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Structure and Functions of Important Endocrine Glands

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Introduction

A gland is a group of cells that produces and secretes or gives off chemicals

A gland selects and removes materials from the blood, processes them and secretes the finished chemical product for use somewhere in the body

Some types of glands release their secretions in specific areas

There are 2 types of glands



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- They are **exocrine glands** are glands that secrete their products (enzymes excluding hormones and other chemical messengers like Neurotransmitter - communicates to adjacent cells, Neuropeptide - a protein sequence which acts as a hormone or neurotransmitter, Pheromone - a chemical factor that triggers a social response in members of the same species) into ducts
- Exocrine glands release their secretions through ducts into the external environment (Silverthorn 2004) or directly onto the exterior surface or an area contiguous with the exterior surface



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Typical exocrine glands include sweat glands, salivary glands, stomach, liver, pancreas

The chemical substances released by exocrine glands include sweat, digestive enzymes and tears (through tear ducts)

Endocrine glands on the other hand, release or secrete more than 20 major hormones or chemicals directly into the bloodstream where they can be transported to cells in other parts of the body



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The hormones play important role in the chemical co-ordination in animal body

In fishes many endocrine gland are present which secrete many hormones and control various process of body

The endocrine system is slower than the nervous system because hormones must travel through the circulatory system to reach their target



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But the nervous system conducts signals much quicker than the endocrine system

Chemicals that interfere with the normal functioning of this complex system are known as "endocrine disruptors"

Disruption of the endocrine system can occur in various ways



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• **The major endocrine glands of the body are following**

• **Hypothalamus**

- The pituitary gland
- The thyroid gland
- Adrenal cortical tissue or Inter-renal tissue
- Chromaffin tissue
- The ultimo-branchial gland
- Islets of langerhans or Endocrine Pancreas
- The corpuscles of stannius
- The urophysis (Caudal neurosecretory System)
- Gonads
- Gastro-Intestinal hormones or intestinal mucosa
- Pineal gland
- Pheromones



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- One of the most important functions of the hypothalamus is to link the nervous system to the endocrine system via the pituitary gland (hypophysis)
- The brain is made of three main parts: the forebrain, midbrain, and hindbrain
 - The forebrain consists of the cerebrum, thalamus, and hypothalamus (part of the limbic system)
 - The midbrain consists of the tectum and tegmentum
 - The hindbrain is made of the cerebellum, pons and medulla



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Function of thalamus

The blood vessel that carries hypothalamic-releasing hormones from the hypothalamus to the pituitary is called a **portal vein** because it connects two capillary beds

Release-inhibiting hormones produced by the hypothalamus inhibit the pituitary from secreting its hormones



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The pituitary gland

Pituitary or the hypophysis is the most important endocrine gland in teleosts and consists of 2 main parts or components, the neurohypophysis (the posterior pituitary), neural part and the adenohypophysis (the anterior pituitary), a glandular part

While the pituitary gland is known as the 'master' endocrine gland because it controls other glands

But both of the lobes are under the control of the hypothalamus



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Anatomy of pituitary gland - Anterior pituitary

Rostral pars distalis

Rostral pars distalis is the anterior most part of the adenohypophysis and is composed of acidophilic cells

These cells are stained by azocarmine or orange G stains

Along with the acidophils, a few cyanophils are also present



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proximal pars distalis

It lies between the rostral pars distalis and the pars intermedia

This contains acidophils, cyanophils and chromophobes cells and may vary in size during different parts of the year



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The pars intermedia

It is the posterior part of the hypophysis and may be of various sizes in different species

Cyanophils that are stained with aniline blue

Acidophils that can be stained with azocarmine or orange G

Anatomy of pituitary gland - Posterior pituitary (Neurohypophysis)



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Hormones of the pituitary gland

Atleast 9 hormones are produced by the pituitary in fish and all hormones are made up of proteins or polypeptides

Hormones of the adenohypophysis

These hormones are released from the anterior pituitary under the influence of the hypothalamus

Six different hormones produced by the anterior lobe will be studied here



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Anterior pituitary hormones that regulate other glands

The pituitary also controls other glands and is often referred to as the "master gland"

Thyroid Stimulating Hormone (TSH) → thyroid → thyroxin

Adrenocorticotrophic Hormone (ACTH) → adrenal cortex → cortisol

Gonadotropic Hormones (FSH and LH) → ovaries and testes → sex hormones; controls gamete production



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Hypothalamus, pituitary and each of the glands they control

Somatotrophs (STH cells) or growth hormone (GH): These hormones are secreted by somatotroph cells and are mainly found in pars distalis

Prolactin (PRL): Prolactin (PRL), also known as 'Luteotropic' hormone (LTH). It is released by lactotroph cells under the influence of multiple hypothalamic Prolactin Releasing Factors (PRH). These cells secrete prolactin hormone which is involved in osmoregulation



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- Melanocyte-Stimulating Hormone (MSH):** This influences the pigments of the skin i.e., darkening of skin in fishes
- **Thyrotrophs or Thyroid Stimulating Hormones (TSH):** It is released by the thyrotroph cell of adenohypophysis under influence of hypothalamic Thyrotropin Releasing Hormone (TRH)
 - It stimulates the thyroid gland to secrete thyroxine



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- Gonadotrophs (FSH and LH cells):** There two 'Gonadotropins' and are released by the gonadotroph cell. The gonadotrophic hormones of the pituitary gland appear to be regulated by the gonadotrophic releasing hormone (GnRH) identified in different locations of the teleostean brain
- **Corticotrophs or Adrenal Corticotrophic Hormone (ACTH):** It is released by corticotroph cells under influence of hypothalamic Corticotropin Releasing Hormone (CRH)



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Hormones of the neurohypophysis

Vassopressin hormone

Oxytocin

It controls mating in fishes and also controls process of egg laying

Neuro-endocrine regulation of the pituitary gland

Pituitary gland controls a number of metabolic activities of the fish through its hormones



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The thyroid gland

- The thyroid gland in teleosts is present in a diffused condition
- Under a microscope, large number of follicles is seen in the thyroid tissue
- Thyroid follicles vary in shape and size and are bound together by connective tissue and are richly supplied with blood capillaries
- The first chamber in the heart is called the sinus venosus, it is the preliminary collecting chamber. In teleosts it is filled from two major veins called the hepatic



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Functions

- Thyroid follicles synthesize thyroid hormone after extracting iodine from the blood and combining it with tyrosine (an amino acid)
- TSH then stimulates the thyroid gland to increase its uptake of iodine from the blood, so that more thyroxine (T_4) can be synthesized
- Thyroxine also promotes maturation in fishes
- Scale and bone formation in fishes is also controlled by thyroxine



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Adrenal cortical tissue or Inter-renal tissue

There is no true adrenal gland present in most fish

Only a few renal tubules are seen in the head kidney

The inter-renal cells may be located in 1 or several layers along the post cardinal vein

The inter-renals play an important role in the osmotic regulation of the fish. They are involved in gluco-genesis



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Chromaffin tissue

Chromaffin cells (adrenaline producing) are generally dispersed in the head kidney near the post cardinal vein and exhibit considerable variation in their distribution in teleosts

- The chromaffin cells may occur singly or in groups in different locations in the head kidney
- They may be
- Embedded in the vein wall or
- Associated with the inter-renal tissue or
- Dispersed in the inter-renal tissue and the vein walls
- Present in the ovary of teleosts



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Chromaffin tissue is reported to be present in the ovary of several freshwater teleosts like *L. rohita*, *Catla*, *Mrigala*, *Puntius spp*, *Channa spp*, *Notopterus* inside the ovarial folds along the lamellae



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The ultimo-branchial gland

The ultimo-branchial gland originates from the pharyngeal epithelium of the last or 'ultimate' gill pouch

It is unpaired. In chondrichthys, an ultimo-branchial gland is present between pericardium and pharynx

In bony fishes, the gland is present between the abdominal cavity and sinus venosus ventral to the oesophagus



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- In teleosts, the gland is seen as a band of white tissue on the septum
- **Parathyroid gland** - An endocrine organ usually associated with the thyroid gland and possessed by all vertebrates except the fishes
- This organ secretes calcitonin that acts with hypocalcin to regulate calcium metabolism
- Calcitonin is a hormone which lowers blood Ca^{2+} levels
- The gland may also be involved in migration and reproductive behaviour of fishes



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Islets of langerhans or Endocrine Pancreas

- The endocrine pancreas is present in most fish as islet of Langerhans or Brockman bodies
- Islet of Langerhans is present near gall bladder or spleen. In some species the islets are very large and may be grossly visible
- During the spawning season the size and number of islet will increase in some fish
- It consists of 3 types of cells- alpha cells, beta cells and D cells
- A **germ layer**, occasionally referred to as a **germinal epithelium** , is a group of cells , formed during animal embryogenesis



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Endoderm

The endoderm produces tissue within the lungs , thyroid and pancreas

The **endoderm** is one of the germ layers formed during animal embryogenesis

The endoderm consists at first of flattened cells, which subsequently become columnar

It forms the epithelial lining of the whole of the digestive tube except part of the mouth and pharynx and the terminal part of the rectum (which are lined by involutions of the ectoderm)



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Mesoderm

The mesoderm aids in the production of cardiac muscle , skeletal muscle , smooth muscle , tissues within the kidneys , and red blood cells

The **mesoderm** germ layer forms in the embryos of triploblastic animals

During gastrulation, some of the cells migrating inward contribute to the mesoderm



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Ectoderm

The **ectoderm** produces tissues within the epidermis, aids in the formation of neurons within the brain, and constructs melanocytes

The **ectoderm** is the start of a tissue that covers the body surfaces

It emerges first and forms from the outermost of the germ layers



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Neural crest

The corpuscles of stannous (CS) were first observed by H. Stannius in 1839

The corpuscles of stannius are generally small nodular bodies present partly or completely embedded on dorsal or dorso-lateral or ventro-lateral sides of the kidney in teleosts

The number of corpuscles of stannius is variable in different fishes like *Channa*, *mystus*, *Catla*, etc



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Function of corpuscles of stannius

Corpuscles of stannius perform following functions

Presence of renin activity

Osmoregulatory function

Effect on kidney function



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The urophysis (Caudal neurosecretory System)

- Most fish also possess a urophysis, a neural secretory gland very similar in form to the posterior pituitary, but located in the tail and associated with the spinal cord
- The hormones of urophysis are called “urotensins” and four kinds of them are identified
- These are urotensin I, II, III and IV
- These are peptides and all the 4 may not be present in the same fish
- However, urotensin I and II are commonly found in a fish and their release is controlled by the central nervous system



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Urotensin I

Urotensin II

Urotensin III

Urotensin IV



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Gonads

The hypothalamus produces **gonadotropin-releasing hormone (GnRH)**.

Gonadotropin releasing hormone (GnRH) is thought to stimulate the **pituitary**, a small gland located beneath the brain, to produce and release **gonadotropin hormones (GtHs)**. Gonadotropin hormones (GTH) act on the ovaries and testes (**gonads**).



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In fish, sex hormones are produced by the gonads and these control maturation and development of secondary sexual characters

In male fish, hormones are believed to be secreted by the interstitial cells of the testis and these cells are involved in steroidogenesis

LH stimulates the testes to produce several kinds of steroid hormones called **androgens**

LH stimulates the ovaries produce **estrogen** and **progesterone**, the female sex hormones



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Estrogens (AmE), **oestrogens** (BE), or **œstrogens**, are a group of compounds named for their importance in the estrous cycle of humans and other animals, and functioning as the primary female sex hormones

The hormones of the reproductive system of vertebrates (sex hormones) are steroids

In fish, sex hormones are produced by the gonads and these control maturation and development of secondary sexual characters



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LH stimulates the testes to produce several kinds of steroid hormones called ***androgens***

One of these androgens is ***testosterone***

LH stimulates the ovaries produce ***estrogen*** and ***progesterone***



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Gastro-Intestinal hormones

Secretion of gastric and pancreatic juice is regulated by hormones secreted by the intestinal mucosa in mammals and other vertebrates

These hormones are gastrin, secretin and cholecystokinin (CCK)

Salmon and some other teleosts exhibit gastrin like activity in the stomach



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Pineal gland

The pineal gland is a light sensitive neuroendocrine structure that lies in the anterior brain and is a well-vascularized organ

This gland secretes melatonin that may play a role in controlling reproduction, growth, and migration