the actions controlled by spinal cord by using reference books from your school library.(AS4)
23. Read the following sentences and compare with endocrine glands.(AS4)

Pheromones are chemical substances secreted by organisms. These act as chemical signals secreted by exocrine glands. Pheromones are used as signals by the members of same species. Honey bee secretes pheromones that attract other bees to the location of food.

24. Collect the information about cranial nerves. Spinal nerves from internet or from your school library.(AS4)

25. Draw a picture representing connection between axon-axon, axon-dendrite. Why do they connect like that?(AS5)
26. Draw a neatly labelled diagram of Brain and write few points how it is protected.(AS5)
27. You are walking in the traffic suddenlyyou heard a loud sound. How coordination takes place in this situation among respected organs? Draw a block diagram to explain this situation.(AS5)
28. Make a model of neuron using suitable materials.(AS5)
29. Draw a labelled diagram of brain.(AS5)
30. Observe different actions performed by your classmate for a period of 45 minutes. Out of those action which are controled by voluntary and involuntary pathways.(AS5)
31. Its very interesting to watch a creeper entwining its tendril to the support. Is not it? How do you express your feelings in this situation?(AS6)
32. Hormones are released at a speicific place, specific time for a specific function. Prepare a cartoon on hormones with a nice caption.(AS7)

Fill in the blanks

1. The largest region of the brain is _____
2. A point of contact between two neurons is _____
3. _____ phytohormon is resposible for cell elongation and differentiation of shoots and roots.
4. Thryoxin is resposible for _____
5. Gibberellins and auxins promote growth in plants while abscisic acid arrests the same. Some situations are discussed here, State which hormones would be needed and why?
   a) A gardener wants large dahlias he should use along with nutrients and other things _____ hormone.
   b) In a dwarf plant the branches have to be thickened one would use _____ hormone.
   c) Seeds are to be stored for a long time _____ hormone can help.
   d) Cutting the apex or tip of plants so that there are several lateral buds _____ hormone can be used.
   e) The part of the brain that helps you in solving puzzles is _____.

Choose the correct answer

6. A person has loss of control on emotions, which part of brain stops it's function. ( )
   a. cerebrum b. diencephalon c. mid brain d. cerebellum
7. Leaf movement in mimosa helps to ( )
   a. reduce photosysthesis b. protect from greazers
   c. releasing phyto hormones d. regulate it's growth
8. Diabetes is related to this gland. ( )
   a. Thyroid b. pancreas c. adrinal d. pitutary