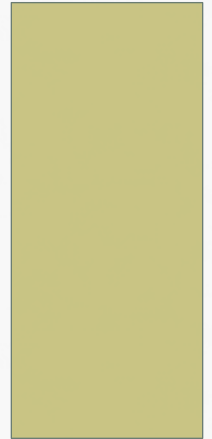


Fish Physiology

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General characters of fish:-

- Fish are cold blooded animals living in water.

- They do not have a **thermo-regulatory center** and their body temperature is dependent on the temperature of their surrounding water

- The aquatic environment differs from the atmospheric environment

(How?)

all elements are present in their dissolved form while in the atmospheric environment they are present in their gaseous form. So fish are anatomically and physiologically adapted to live in aquatic environment.

- The aquatic environment is usually a good media for different microbial and parasitic organisms as well as non-living harmful toxic irritants.

- And fish do not have bone marrow or lymph nodes, the main components of immune system in land animals and man.

- They have **mucus secreting cells** in their skins which secrete mucus containing **IgM immunoglobulin and lytic enzymes**

Regional anatomy of fish:

Three main body regions are easily distinguished grossly including:

1- **Head region** (anterior part)

- **Digestive system**: mouth opening, mouth cavity and pharynx
- **Respiratory system**: gills and gill cover
- **Nervous system**: brain and spinal cord
- **The sensory organs**: eyes, nostrils and barbels in some fish
- Beside some important regions as snout, occiput dorsally and isthmus region ventrally.

2- **Trunk region (middle part)**

Nuchal region (the dorsal surface just behind the occiput), **Breast** (the ventral area just behind the isthmus), **Belly** (the area behind the breast), **Caudal peduncle** (the constricted part separating the trunk from the tail) and the lateral line.

3- **Tail region** (posterior part).

The fish tail is located posterior to the caudal peduncle and is composed of caudal fin.

Function of fins :

1. **Control** the motion and balance of the fish
2. Anal fins has the ability to **modify** for reproduction in some fishes like shark.
3. It **give an indication** about the moods of the fish.
4. **Has an important role in the defense mechanism** as it serve as weapons.
5. **Act** as organ of camouflage.

❖ **The fish has the ability to compensate any loss in their fins in order to control their balance.**

Pancreas

1- Secretes **proteolytic**, **lipolytic** and **amylolytic** enzymes which has great role in digestion.

2- It has endocrine function

The position of the pancreas differ according to fish species, it may be present in the mesentery, along the portal vein or in liver tissue (

Circulatory system:

- Circulation in fish is much slower than other vertebrates.
- The heart is composed of 4 compartments (sinus vinosus, atrium, ventricle and bulbous arteriousus).
- The heart received unoxygenated blood which circulate in gills where gas exchange occurs and then the oxygenated blood is distributed to the different organs.

Excretory organs:

1- **Kidney** : Excrete **urea** and other waste products from the blood via

- Ureter
- Urinary bladder
- Urogenital opening just posterior to the anus.

2- **Gills** : Excrete **urea** and **ammonia**

Absorb or excrete some ions such as **Na, K** and **Cl** by means of **chloride cells which present in the gills.**

Respiratory system

- Most **vertebrates** have **internal lungs** that perform the respiration through the bi-directional flow of the air.
- **In contrast** most fish have external respiratory organ (gills) that are ventilated by unidirectional flow of the water.
- **Other Fish species** could **obtain oxygen** from aquatic environment **through skin** (some scaleless fish) and **through lung** (African lungfish).

Structure of gills :

- Gills are arranged in rows on both sides of the head
- The gill is formed of :

1. **Gill arch** → they are 4 in each side and each one bears 2 rows of gill filaments.
2. **Gill filaments** → arranged one above the other and water pass in between and they are abundantly supplied with blood. The upper and lower surfaces of each filament is folded into secondary folds (lamellae) where gas exchange takes place.
3. **Gill raker** → adapted according to the type of food; hair like and fine in fish eating fine food but widely separated and coarse in carnivorous fish.
4. **There are small adductor muscle** in the septa of gills that contract and draw the filaments of each branchial arch closer from each other and enlarge the slit.

Mechanism of respiration :

- **At the starting of inspiration** → the mouth is opened and various muscles contract as well as gill covers is closed so the mouth cavity enlarged → negative pressure is created → water drawn into the mouth.
- **After little time**, the space between gills and operculum is enlarged **because** the gill covers are abducted anteriorly while the opercular skin flaps are still closed posteriorly by the outside water pressure → create negative pressure in the gill cavity and together with pressure pump of oral cavity that resulted from closure of oral opening and reduction of the volume of oral cavity → the water moves over the gills in opposite direction of blood flow in gill filaments (gas exchange). → then the water accumulated in the opercular cavity → ↑ opercular pressure till exceeds the outside water pressure → water moves

Gas bladder :

- It is thin walled sac lying in the dorsal part of the body cavity.
- It contains mixture of oxygen, nitrogen and CO₂ which are secreted from either special structure in the bladder wall or gas gland.
- It may have an opening to anus, oesophagus, stomach and middle ear.

Function

- Act as accessory breathing organ in some fish species.
- Has hydrostatic function as it brings the overall density of the fish closely to that of the surrounding water.
- Sound production and perception.

Blood and water flow patterns in gills (countercurrent exchange system) :

- The **blood in the gill capillaries** flows in the opposite direction from the water in the adjacent channels.
- Dissolved gases diffuse faster between fluids with a large difference in gas concentration (a high concentration gradient) than between fluids with only a small difference.
- In the fish gill, low-oxygen blood enters the capillaries which is thus relatively low in oxygen. As blood travels in the direction opposite to the water, it encounters "fresher" water with ever-higher oxygen concentrations. Thus, along the capillary, a steep diffusion gradient favors transfer of oxygen into the blood.

Oxygen as an environmental factor for fish respiration :

➤ **Source of oxygen :** water oxygen is derived either from atmospheric O₂ or photosynthesis of water plants.

➤ **Solubility of O₂ :** It is much lower than its solubility in air and affected by :

Temperature : ↑ temperature → ↓ solubility.

Salinity : ↑ salinity → ↓ solubility.

Pollution : ↑ pollution → ↓ solubility.

CO₂ : ↑ CO₂ → ↓ solubility as CO₂ is 25-30 times more soluble than O₂

➤ **O₂ requirement of fish :** The metabolic rate in fish is lower than

Osmoregulation

- It is the active regulation of osmotic pressures of an organism's fluid in order to maintain homeostasis of the water content.

- Osmoregulation is so **important** because too much water in animal cells can cause them to burst, while too little water can lead to dehydration and death.

In order to maintain a proper balance of water and solutes (homeostasis), organisms depend on excretion (removal of metabolic wastes) via organs, such as the skin and the kidneys.

- Osmosis is the diffusion of water from an area of high concentration to an area of low concentration. Cell membranes are permeable to water, so water enters and exits cells by osmosis.

Osmoregulation

- If two solutions are separated by a semi-permeable membrane and they have the same osmolarity (osmotic pressure), they are said to be isoosmotic and there will be no net movement of water to one side or the other.
- If one side of the membrane has higher solute concentration than the other side, it is called hyperosmotic. The side with fewer solutes is called "hypoosmotic". The hyperosmotic solution has higher osmotic pressure and higher osmolarity so water will move from the hypoosmotic side to the hyperosmotic side.

Osmoregulation

Two major types of osmoregulation :

Osmoconformers:

- ✓ They are organisms that are isoosmotic, meaning their internal osmotic pressure is equal to the osmotic pressure of the environment.
- ✓ Most marine invertebrates are osmoconformers although their ionic composition may be different from that of sea water.
- ✓ Osmoconformers do not actively exchange solutes with the environment, but keep their body fluids isoosmotic to the external environment by actively regulating their internal concentration of amino acids, ions, and proteins to match the osmolarity of the environment.

Osmoregulation

Two major types of osmoregulation :

Osmoregulators :

- ✓ **They** are tightly regulate their body osmolarity, which always stays constant, and are more common in the animal kingdom.
- ✓ Osmoregulators actively control salt concentrations despite the salt concentrations in the environment.
- ✓ Osmoregulators maintain internal water balance by discharging water in a hypoosmotic environment and taking in water in a hyperosmotic environment. This enables them to live in freshwater

Freshwater fish

- Fresh water fish live in hypo-osmotic environments and must osmoregulate.
- Water tends to diffuse into the fish through the gill membrane into the blood.
- Thus, the fish drink very little water and expel copious amounts of water in very dilute urine.
- The gills also are permeable to respiratory gases, ammonia, waste products and ions. Therefore, while water moves toward the higher osmotic pressure, sodium and chloride ions diffuse out of the fish. Thus, fresh water fishes must have energy to regulate this ion loss and fluid uptake.
- In this case, fresh water fishes retained solute ions from the food they eat, and they also actively transport salts into the body through the gills. Specialized chloride cells move the chloride in the opposite direction (in) from outside where the cells in marine fish move chloride (out).

Marine fish :

have the opposite situation of fresh water fish as their bodies are hypotonic to their saltwater environment so it tends to lose water and gain

Reproduction in fish

❖ There are three types of reproduction

1- Bisexual reproduction: Is the prevalent type and in which sperms and eggs develop in separate male and female individuals

2- Hermaphroditic: both sexes are present in one individual and self fertilization occurs. This is prevalent in salmonids species.

3- Parthenogenesis : the young developed without fertilization. In this case, mating is also required and the sperm only allow the eggs to develop and not participate in heredity and the resulting Youngs are always females which is prevalent in some tropical fishes.

Reproduction in fish

Female reproductive organs :

Ovary :

- There are 2 ovaries in the fish and vary in structure from simple clusters of ovarian follicles to a very complex organs which not only produce eggs but also give young fry (viviparous).
- Ovary is hollow sac (cystovarian) or solid body (compact).
- There are layers of follicular cells surround each oocyte during its early development.
- With growth of oocytes, these cells increase and form a continuous follicular layer (granulosa cell layer) that secretes estrogen and after ovulation, it makes phagocytosis of yolk and could be transformed into Oogonia.
- The outer connective tissue stroma form a distinct outer

Reproduction in fish

Female reproductive organs :

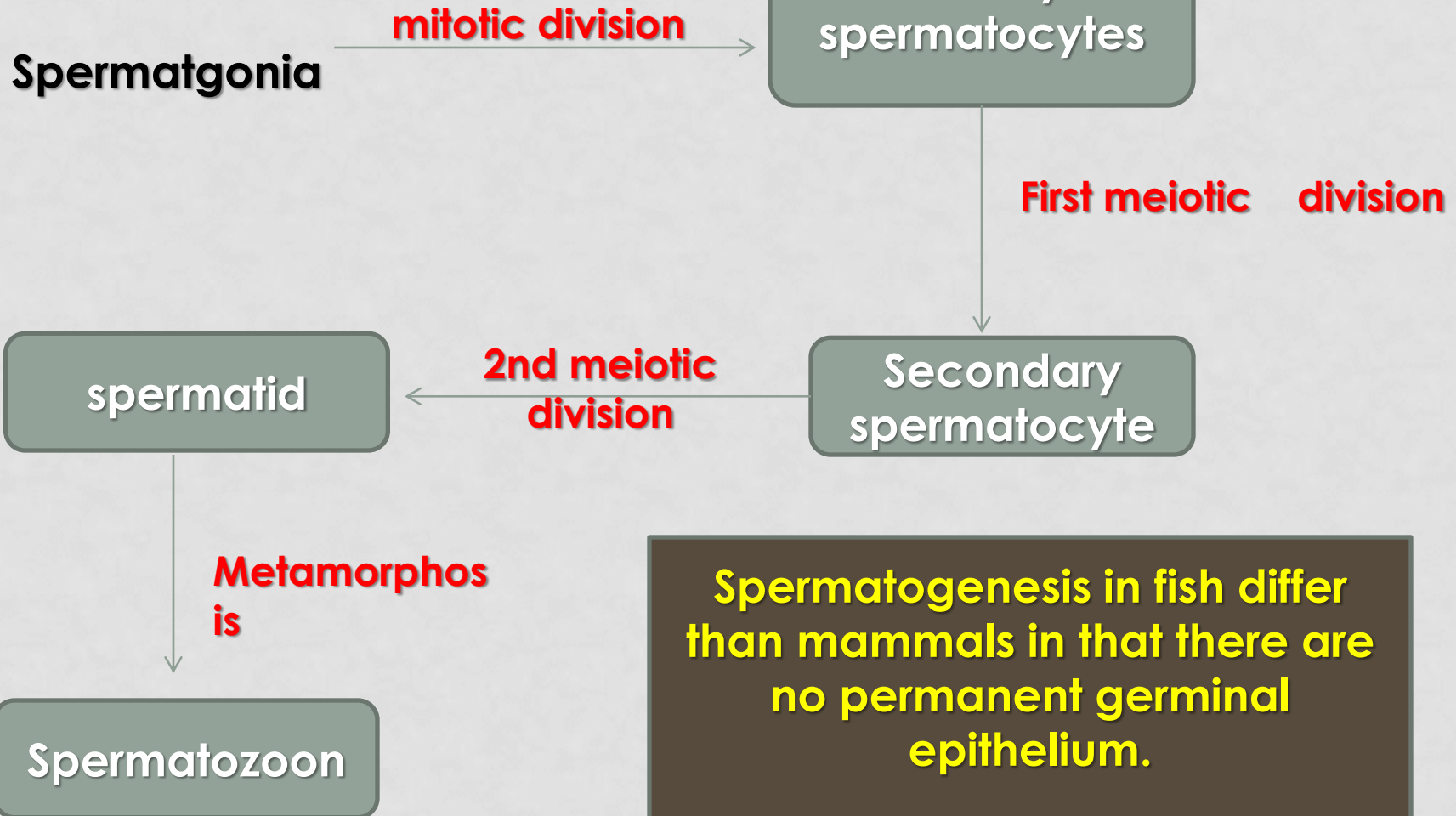
Ovary :

- **In oviparous**, fertilization occurs externally as the female deposit the eggs during spawning and the male release milt on the eggs.
- **In ovoviviparous** fish, the mature eggs are fertilized internally and the young are retained for some or all embryonic development period.
- **In viviparous fishes**, viable sperms are stored for long period in localized expansions of the epithelium of ovarian cavity overlaying each developing oocytes to form "delle" a specialized seminal receptacle into the ovarian cavity. The delle terminate directly on the follicle to allow the sperms to access to the oocyte during fertilization.

Reproduction in fish

Sexual maturation: It means the increase of gonadal activity and may start before time of maturation.

❖ Spermatogenesis



Reproduction in fish

❖ Oogenesis



- Then the oocytes enter a period of growth which varies from species to another.
- These stages named; chromatin nuclear stage, perinuclear stage, yolk vesicle stage, yolk globule stage, yolk granule stage, maturation stage and spent ovary stage.

Reproduction in fish

❖ Vitellogenesis (yolk formation) :

- Vitellogenin is a female specific phosphoglycolipoprotein complex that synthesized in liver under the effect of estrogen and combined with calcium.
- It is released in circulation and incorporated into growing oocyte under the effect of gonadotropins.

Hormonal control of vitellogenesis:

1- Estrogen :

- It elevates in blood of fish till the vitellogenesis is completed and then decline
- It increases blood calcium, protein, lipids and protein pound phosphorus which are precursor for vitellogenin and it also stimulates the liver to synthesize it.

2- Pituitary hormones :

- Stimulate incorporation of yolk into the oocytes
- Bind with the ooplasm of yolk oocytes and stimulate incorporation of vitellogenin
- Regulate gonadal mitosis
- Stimulate growth of vitellogenic oocytes and lipid uptake by the ovary.
- Increase plasma concentration of triglyceride and cholesterol which are mobilized to the liver by the effect of estrogen.

Reproduction in fish

❖ Ovulation

- Release of the ova from the follicles into the ovarian or peritoneal cavity and this occurs after the meiotic division.
- Ovulation begins by follicular cell separation till formation of holes in the follicular layer then, by active contraction of the theca resulting in expulsion of the ova outside.
- Ovulation is controlled by gonadotropins and PF2α.

Reproduction in fish

Fertilization : Union of male and female pronuclei in fish



Internal
(Ovoviviparous
and viviparous)

External
(Oviparous)

External fertilization :

- Occurs when the **eggs and spermatozoa are close from each other.**
- The male and its conspecific female must be synchronized in order to discharge of gametes.
- The spermatozoa retain **its fertilizing capacity for 1-2 minutes** in fresh water and **for longer period** in salt water and they remain immotile in the fish body by substances secreted from male genitalia.
- The mature egg of fish is surrounded by **vitelline membrane, perivitelline space** (filled with colloidal substance which transformed into hard substance on exposure to water) **and capsular membrane.**
- After fertilization, the capsular membrane is lifted and water moves to the perivitelline space that form a

Internal fertilization:

- Internal fertilization is common among cartilaginous fish and few species of teleosts.

a- Cartilaginous fish : as shark.

The pelvic fin is modified to form copulatory organ which is erectile and vascular tissue

b- bony fish (teleosts) : the copulatory organ is usually an enlarged genital papillae or a specialized anal fin.

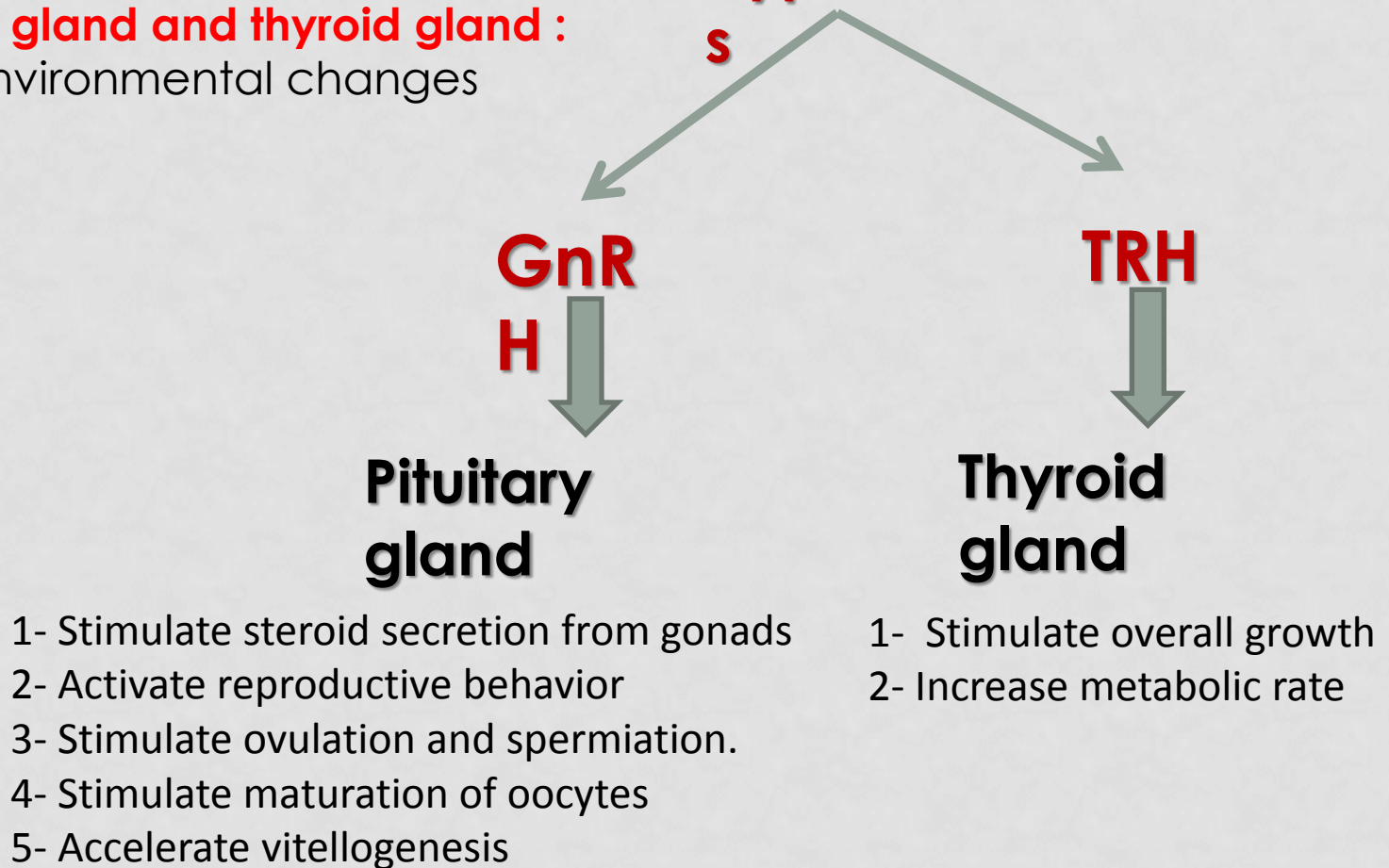
Factors controlling reproduction in fish

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A- Endogenous (hormonal) factors

1- Pituitary gland and thyroid gland :

Suitable environmental changes



Factors controlling reproduction in fish

:

2- Estrogen :

It is produced from granulosa cell layer and probably from theca layer in some species.

Function : 1- Stimulate vitellogenesis.

2- Accelerate secondary sex characters.

3- Testosterone :

1. Stimulate spermatogenesis.
2. Stimulate testicular development
3. Accelerate secondary sex characters.
4. In female, stimulate final maturation.

4- progesterone and corticosteroids (MH) :

1. Stimulate maturation and ovulation in females.
2. In male, they stimulate spermiation.

5- Prostaalandin F2a :

Factors controlling reproduction in fish

:

B- Exogenous factors :

1- Light : Light (stimulus) → pineal gland (has photoreceptors) → transmit the impulses via pineal stalk which contain nerve fibers → the brain.

2- Temperature : Has great role on poikilothermic animals as fish
It control the general metabolism of the body.
Has a direct effect on gonadotropin secretion,
Has great role on metabolic clearance of hormones
Increase the responsibility of target organs to hormones.

3- Feeding :

Good quality and quantity of nutrition especially protein, phospholipids, calcium and phosphorus which elevate the general metabolism and also their importance as a constituent of milt or eggs.

4- pollutant :

Thanks