Chapter 13

NERVOUS SYSTEM

Outline

Division of Nervous System
Central Nervous System (CNS)
- Meninges
- Spinal cord
- Brain
  - Telencephalon
  - Diencephalon
  - Mesencephalon
  - Metencephalon
  - Myelencephalon
  - Ventricular system

Peripheral Nervous System (PNS)
- Cranial nerves
- Spinal nerves
  - Brachial plexus
  - Lumbo-sacral plexus

Cerebrospinal fluid (CSF)
Contents of vertebral canal

The nervous system is a complex mechanism by which the organism is brought into functional relation with its environment, and its various parts are coordinated.

DIVISION OF NERVOUS SYSTEM

For purpose of gross description, the entire nervous system is divided primarily into two parts: the **central nervous system** (**CNS**) and the **peripheral nervous system** (**PNS**).

Central Nervous System comprises ……(a) the spinal cord, and (b) the brain.
Peripheral Nervous System includes …… (a) the cranial and spinal nerves with their ganglia, and (b) the sympathetic nervous system.

Central Nervous System (CNS)

MENINGES

The covering of spinal cord and brain are the meninges (singular meninx). They include three layers, from deep to superficial, the pia mater, the arachnoid, and the dura mater.

PIA MATER

The pia mater, the deepest of the meninges, is a delicate and very vascular membrane that invests the brain and spinal cord, following the grooves and depressions closely.
The pia mater forms a sheath around the blood vessels and follows them into the substance of the CNS.

ARACHNOID MATER

The arachnoid is a very delicate and transparent membrane which is situated between the dura and pia mater. Together, the pia mater and arachnoid constitute the *leptomeninges* (from the Latin word *lepto*; delicate), reflecting their fine, delicate nature.

SUBARACHNOID SPACE:The space between the two layers bridged by arachnoid trabeculae, is the subarachnoid space. It contains the cerebrospinal-fluid (*CSF*).

DURA MATER

The dura meter is a dense and tough fibrous outer covering of the CNS. Within the cranial vault, the dura mater is intimately attached to the inside of the cranial bones and so fulfills the role of periostium. However, the dura mater of spinal meninges is separated from the periosteum of the vertebral canal by a fat-filled space, the *epidural space*.

It also forms the *falx cerebri*, a median sickle-shaped fold that lies in the longitudinal fissure and partially separates the cerebral hemispheres. Another fold of dura mater, the *tentorium cerebelli*, runs transversally between the cerebellum and the cerebrum.

SPINAL CORD

The spinal cord is the part of the central nervous system which is situated in the vertebral canal. It is the caudal continuation of the medulla oblongata. The cranial end of the spinal cord is continuous with the medulla oblongata of the brain at the level of the foramen magnum. Unlike the cerebrum, the spinal cord's gray matter is found at the center of the cord, forming a butterfly shape on cross section.

EXTERNAL FEATURES

Examination of cross sections of the spinal cord shows that it is a bilaterally symmetrical structure, incompletely divided into right and left halves by a ventral fissure and a dorsal septum.

***Dorsal median sulcus:* The spinal cord has this sulcus along its entire length.**

***Ventral median sulcus*: On the ventral surface, ventral median sulcus runs along its entire length.**

INTERNAL STRUCTURES

Basically, the spinal cord is made up of white and grey matter.

WHITE MATTER: It forms the dorsal column, ventral column and lateral columns.

GREY MATTER: It forms dorsal horn, ventral horn and the central canal.

DIVISION

According to the attachment of the spinal nerves, the spinal cord may be divided into five regions.

(i) Cervical (ii) Thoracic (iii) Lumber (iv) Sacral and (v) Coccygeal

BRAIN

The brain is central part of the central nervous system that is situated in the cranial cavity.

The gross sub-divisions of the adult brain include;

a) **Cerebrum**
b) **Cerebellum**
c) **Brain stem**

Dorsal view of Brain ..... (See Figure 13- 1)
Ventral view of Brain ..... (See Figure 13- 2)
Median section of Brain ..... (See Figure 13- 3)

Telencephalon (End Brain)

The telencephalon, or end brain comprises two principal parts, the cerebral hemispheres and the optic part of the hypothalamus (rhinencephalon).

CEREBRAL HEMISPHERES

The cerebral hemispheres form the greater part of the fully developed brain. Viewed from above, they form an ovoid mass, of which the broader is posterior, and the greatest transverse diameter is a little behind the middle.

LONGITUDINAL FISSURE: The two hemispheres are separated by a deep median cleft, the longitudinal fissure of the cerebrum, which is occupied by a sickle-shaped fold of dura mater, the falx cerebri. TRANSVERSE FISSUERE: The transverse fissure separates the hemisphere from the cerebellum, and contains the tentorium cerbelli.

EXTERNAL FEATURES

The surface area of the cerebrum is increased by numerous foldings to form convex ridges, called *gyri* (singular gyrus), which are separated by furrows called *fissures* or *sulci*. A particularly prominent fissure, the *longitudinal fissure*, lies on the median plane and separates the cerebrum into its right and left hemispheres.

INTERNAL STRUCTURE

Unlike the spinal cord, the in the cerebrum the gray maters are the on the exterior. This layer of cerebral grey matter is called *cerebral cortex*. It is the site at which voluntary movements are initiated, and higher functions, such as reasoning and planning, take place.

RHINENCEPHALON

The rhinencephalon or olfactory part of the brain comprises the olfactory bulb, tract and stria, the trigonum olfactorium, , and the piriform lobe.

Olfactory bulb

The olfactory bulb is an oval enlargement which curves upward in front of the frontal pole of the hemisphere. Its covex face fits into the ethmoidal fossa and receives numerous olfactory nerve-fibers.

Olfactory tract

The olfactory tract is a very short but wide band of white substance which arises to the olfactory bulb and extends back to be continued by the olfactory stria. It contains a canal which connects the ventricle of the bulb with the lateral ventricle.

Olfactory stria

The olfactory stria, are two in number. The lateral stria is much the largest and most distinct. It is clearly defined dorsally by the sulcus rhinalis and is marked off from th etrigonum olfactorium by the sul;cus arcuatus. The medial stria is smaller, short, and not so well-defined.

Trigonum olfactorium

The trigonum olfactorium is the prominent gray area situated in the eagle of divergence of the medial and lateral olfactory stria. It is bounded laterally by the lateral olfactory strai, from which it is defined by the sulcus arcuatus.

Piriform lobe

The piriform lobe is the well-marked prominence on the base lateral to the optic tract and cerebral peduncle, from which it is separated by a deep fissure.

Diencephalon (Inter Brain)

The diencephalon or *inter-brain* comprises the thalamus and a number of other structures group about the third ventricle.

THALAMUS

The thalamus is the principal body in this part of the brain. It is an important relay center for nerve fibers connecting the *cerebral hemispheres* to the *brainstem* and *spinal cord*. It is a large, ovoid mass placed obliquely across the dorsal face of the each cerebral peduncle, so that the long axes of the two thalami would meet in front about at right angle.

PINEAL BODY

The pineal body (*epiphysis cerebri*) is a small ovoid or fusiform red brown mass situated in a deep central depression between the *thalami* and *corpora quadrigemina*.

MAMMILARY BODY

The mammilary body is a white, round elevation a little larger than a pea which projects ventrally at the anterior end of the median furrow of the interpeduncular fossa.

PITUITARY BODY

The pituitary body (*hypophysis cerebri*) is one of the most important endocrine glands. It was mentioned as covering part of the interpeduncular fossa. It is oval in outline, flattened dors0-ventrally. It is attached by a delicate tubular stalk, the *infundibulum*, to the *tuber cinereum*, a single gray prominence situated between the optic chiasm in front and the mammilary body behind.

OPTIC CHIASM AND TRACTS

The optic chiasm and tracts form the anterior boundary of the interpeduncular fossa. The *optic chiasm* is formed by the union of the both, right and left optic tracts. From the chiasm each *optic tract* curves obliquely around the cerebral peduncle to the posterior part of the thalamus.

Mesencephalon (Mid Brain)

The *mesencephalon* or *mid-brain*, lies between the diencephalon rostrally and the pons caudally. It consists of a dorsal part, the corpora quadrigemina, and a larger ventral part, the cerebral peduncles.

CORPORA QUADRIGEMINA

The corpora quadrigemina are four rounded eminences which lie under the posterior part of the *cerebral hemispheres.* They consist of two pairs, separated by a transverse groove. The anterior pair is larger and much higher than the posterior pair.

CEREBRAL PEDUNCLES

The cerebral peduncles appear on the base of the brain as two large, rope-like stalks which emerge from the pons close together and diverge as they pass forward to enter the cerebrum. These peduncles consist of both sensory and motor fiber tracts.

Metencephalon

The metencephalon includes the *cerebellum* dorsally and the *pons* ventrally.

CEREBELLUM

The cerebellum is situated in the posterior fossa of the cranium, and is separated from the cerebral hemispheres by the transverse fissure and the *tentorium cerebelli* which occupies it. It overlies the pons and the greater part of the medulla, from which it is separated by the fourth ventricle.

The cerebellum features two *lateral hemispheres* and a median ridge called the *vermis* because of its resemblance to a worm. The surface of the cerebellum consists of many laminae called *folia*. In the cerebellum, like the cerebrum, the white matter is central, and the gray matter is peripheral in the *cerebellar cortex*.

PONS

The pons is that part of the brainstem which lies between the medulla and the cerebral peduncles. Its surface possesses visible *transverse fibers* that form a bridge from one hemisphere of the cerebellum to the other.

Myelencephalon

The myelencephalon becomes the *medulla oblongata* in the adult.

MEDULLA OBLONGATA

The medulla oblongata (often simply called the medulla) is the cranial continuation of the *spinal cord*, from which it is arbitrarily distinguished at the *foramen magnum*. It lies on the basilar part of the *occipital bone*. The medulla oblongata contains a number of important autonomic centers and nuclei for cranial nerves.

Ventricular System

The internal cavities of the brain are referred as *ventricles* of the brain.
The ventricles are the remnants of the lumen of the *embryonic neural tube*.
There are four ventricles in the brain;

i) Two Lateral Ventricles: Right and left ventricles lie within the respective cerebral hemispheres. ii) Third Ventricle: It is the internal brain cavity between the thalami. Most of the third ventricle is surrounded by the diencephalon. iii) Fourth Ventricle: It is situated between the cerebellum and the medulla oblongata.

COMMUNICATION

The *lateral ventricles* communicate with the midline third ventricle by way of the *interventricular foramina*.
The *third ventricle* connects with the fourth ventricle by way of the *cerebral aqueduct* passing through the midbrain.
The *fourth ventricle* communicates with the subarachnoid space surrounding the CNS through two *lateral apertures*.

Each ventricle features a *choroid plexus*, a tuft of blood capillaries that protrudes into the lumen of the ventricle. The plexus of capillaries is covered by a layer of ependymal cells that are continuous with the lining membranes of the ventricles.

Peripheral Nervous System

The PNS includes the cranial and spinal nerves with their ganglia, and the sympathetic nervous system. Its purpose is to convey sensory informations to the brain and spinal cord and to produce movements of muscle and secretion from glands via motor nerves.

CRANIAL NERVES

Classically, 12 pairs of cranial nerves arising from the basal surface of the brain are described. They are designated by Roman numerals, numbered from most rostral (I) to most caudal (XII).

Number	*Name*	*Type*	*Arises from*	*Distribution*
I	**Olfactory**	Sensory	Olfactory bulb	Olfactory mucosa
II	**Optic**	Sensory	Interbrain	Retina of the eye
III	**Oculomotor**	Motor	Midbrain	Extrinsic muscles of the eye.
IV	**Trochlear**	Motor	Midbrain	Obliquus dorsalis muscle.
V	**Trigeminal**	Mixed	Pons	Skin of face, Conjunctiva of eye and muscles of mastication.
VI	**Abducens**	Motor	Medulla	Rectus lateralis, Retractor bulbi muscles (of eye).
VII	**Facial**	Mixed	Medulla	Muscles of facial expression.
VIII	**Vestibulochochlear**	Sensory	Medulla	Semicircular canals and cochlea of the ear.
IX	**Glossopharyngeal**	Mixed	Medulla	Skin of internal auditory

				meatus and taste buds of the tongue.
X	**Vagus**	Mixed	Medulla	Skin of external auditory meatus.
XI	**Accessory**	Motor	Medulla	Trapezius and sternocephalicus muscles.
XII	**Hypoglossal**	Motor	Medulla	Muscles of the tongue.

SPINAL NERVES

The spinal nerves are arranged in pairs, of which there are usually thirty six (36) in case of Goat.

DISTRIBUTION

The spinal nerves are designated according to their relation to the vertebral column as;

No.	Name of Regional nerves	Number of nerve pairs
I	Cervical nerves	8
II	Thoracic nerves	13
III	Lumber nerves	6
IV	Sacral nerves	5
V	Coccygeal nerves	4

FORMATION

Doral and ventral roots arise from the spinal cord and fuse, generally close to the intervertebral foramen. At this point, the conjoined sensory fibers of the dorsal roots and motor fibers of the ventral root become the *spinal nerve*, which is characterized as a *mixed nerve*.

BRANCHES

As soon as the spinal nerve emerges through the intervertebral foramen, it divides into two branches;

(i) Dorsal branch (ii) Ventral branch

INNERVATION

The spinal nerves tend to innervate the region of the body in the area adjacent to where they emerge. The limbs, however, are supplied with sensory and motor fibers within tangled arrangement of spinal nerves known as *plexuses*. Here, only two important plexuses of the limbs; brachial plexus of thoracic limb and the lumbo-sacral plexus of hind limb are described.

Brachial Plexus

Each thoracic limb is supplied by a *brachial plexus*.

FORMATION

The brachial plexus is a network of nerves derived from the ventral branches of the *last three cervical* and *first thoracic* nerves.

BRANCHES

The brachial plexus gives rise to specific named nerves that innervate the muscles of the thoracic limb. The branches arising from this plexus are described below with the muscles supplied by each.

Nerve	Muscles Innervated
Suprascapular	Supraspinatus & infraspinatus

Subscapular	**Subscapularis**
Thoracodorsal	**Latissimus dorsi**
Long thoracic	**Serratus ventralis**
Pectoral	**Superficial, deep pectoral**
Musculocutaneous	**Biceps brachii, Coracobrachialis, Brachialis**
Axillary	**Teres major et minor, Deltoideus**
Radial	
Superficial branch	**Triceps brachii, Anconeus**
Deep branch	**Extensor carpi radialis, Common & lateral digit. extensors, Ulnaris lateralis**
Ulnar	**Flexor carpi ulnaris, Deep digital flexor**
Median	**Pronator teres, Flexor carpi radialis, Superficial and deep digital flexor.**

Lumbosacral Plexus

The right and left lumbosacral plexuses supply nerves to the respective pelvic limbs.

FORMATION

The lumbosacral plexuses are made up of the ventral branches of the last few lumber and first two sacral nerves.

BRANCHES

The nerves derived from the lumbosacral plexus are described below in the table.

Nerve	Muscles Innervated
Cranial gluteal	**Middle and deep gluteal, Tensor fascia latae**
Cudal gluteal	**Parts of middle gluteal, Semitendinosus**
Femoral	**Sartorius, Quadriceps femoris, iliopsoas**
Obturator	**Adductor, Gracilis, Pectineus, Obturator externus**
Sciatic	**Semitendinosus, Semimembranosus, Biceps femoris, Quadratus femoris, Obturator internus**
Peroneal	**Cranial tibial, Long and lateral digital extensor, Proneus (longus & tertius)**
Tibial	**Gastrocnemius, Deep digital flexor, Popliteus**

CEREBROSPINAL FLUID (CSF)

The *cerebrospinal fluid* (CSF) is a modified tissue fluid. It is contained in the ventricular system of the brain and in the subarachnoid space around the brain and spinal cord. CSF replaces lymph in the CNS.

FORMATION

1. **The bulk of the CSF is formed by the choroid plexuses of the lateral ventricles, and lesser amounts by the choroid plexuses of the third and fourth ventricles.**
2. **Possibly it is also formed by the capillaries on the surface of the brain and spinal cord.**

CIRCULATION

The circulation of cerebrospinal fluid beings in the two lateral ventricles (where majority is produced), flows through the *interventricular foramina* into the third ventricle, then by way of the *cerebral aqueduct* into the fourth ventricle, and finally through the lateral apertures into the *subarachnoid space*, where it surrounds the brain and spinal cord.

ABSORPTION

1. **CSF is absorbed chiefly through the arachnoid villi and granulations.**
2. **It is also absorbed partially by the perineural lymphatics around the few cranial nerves.**
3. **It is also absorbed by veins related to spinal nerves.**

FUNCTIONS

It is (a) protective, (b) nutritive, and (c) a pathway for excretion from the central nervous system (CNS).

NEURON

Neurons are the basic building blocks of the nervous system. These specialized cells are the information-processing units of the brain responsible for receiving and transmitting information. Each part of the neuron plays a role in the communication of information throughout the body.

STRUCTURE OF A TYPICAL NEURON …… (See Figure 13 – 4)

Dendrites: Dendrites are treelike extensions at the beginning of a neuron that help increase the surface area of the cell body and are covered with synapses. These tiny protrusions receive infor-mation from other neurons and transmit electrical stimulation to the soma.

CONTENTS OF THE VERTEBRAL CANAL

…… (See Figure 13 – 5)

The vertebral canal contains the following structures from without inwards.

1. **Epidural space**
2. **Thick dura mater**
3. **Subdural capillary space.**
4. **Delicate arachnoid mater**
5. **Wide subarachnoid space (containing CSF)**
6. **Firm pia mater (the arachnoid and pia together form the leptomeninges).**
7. **Spinal cord and the cauda equina.**

Epidural Space

It lies between the spinal dura mater, and the periosteum and ligaments lining the vertebral canal.

Spinal Dura Mater

It is a thick, tough fibrous membrane which forms a loose sheath around the spinal cord.

Subdural Space

It is a capillary (potential) space between the dura and the arachnoid, containg a thin film of serous fluid.

Arachnoid Mater

This is a thin, delicate and transparent membrane that loosely invests the entire central nervous system.

Subarachnoid Space

It is a wide space between the pia and the arachnoid, filled with cerebrospinal fluid (CSF). It surrounds the brain and spinal cord like a water cushion.

Spinal Pia Mater

The spinal pia is a thicker, firmer, and less vascular than the cerebral pia.

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Chapter 14

ENDOCRINE SYSTEM

Outline

- **Hormones**
- **Response of a hormone**
- **Endocrine Glands, location and their hormones**
  - **Hypothalamus**
  - **Pituitary gland**
  - **Pineal gland**
  - **Thyroid gland**
  - **Parathyroid gland**
  - **Thymus gland**
  - **Adrenal glands**
  - **Pancreas**
  - **Liver**
  - **Kidneys**
  - **Heart**
  - **Testes**
  - **Ovaries**

In order to survive, animals must constantly adapt to changes in the environment. The *nervous* and *endocrine* systems both work together to bring about this adaptation. In general the nervous system responds rapidly to short-term changes by sending electrical impulses along nerves and the endocrine system brings about longer-term adaptations by sending out chemical messengers called *hormones* into the blood stream.

The classic *endocrine system* consists of a group of ductless glands that secrete hormones. Unlike exocrine glands, endocrine glands have no ducts, but release their secretions directly into the blood system, which carries them throughout the body.

Hormones

Hormones are chemicals messengers that are secreted by endocrine glands and function in extremely small concentration.

Response of a hormone

A nerve impulse travels rapidly and produces an almost instantaneous response but one that lasts only briefly. In contrast, hormones act more slowly and their effects may be long lasting. Target cells respond to minute quantities of hormones and the concentration in the blood is always extremely low.

ENDOCRINE GLANDS

The major glands of the endocrine system are:

1. **Hypothalamus**
2. **Pituitary gland**
3. **Pineal gland**
4. **Thyroid gland**
5. **Parathyroid glands**
6. **Thymus gland**
7. **Adrenal glands**

8. Pancreas
9. Liver
10. Kidneys
11. Heart
12. Testes
13. Ovaries

1. HYPOTHALAMUS

The hypothalamus secretes hormones that stimulate or suppress the release of hormones in the pituitary gland, in addition to controlling water balance, sleep, temperature, appetite, and blood pressure.

LOCATION

The hypothalamus is located in the brain, at the base of the optic chiasm. This small but vital region of the brain lies just above the pituitary and provides the link between the nervous and endocrine systems.

Secreted hormone	From cells	Effect
Thyrotropin-releasing hormone (TRH)	Parvocellualar neurosecretory neurons	Release thyroid-stimulating hormone from anterior pituitary. Stimulate prolactin release from anterior pituitary
Gonadotropin-releasing hormone (GnRH)	Neuroendocrine cells of preoptic area	Release of FSH and LH from anterior pituitary
Growth hormone-releasing hormone (GHRH)	Neuroendocrine cells of arcuate nucleus	Release growth hormone from anterior pituitary
Corticotropin-releasing hormone (CRH)	Parvocellular neurosecretory neurons	Release ACTH from anterior pituitary
Growth hormone-inhibiting hormone (GHIH) or somatostatin	Neuroendocrine cells of Periventricular nucleus	Inhibit release of GH and TSH from anterior pituitary
Prolactin inhibiting factor (PIF) or Dopamine	Dopamine neurons of arcuate nucleus	Inhibit release of prolactin and TSH from anterior pituitary
Prolactin-releasing hormone (PRH)	---	Release prolactin from anterior pituitary

2. PITUITARY GLAND (Hypophysis)

The pituitary gland is often called the "master" endocrine gland because it controls many of the other endocrine glands in the body.

LOCATION

The pituitary gland is a pea-sized structure that is attached by a stalk, the infundibulum, to the underside of the cerebrum of the brain

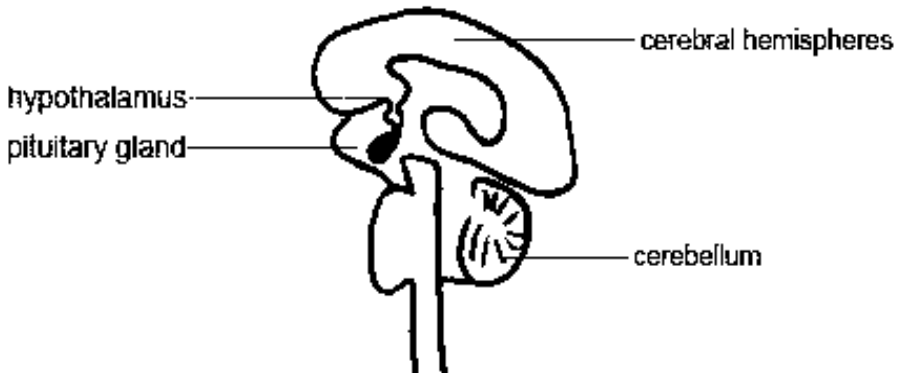

Figure 14.1: Position of Pituitary gland and Hypothalamus

DIVISION

The pituitary gland is divided into three lobes with different functions;

(i) Anterior pituitary (*Adenohypophysis*)
(ii) Posterior pituitary (*Neurohypophysis*)
(iii) Intermediate pituitary (*Pars intermedia*)

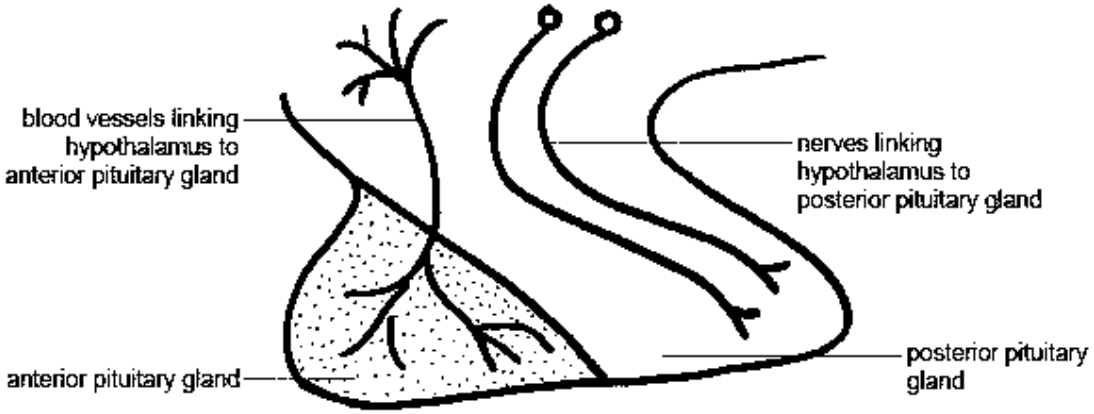

Figure 14.2: Lobes of Pituitary Gland

Anterior Pituitary Lobe (Adenohypophysis)

The anterior pituitary lobe secretes hormones that regulate a wide range of activities in the body.

Secreted hormone	From cells	Effect
Growth hormone (GH)	Somatotropes	Stimulates growth and cell reproduction Release Insulin-like growth factor (IGF) from liver
Prolactin (PRL)	Lactotrophes	Milk production in mammary glands Sexual gratification after sexual act
Adreno-corticotropic hormone (ACTH)	Corticotropes	Synthesis of corticosteroids in adrenocortical cells
Thyroid-stimulating hormone (TSH)	Thyrotropes	Stimulates thyroid gland to secretes its hormones
Follicle-stimulating hormone (FSH)	Gonadotropes	In female: stimulates maturation of Graafian folicles In male: Spermatogenesis, enhancing prod. of

		ABP.
Luteinizing hormone (LH)	Gonadotropes	In female: ovulation In male: stimulates leydig cell production of T4.

Posterior Pituitary Lobe *(*Neurohypophysis*)*

The hormones of the posterior pituitary lobe are not secreted in this lobe, merely stored.

Secreted hormone	From cells	Effect
Oxytocin	Magnocellular neurosecretory cells	Contraction of cervix and vagina Release milk from milk glands, Involved in orgasm, trust between people. and circadian homeostasis.
Antidiuretic hormone (ADH) or Vesopressin	Magnocellular neurosecretory cells	Retention of water in the kidneys Moderate vasoconstriction

Intermediate Pituitary Lobe (Pars intermedia)

Secreted hormone	From cells	Effect
Melanocyte-stimulating hormone (MSH)	Melanotroph	Melanogenesis by melanocytes in skin and hair

3. PINEAL GLAND (Epiphysis)

The pineal is a small ovoid or fusiform mass which is found deep within the brain.
It is sometimes known as the '*third eye*" as it responds to light and day length.

LOCATION

The pineal gland (epiphysis) is situated in a central depression between the thalami (sing. thalamus) and corpora quadrigemina (also called colliculi).

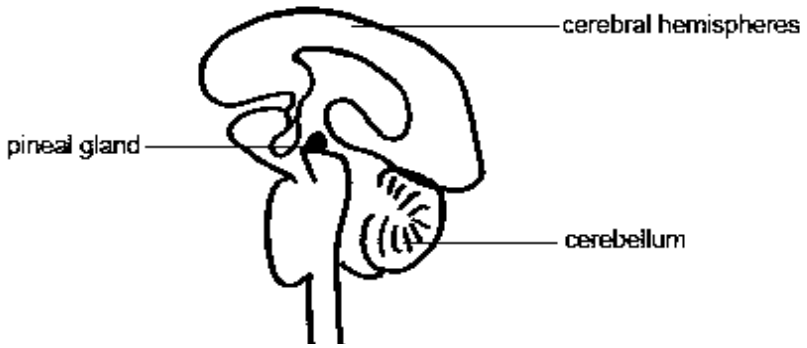

Figure 14.3: Position of Pineal gland

Secreted hormone	From cells	Effect
Melatonin	Pinealocytes	Influences the development of sexual maturity and the seasonality of breeding and hibernation.

4. THYROID GLAND

The thyroid is a very vascular ductless gland, firm in texture and dark red-brown in color.

LOCATION

It is situated below the larynx (voice box), on the anterior part of the trachea, to which it is loosely attached.

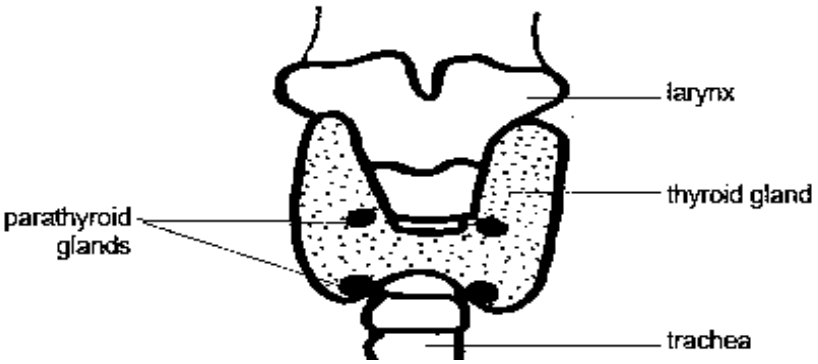

Figure 14.4: The Thyroid and Parathyroid Glands

SECRETED HORMONE

Secreted hormone	From cells	Effect
Triidothyronine (T3)	Thyroid epithelial cell	Potent form of thyroid hormone; Increase the basal metabolic rate. Affect protein synthesis
Tetraidothyroxine (T4)	Thyroid epithelial cells	Less active form of thyroid hormone; increase the basal metabolic rate. Often functions as a prohormone
Calcitonin	Parafollicular cells	Construct bone Reduce blood Ca+

5. PARATHYROID GLAND

The parathyroid are pale in color and not so dense as thyroid.

LOCATION

They are small glandular bodies found in the thyroid gland.

SECRETED HORMONE

Secreted hormone	From cells	Effect
Parathyroid hormone (PTH)	Parathyroid chief cell	Increase blood Ca+ - Ca+ reabsorption in kidney - activate vitamin D (Slightly) decrease blood phosphate:

6. THYMUS GLAND

The thymus is a ductless gland which has close resemblance to the lymphoid tissue.

LOCATION

It is situated in the anterior mediastinal space of the thoracic cavity.

FUNCTION

The main function of the thymus is to provide an area for T lymphocyte maturation, and is vital in protecting against autoimmunity.

The stock of T-lymphocytes is built up in early life, so the function of the thymus is diminished in adults. It is largely degenerated in elderly adults

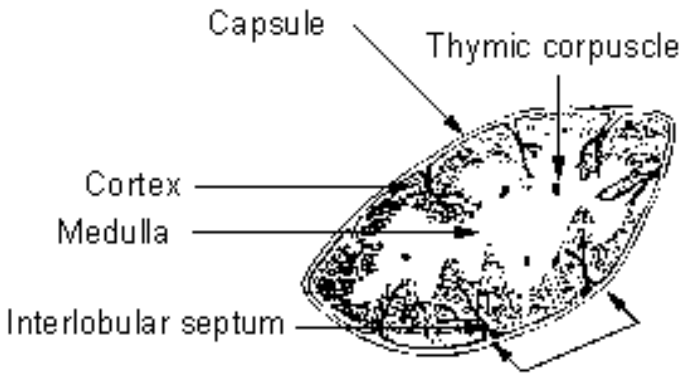

Figure 14.5: Internal Structure of Thymus

and is barely identifiable, consisting mostly of fatty tissue; however it continues to function as an endocrine gland important in stimulating the immune system.

7. ADRENAL GLANDS

The adrenal glands are two small, bean-shaped organs.

LOCATION

The right adrenal gland lies along the anterior part of the medial border of the kidney, at the angle of the junction of the right renal vein & caudal vena cava. The left one is usually longer, flatter and somewhat bent.

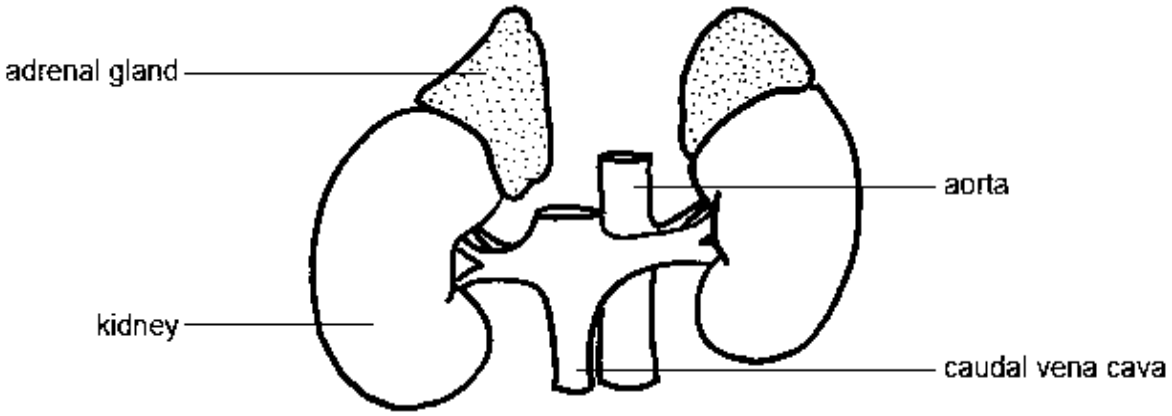

Figure 14.6 : The Adrenal Glands

STRUCTURE

Each adrenal body presents two differential parts;

(i) An outer *cortex*

(ii) An inner *medulla*

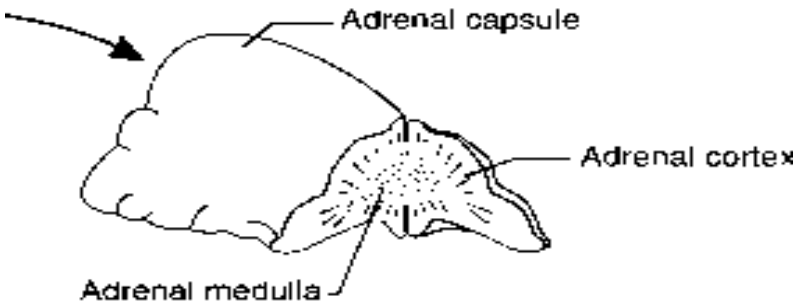

Figure 14.7 : Internal Structure of an Adrenal Gland

Secreted hormone	From cells	Effect
Glucocorticoids (chiefly) Cortisol	Zona fasciculata & zona reticularis	Stimulation of gluconeogenesis Inflammatory and immunosuppressive
Mineralocorticoids (chiefly) Aldosterone	Zona glumerulosa	Increase blood volume by reabsorption of Na+ in kidney Potassium and H+ secretion in kidney
Androgens (include Testosterone)	Zona fasciculata and zona reticularis	Virilization Anabolic

(ii) Adrenal Medulla

Secreted hormone	From cells	Effect
Adrenaline (epinephrine)	Chromaffin cells	Fight-or-flight response - Boost the supply of oxygen and glucose to brain and muscles (by increasing heart rate, vasodilation, increasing catalysis of glycogen in liver, breakdown of lipids in fat cells) - Dilate the pupils - Suppress non-emergency bodily process (e.g. digestion) - Suppress immune system
Noradrenaline (norepinephrine)	Chromaffin cells	Fight or flight response - Boost the supply of oxygen and glucose to brain and muscles (by increasing heart rate, vasoconstriction, increased blood pressure, breakdown of lipids in fat cells) - Increase skeletal muscle readiness.

8. PANCREAS

The pancreas is an oblong, pinkish organ that lies in the first bend of the small intestine

LOCATION

The pancreas lies entirely to the right of the median plane.
It mostly lies on the visceral surface of the liver and attached with the duodenum.

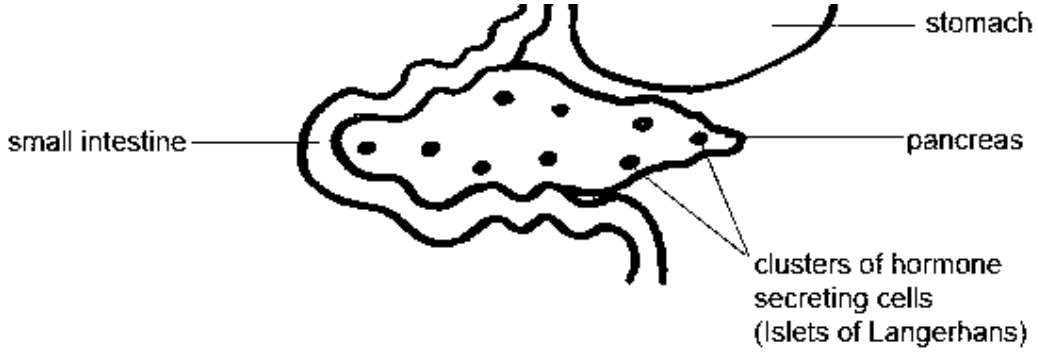

Figure 14.8 : The Pancreas

Secreted hormone	From cells	Effect
Insulin	B islets cells	Intake of glucose, glycogenesis and glycolysis in the liver and muscle from blood Intake of lipid and synthesis of triglycerides in adipocytes
Glucagon	α islets cells	Glycogenolysis and gluconeogenesis in liver Increase blood glucose level
Somatostatin	d Islets cells	Inhibit release of insulin Inhibit release of glucagon. Suppress exocrine secretory action

9. LIVER

The liver is the largest gland of the body, constituting 1-2 % of total adult body weight.

LOCATION

The liver is always located immediately caudal to the diaphragm (in contact with it) and tends to be located on the right side as the reticulorumen pushes everything else to the right.

Secreted hormone	From cells	Effect
Insulin-like growth factor (IGF)	Hepatocytes	Insulin-like effects Regulate cell growth and development
Angiotensinogen and angiotensin	Hepatocytes	Vasoconstriction Release of aldosterone from adrenal cortex.

10. KIDNEYS

The kidneys are a pair of excretory organs situated in the dorsal part of the abdominal cavity on each side of the aorta and caudal vena cava, just ventral to the first few lumber vertebrae.

LOCATION

The kidneys usually lie ventral to the first three lumbar transverse processes; against the dorsal wall of the abdominal cavity.

Secreted hormone	From cells	Effect
Renin	Juxtaglomerular cells	Activate the renin-angiotensin system by producing angiotensin I of angiotesinogen
Eryhtropoietin (EPO)	Extraglomerular mesangial cells	Stimulates erythrocyte production
Calcitriol (1,25-dihydroxycholical-ciferol)	---	Active form of Vitamin D3 Increase intestinal absorption of calcium, inhibit release of PTH
Thrombopoietin	---	Stimulates megakaryotes to produce platelets

11. HEART

The heart is a conical hollow muscular organ that pumps blood to various parts of the body to meet their nutritive requirements.

LOCATION

The heart is situated in the middle mediastinum and is enclosed within the pericardium.

Secreted hormone	From cells	Effect
Atrial-natriuretic peptide (ANP)	Cardiac myocytes	Reduce blood pressure Increase Na+ excretion by kidneys
Brain-natriuretic peptide (BNP)	Cardiac myocytes	Reduce blood pressure (to a minor degree than ANP)

12. TESTES

The testes (testicles) are the male gonads. They are homologue with the ovary of the female. The spermatic cord suspends each individual testis within the scrotum.

LOCATION

The testicles are held near to the sigmoid (S-shaped) flexure of the penis.

Secreted hormone	From cells	Effect
Androgens (chiefly Testosterone)	Leydig cells	*Virilizing*: ● maturation of male sex organs and development of male secondary sex characteristics. ● Deepening of voice *Anabolic:* ● growth of muscle mass and strength,

		increase bone density, growth and strength.
Estradiol	**Sertoli cells**	**Prevent apoptosis of germ cells**
Inhibin	**Sertoli cells**	**Inhibit production of FSH**

13. OVARIES

The ovaries, like the testes in the male, are the primary organs of reproduction in the female.

LOCATION

The ovaries are paired glands usually found in the lumber region of the abdominal cavity, a short distance caudal to the kidneys. These are almond-shaped.

Progesterone	**Granulosa cells, theca cells**	**Support pregnancy:** ● Convert endometrium to secretory stage ● Make cervical mucous permeable to sperm ● Inhibit immune response ● Decrease uterine smooth muscle contractility ● Inhibit lactation and onset of labor **Other:** ● Raise epidermal growth factor-I levels ● Increase core temperature during ovulation ● Reduce spasm and relax smooth muscles. **Anti-inflammatory:** ● Reduce gall-bladder activity ● Normalize blood clotting and vascular tone, cell O2 levels. ● Increase resilience in bone, teeth, gums, joints, tendon, ligament, and skin. ● Promote healing by regulating collagen ● Provide nerve function and healing by regulating myelin ● Prevent endometrial cancer by regulating effects of estrogen
Estrogens (chiefly estradiol)	**Granulosa cells**	**Structural:** ● Promote formation of female secondary sex characteristics ● Reduce muscle mass ● Stimulate endometrial growth ● Increase uterine growth ● Reduce bone resorption and increase bone formation **Protein synthesis:** ● Increase hepatic production of binding proteins **Coagulation:** ● Increase circulating level of blood clotting factors. ● Increase platelet adhesiveness ● Increase HDL, triglycerides ● Decrease LDL, fat deposition **Fluid balance:** ● Regulate salt and water retention ● Increase growth hormone **Gastrointestinal tract:** ● Reduce bowel motility ● Increase cholesterol in bile **Melanin:** ● Increase pheomelanin, reduce eumelanin

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Chapter 15

ORGAN OF VISION----THE EYE

Outline

- **Orbit**
- **Periorbita**
- **Eyelids**
  - **Upper and lower**
  - **Third**
- **Conjunctiva**
  - **Palpebral**
  - **Bulbar**
- **Eyeball**
- **Layers of Eyeball**
  - Fibrous tunic
    - **Sclera**
    - **Cornea**
  - Vascular tunic
    - **Choroid**
    - **Ciliary body**
    - **Iris**
  - Nervous tunic
    - **Retina**
- **Extraocular Muscles**
- **Tarsal glands**
- **Gland of third eyelid**
- **Lacrimal Apparatus**
  - Lacrimal gland

The eye is an elaborate organ whose primary function is to collect and focus light upon the photosensitive retina.

SITUATION

It lies within a cone-shaped cavity of the skull, the *orbit*, which houses the *eyeball* (globe) anda number of other soft tissue structures, the *ocular adnexa* (e.g. muscles, glands).

COMPONENTS

The eye or organ of vision consists of;

(i) Eyeball (ii) Optic Nerve (iii) Accessory organs.

Orbit

The orbit is a conical cavity containing the eyeball and the ocular adnexa.
The orbit is formed by the frontal, lacrimal and the zygomatic bones of the face.

Periorbita

The periorbita is a cone shaped sheath of connective tissue that surrounds the eyeball and its muscles, nerves and vessels.

Eyelids

Upper and Lower

The eyelids (palpebrae), *upper* and *lower*, are two mobile folds of haired skin protect the anterior aspect of the eyeball. PALPEBRAL FISSURE: the interval between the margins of the two palpebrae is the palpebral fissure. The ends of the fissure are the angles or canthi of an eye. i.e. (i) Medial canthus (ii) Lateral canthus

Third

The third eyelid, or *nictitating membrane* is a fold of the mucous membrane arising from the ventromedial aspect of the conjunctival sac between the eyeball and eyelids (palpebrae).
It is given rigidity by a T-shaped cartilage, and it smoothes the tear film and protects the cornea.

Conjunctiva

The conjunctiva is the mucous membrane that lines the eyelids and anterior part of the eyeball (globe). Conjunctival Sac: It is a very small space between the eyelids and the surface of the eye.

DISTRIBUTION

(a) Palpebral conjunctiva
It is the part of conjunctiva that is in contact with or lines the eyelids (palpebrae).

(b) Bulbar conjunctiva
It is that part of conjunctiva which is reflected upon the anterior part of the eyeball (globe).

Eyeball

The eyeball (globe) is situated in the anterior part of the orbital cavity.
It is protected in front by the eyelids and conjunctiva.

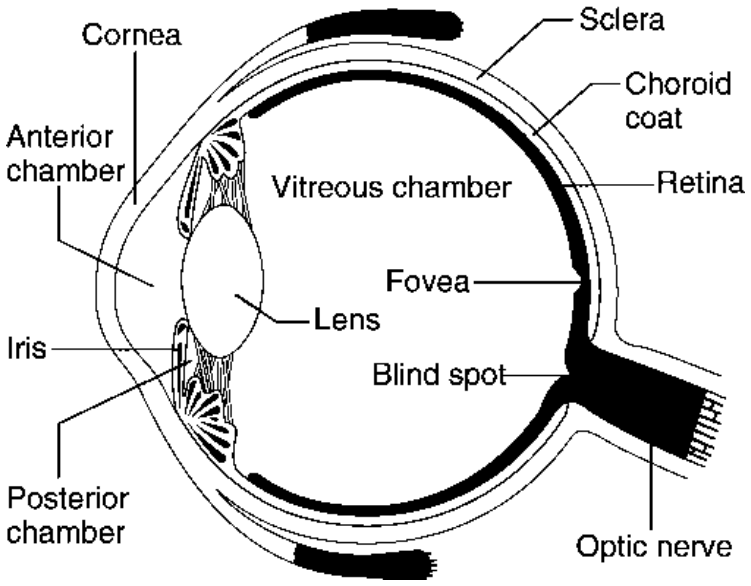

Figure 15 -1: Structure of Eyeball (Globe)

Layers of the Eyeball

The eyeball comprises three concentric layers which are also named coats or tunics of the eyeball.
These three layers (tunics) are named; (i) the fibrous tunic, (ii) the vascular tunic, and (iii) the nervous tunic.

FIBROUS TUNIC

The outer *fibrous tunic* of the eyeball is made up of a posterior opaque *sclera* and an anterior transparent *cornea*.

Sclera

The sclera is white, variably tinged gray or blue; it meets the clear cornea at a transitional region called the *limbus*. It is in general white, but may have a bluish tinge in its thinnest part. The tough sclera is the site of insertion for the extraocular eye muscles.

Cornea

The cornea is the transparent anterior part of the fibrous tunic. It is the most powerful reflecting layer of the eye.

VASCULAR TUNIC

The middle tunic of the eyeball, the *vascular tunic*, is composed of three parts; choroid, ciliary body and iris.

Choroid

The vascular tunic in the posterior portion is the choroid. It is highly vascular and possesses multiple layers. The deepest of these is the *tapetum*. The tapetum is confined to the dorsal part of the posterior globe. The ventral portion of the choroid is usually not reflective.

Ciliary body

The ciliary body is the anterior continuation of the vascular tunic. It is a circumferential thickening of the vascular tunic, and it gives rise to many fine *suspensory ligaments* that support the lens.

Iris

The iris is the most anterior portion of this tunic and the only part of the vascular tunic normally visible in the living animal. It consists of a pigmented ring of tissue, perforated in its center by the *pupil*. The iris divides the aqueous filled *anterior* segment of the eye into *anterior* and *posterior chambers*.

NERVOUS TUNIC

The deepest layer of the eyeball is the *nervous tunic* or *retina*.

Extraocular Muscles

The globe of the eye moves by the action of seven striated muscles, designated *extraocular muscles* to distinguish them from the intraocular muscles that lie entirely within the eyeball.

Muscle Type	Name of Muscle
Four straight muscles	Rectus dorsalis, Rectus ventralis
	Rectus medialis, Rectus lateralis
Two oblique muscles	Obliquus dorsalis, Obliquus ventralis
One retractor muscle	Retractor bulbi or oculi

Tarsal Glands

Abundant modified sweat and sebaceous glands are associated with the lid margin. A row of large modified sebaceous glands, the tarsal glands, is specially of great importance.

LOCATION

The tarsal glands are present in both palpebrae and open into a shallow furrow near the muco-cutaneous junction of the eyelid.

APPEARANCE

The glands are visible as yellowish-white columns under the mucous membranes on the inner surface of lid.

PRODUCTION

The tarsal glands produce an important oil layer of the tear film.

Gland of Third Eyelid

The third eyelid (nictitating membrane) has at its base a serous gland, called simply the gland of the third eyelid.

SECRETION

It normally contributes about 50% of the tear film.

Lacrimal Apparatus

The Lacrimal apparatus comprises a series of serous, seromucous and mucous glands and the duct system that drain their secretions.

FUNCTION

This apparatus provides a moist environment for the anterior surface of the eye.

Lacrimal Gland

The Lacrimal gland lies in the dorso-lateral portion of the orbit.

SECRETION

The secretion of lacrimal gland, together with that of the gland of third eyelid, is the major contributor to the tear film.

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