Introduction

John B. Watson (1878 - 1958) was the principal founder of a new approach to the study of behaviour, behaviourism. The basic tenet of behaviourists is that behaviour consists of an animal's responses, reactions or adjustments to stimuli or complexes of stimuli.

Behaviour includes all those processes by which an animal senses the external world and the internal state of its body and responds accordingly. Many such processes will take place inside the nervous system and not be directly observation.

Also, communication within the organism or the behavioural pattern is performed by the chemical messengers termed "hormones" which are transported by the bloodstream. In 1849, A.A. Berthold noted that cockerel, if castrated, showed a reduction in the size of comb and spurs, a cessation of crowing and a loss of sexual behaviour.

The nervous system has a parallel system of feedback and control of behaviour in vertebrates. This is the endocrine (hormonal) system. Behaviour is controlled in 2 ways:—

1. Neural
2. Hormonal.

Neural Control of Behaviour :—

Nerve cells :—

Nervous systems are made up of nerve cells called neurons, which are specialized for transmitting information to one another. Each neuron has a cell body, containing the nucleus, and a number of branching protrusions, short branches called dendrites and a single long protrusion, called the axon. The dendrites connect with other nearby neurons, while the axons convey messages over relatively long distances.

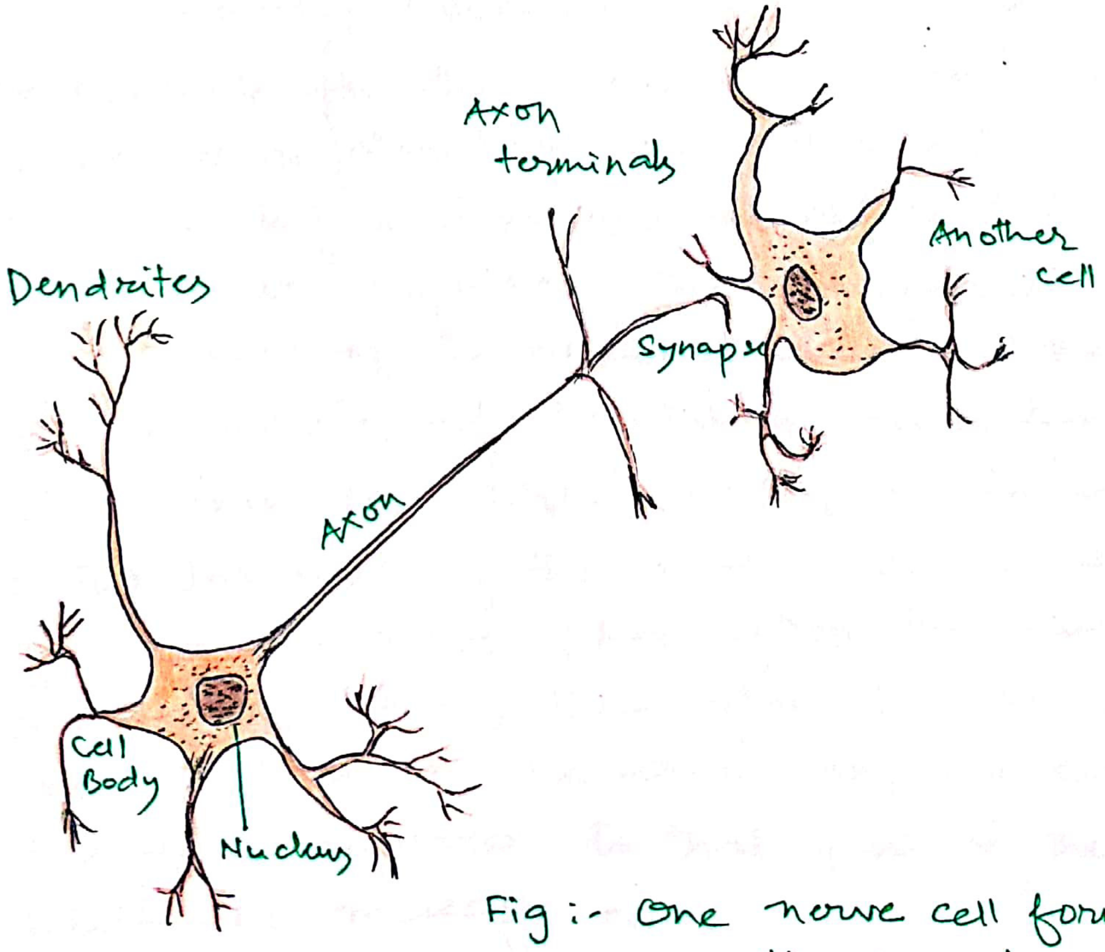

Fig :- One nerve cell forming a synaptic connection with another.

The membranes of axons and dendrites do not make physical connections with other neurons but come very close at junctions called synapse usually, very small quantities of chemical neuro-transmitters are released at the synapse, which influence the resting potential of the recipient membrane and hence the readiness of the receiving neuron to generate action potentials.

Neurons can be stimulated by other neurons, by injury, or by sensory receptors.

Sensory receptors:

Sensory receptors are specialized nerve cells responsible for the transmission and transduction of neural information. The action potentials conveying sensory information are no different than any other nerve impulses. Their magnitude is determined by the size of the neuronal axon and their frequency by the intensity of stimulation. Each type of receptor sends impulses, either directly or indirectly, to a particular part of the brain. In the case of pain, for eg. the nerve fibers from the hand go to one part of the brain, those from the arm go to another, and so on. The "pain" experienced by the brain is referred to that part of the body from which the message came.

System responsible for bodily sensations, is called the somesthetic system.

Somesthetic system :-

It is important for an animal's brain to recieve information about the state of the body. The positions of limbs, pressure on internal organs, the temperature of various parts of the body, and many other features are monitored by the central nervous system. This system, responsible for bodily sensations, is called somesthetic system.

Numerous types of sensory receptors exist in the skin, skeletal muscles and viscera of vertebrates. Some examples are shown below.

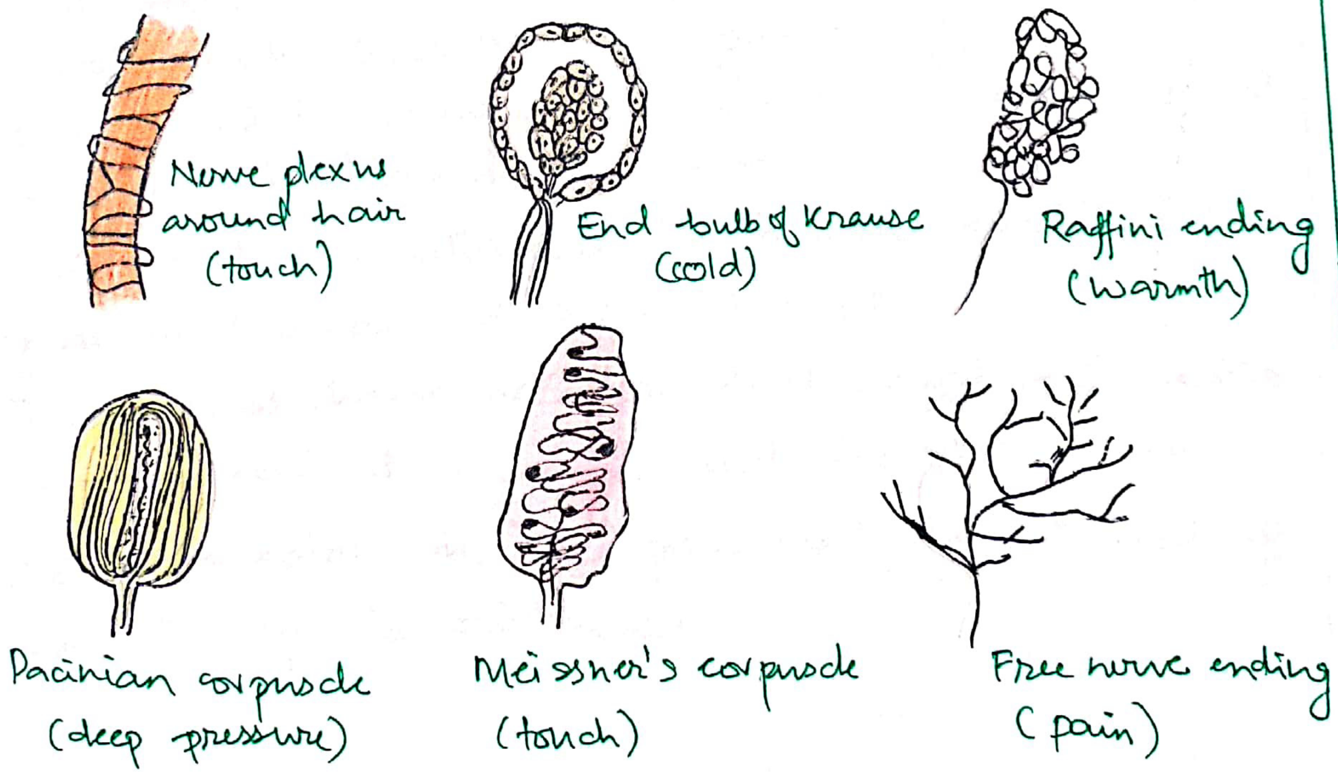

Fig:- Some sensory receptors found in the skin and the senses with which they are associated.

skin receptors give early warning of environmental changes that are likely to affect the body, like changes in temperature.

Receptors deep inside the body serve a wide variety of functions, including detection of changes in blood pressure, the tension of muscles, the amount of salt in the blood, etc. Majority of the interoreceptors do not give rise to sensations, sometimes their effects combine to produce sensations of hunger, thirst or nausea, but these are due to complex processes in the brain, which do not always refer the sensation to particular parts of the body.

Arthropods have numerous kinds of stretch receptors, of which there are two general types -

1) those that lie between exoskeletal elements and that respond to vibrations in the cuticle.
2) those that are attached to tendons and that can signal stretch and pressure changes.

Thus, crabs have receptors that signal both position and movement at a joint, and blowflies have stretch receptors in the gut that inhibit feeding when the gut is distended.

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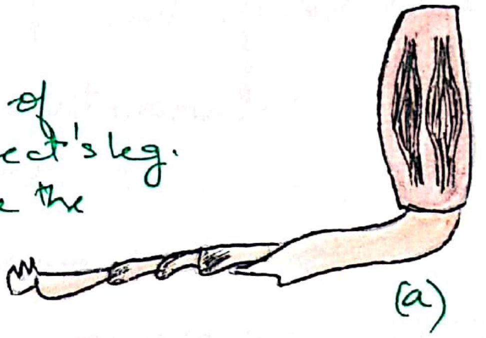
The nervous system is responsible for controlling behaviour, for controlling the animal's internal environment. This control is excercised by commands to muscles and glands. In invertebrates, such as arthropods, the muscles are housed inside a hard exoskeleton, which provides the necessary leverage for opposing sets of muscles. In vertebrates, the internal skeleton provides the leverage and the muscles are arranged so they pull against each other. One set of muscles relaxes when the other contracts.



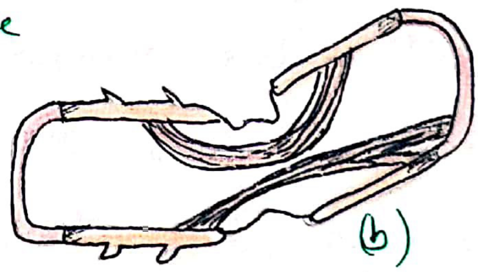


Fig:·Mechanical arrangement of muscle and skeleton in an insect's leg. The muscles are housed inside the skeleton, and in (a) muscle 'a' is the flexor and muscle 'b' is the extensor. In (b) where the muscles span the joint, the arrangement is the opposite. Muscle a is the extensor and muscle b the flexor.

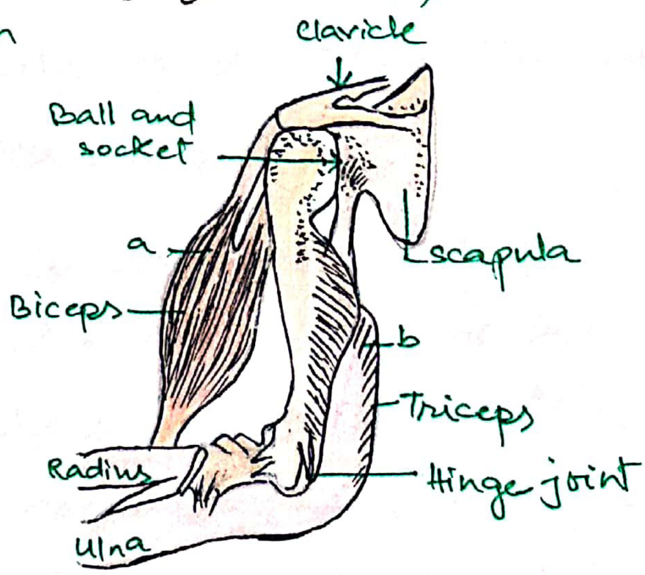


Fig:- Mechanical arrangement of muscle and skeleton in a human arm. The muscles are arranged outside the skeleton. Muscle 'a' is the flexor and muscle 'b' the extensor.

Nervous systems of invertebrate animals :-

A nervous system can be defined as an organized constellation of nerve cells and associated non-nervous cells. Throughout the animal kingdom, nerve cells have common attributes that readily distinguish them from other cells. More advanced nervous system is seen in Platyhelminthes (flatworms). Unlike the coelenterates, the flatworms show bilateral symmetry and possess head and tail like most other invertebrates.

In flatworms such as Planaria, sensory cells on the head respond to touch, temperature and the chemical composition of the water. Conduction of nerve impulses along the nerve cords is faster than in nerve nets. The flatworms, hence, are quick to detect the presence of food and to approach it. They avoid strong light and noxious chemicals and seem to be capable of rudimentary learning.

The more advanced invertebretes follow a general pattern based on the annelids, or segmented worms. Many annelids have a system of giant-fibers containing neuronal axons of large diameter and high conduction velocity. These are involved in rapid escape ~~of~~ withdrawal reactions to danger. Annelids have a fairly restricted repertoire of behaviour patterns and are capable of rudimentary learning. In primitive arthropods, the segmental pattern can be seen clearly, but in more advanced forms there is considerable fusion of ganglia. This fusion of ganglia is characteristic of the evolution of the nervous systems of invertebrates and is associated with increasing complexity of the sensory systems and of behaviour.

Arthropods have evolved a greater variety of types of receptors than any other group including vertebrates. The sensory neurons of these receptors have their cell bodies close to the sensory surface and not grouped into sensory ganglia. Some have few sensory neurons, and others have many, as illustrated in figure in the next page.

Among gastropods there is an enormous range of complexity in nervous system organization. The most highly developed nervous systems are found in the cephalopods. These are the most active molluscs. They hunt mainly by vision and are capable of complex behaviour, including recognition of complex objects, and rapid learning.

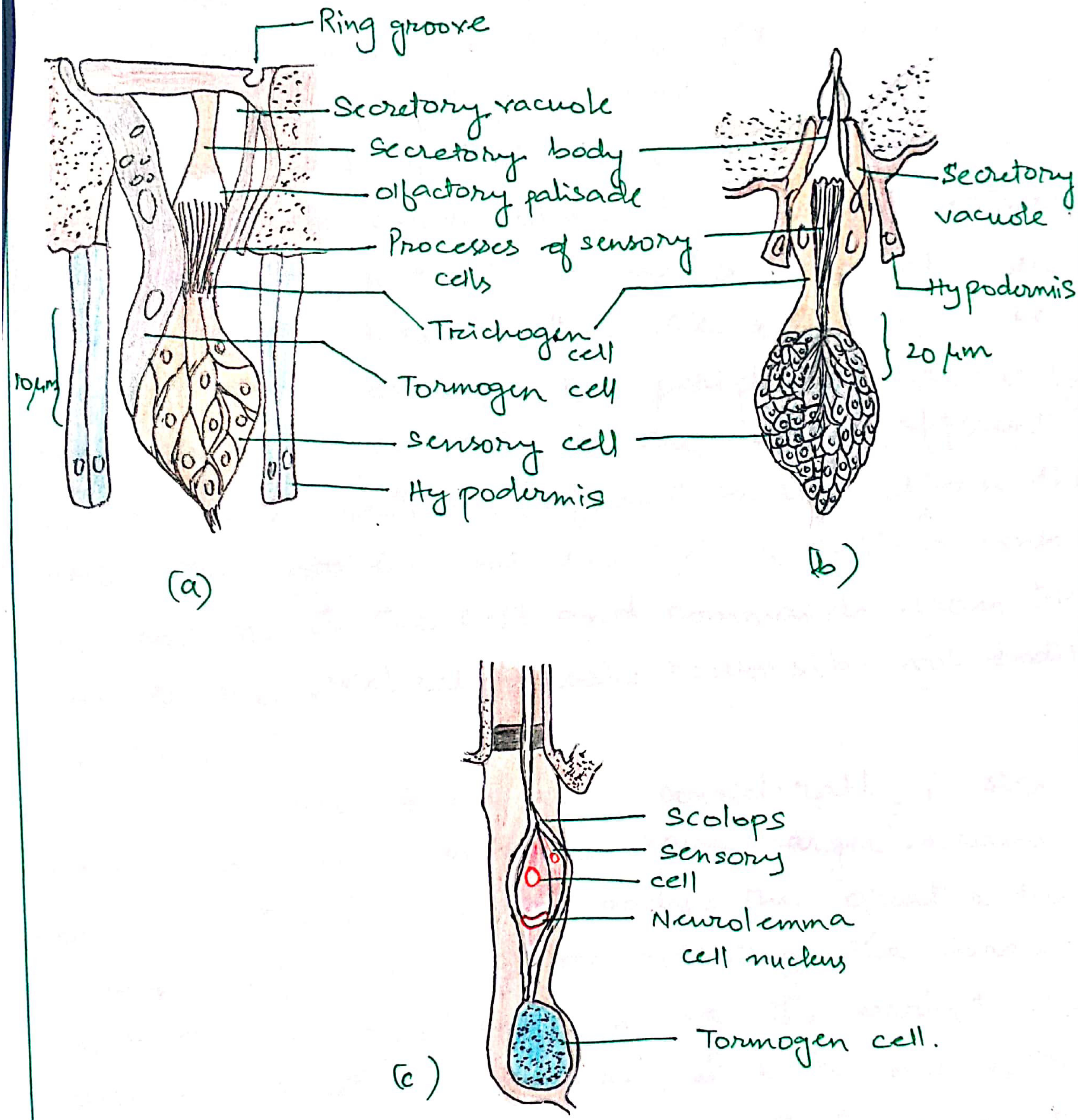


Fig :- Examples of sense organs in arthropods:

a - olfactory plate of a hornet

b - olfactory cone of a hornet

c. antenna hair of a moth.

The Vertebrate nervous system

The organization of the vertebrate nervous system is distinct from that of invertebrates, though it is not always more complex. The vertebrate CNS develops embryologically from a dorsal neural tube to form a brain and single dorsal nerve cord, rather than the brain and dual ventral nerve cords characteristic of invertebrates. The CNS comprises the brain and spinal cord, which are enclosed within the bones of the skull and vertebral column. The peripheral nervous system consists primarily of the inflow (afferent nerves) and outflow (efferent nerves) from the CNS. The somatic nervous system carries sensory information to the CNS and commands from the CNS to the skeletal muscles responsible for bodily movement.

Vertebrate brain vary considerably in size. Larger animals tend to have larger brains because the larger the body, the greater the number of sensory fibers entering the brain and the more fibers leaving the brain to control the muscles. Therefore, it is the size of the brain in relation to the body that we must use as a measure. The brains of animals have evolved as adaptations to the ecological niche. Animals that have specialized sensory systems and forms of behaviour must have correspondingly specialized brain mechanisms.

Hormonal control of Behaviour :-

Autonomous nervous system reacts to the needs of the body with a speedy responses. There is also a much slower response to external events that is carried via messengers in the blood. The system that controls these responses in the endocrine system. And the messengers are called hormones. The endocrine system is similar to the nervous system in some ways. Just as neurons carry particular neurotransmitters substancys that only work at certain receptor sites so the endocrine system releases hormones that, too only work at specific receptors site around the body.

The endocrine system a two-hived system of resistance hormones gland. Glands are defined by the fact that they release hormone into the blood stream. The horonones then have an effect at a variety of body location. The glands are controlled by brain sites that release their own hormones (called Releasing hormone). These releasing hormones tell the glands to release more of their hormones. Endocrine system controls a number of internal body processes.

The most important hormones that influence behavior are indicated as

Source	Hormones	Principal effect
Kidney	Angiotensin	Stimulates vasoconstriction and causes a rise in blood pressure. stimulates thirst.
Testes	Testosterone	Stimulates development and maintenance of female secondary sex characteristics and behavior.
Ovaries	Estrogen	Stimulates development and maintenance of female secondary sex characteristics and behavior.
	Progesterone	Stimulates female secondary sex characteristic and behaviour and maintains pregnancy.
Adrenal medulla	Adrenaline	Stimulates 'fight' or 'flight' reactions.
Anterior pituitary	Follicle stimulating hormone	Stimulates growth of ovarian follicles and seminiferous tubules of the testes.
	Luteinizing hormone	Stimulates secretion of sex hormone by ovaries & testes
	Prolactin	Stimulates milk secretion
Posterior pituitary.	oxytocin	Stimulates release of milk by mammary glands and stimulates contraction of uterine muscles.

There are 3 main ways in which hormones can affect behaviour.

1) they can influence effectors such as special structures involved in behaviour.

2) they can influence peripheral sensory receptors and so modify the input to the brain.

3) they can affect the brain directly.

An example of the first type of effect is seen in the mating behaviour of the African clawed toad (Xenopus laevis). The appearance of the pads during breeding season on the forelimbs depends upon the hormone testosterone, which is released from the testes at the appropriate time.

An example of the influence of human hormones upon peripheral sensory receptors can be seen in the parental behaviour of pigeons. Prolactin induced the parental feeding on its effect on the crop.

The direct action of hormones on the brain is the most important mode of behavioural influence upon behaviour. Hormonal influences upon behaviour may be slow, and prolonged or quick acting and short-lived. Example suckling of cow. The neurohormonal reflex of milk suckling and ejection is shown in the next page.

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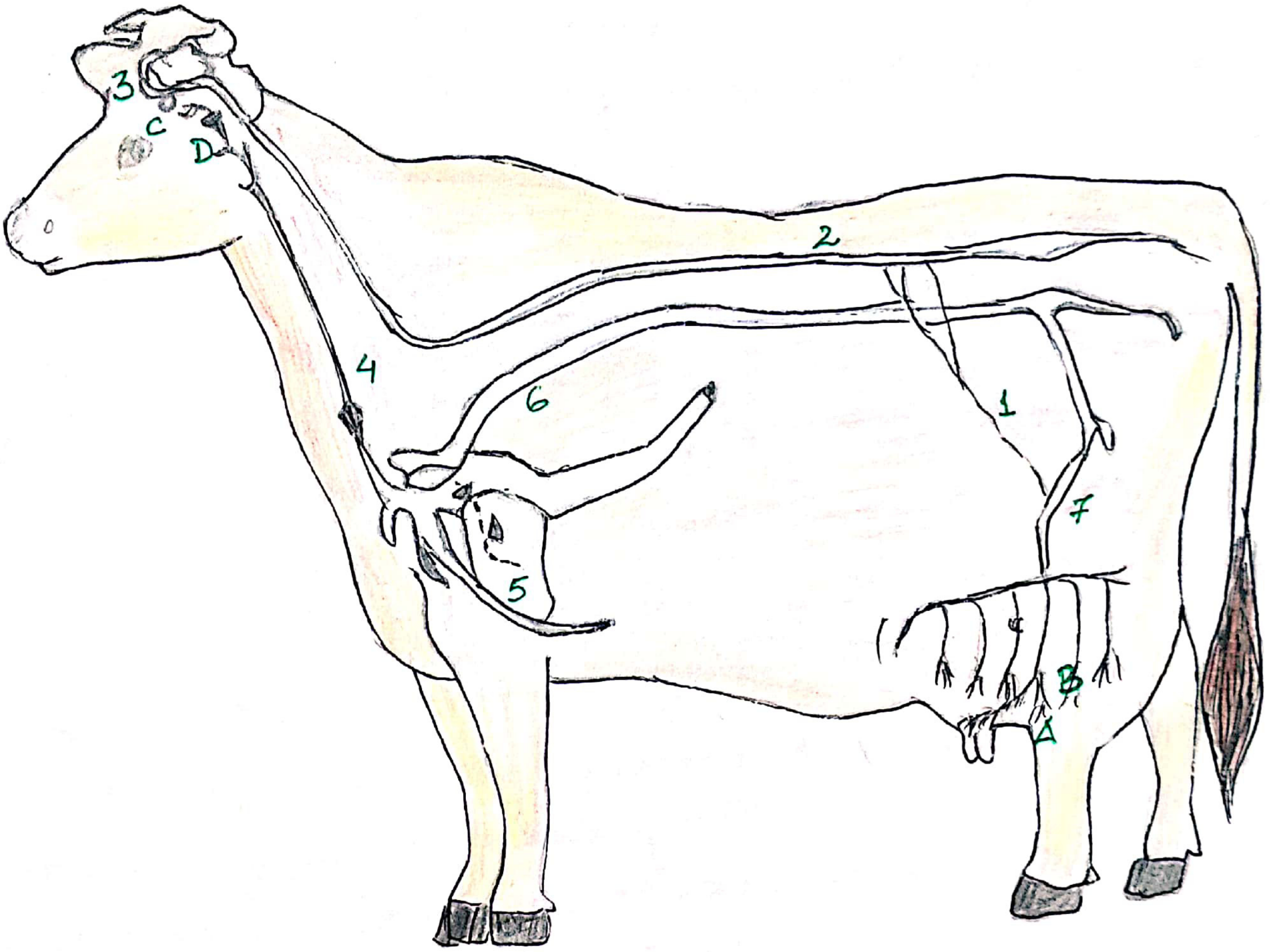

Fig:- The neurohormonal reflex of milk ejection -
A.- a cow associates with milking causes a nerve impulse
B. To travel via the inguinal nerve ① to the spinal cord
② and the brain ③ The brain causes the release of oxy-
tocin
C- oxytocin is released into a branch of the jugular vein
D. from the posterior pituitary ④ and travels to the
heart. ⑤ and is then transported to all parts of the
body by the arterial blood. The oxytocin reaching the udder
leaves the heart by the aorta and ⑥ enters the udder
through the external pudic arteries. ⑦ In the udder, it causes
the myoepithelial cells to contract, resulting in milk ejection.

Hormonal Basis of Breeding seasons:-

The onset of the breeding season is hearalded by changes in the structure and physiology of gonads. The gonadotrophin LH is responsible for the cycling of reproductive and non-reproductive male plu-mmage patterns in weaver finches and antler growth in deer. Spring movement of three-spinned stickle backs, *Gastrosteus aculeatus*, from salt to fresh water occurs normally in castrated ani-mals and can be elicited out of season by thyroxine treatment. In this case, the production of the thyrotropic hormone by the anterior pitu-tary, induced by the lengthening days of spring is claimed to be responsible for onset of the first phage of the breeding cycle.

In vertebrates, the process of relase of gonado-trophins by the anterior pituitary is initiated in the hypothalamus, which is ideally placed to recieve sensory information about external conditions and to respond to endogenous changes within the central nervous system. Neurosecretory cells become active and their products are transported by the hypothalamohypophyseal portal system. Bree-ding behaviour is then maintained by several complex interactions between gonads, pituitary and the environment.

CONCLUSION :—

For many of the hormones that influence behaviour, we now know that there are regions of the brain with cells that possess specific receptor sites for those hormones. Neuro-endocrine structures in invertebrates involve neurons directly with neurosecretory cells, or they are closely tied to the nervous system through nerves connecting with brain and with one another. The dual system of inter-relationships of the neuro-endocrine glands and the nervous system is an important feature of hormonal systems in both vertebrates and invertebrates, these mechanism which exert controlling influences of behaviour, have apparently evolved in close harmony.

In vertebrates, the primary producers of behaviour-related hormones are the gonads and placenta, the adrenal glands and the pituitary gland. A number of hormones have shown to have direct effects on behaviour in addition to whatever other functions they might perform in the body.