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Excretion

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Introduction

The primary excretory organ in fishes as in other vertebrates is the kidney.

In fishes some excretion also takes place in the gills where the waste materials produced during metabolism are given off.



Excretory System Functions

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Collect water and filter body fluids.

Remove and concentrate waste products from body fluids and return other substances to body fluids as necessary for homeostasis.

Eliminate excretory products from the body.



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Structure of the kidney

A pair of kidneys lies above the alimentary canal close to the vertebral column.

In teleosts, the kidneys are elongated structures usually divided into 2 parts called the head kidney and the trunk kidney.

Type I: 2 kidneys are completely fused and there is no distinction between head and trunk part of the kidney.



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- **Type II:** Head and trunk regions of the kidneys are clearly demarcated as they are fused in the middle and posterior regions only.
- **Type III:** The kidneys are fused in the posterior region only and the head and trunk portions are clearly demarcated.
- **Type IV:** Only the extreme posterior parts of the kidneys are fused.
- **Type V:** There is no fusion and the kidneys are completely separate.



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- Kidneys of type I, II, III are usually seen in freshwater teleosts.
- Kidneys of type II are seen in the Cyprinidae in which the middle and posterior parts are fused.
 - In the carps, as *Labeo*, *Cirrhinus* and *Barbus* the trunk kidney (Fig) is broad in the middle and becomes narrow in the posterior part.
 - Each kidney has a mesonephric duct (opisthonephric duct) running along its outer border.



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A kidney is composed of a large number of tubules or nephrons, which develop first in the anterior region of the trunk and proceed posteriorly.

- The collection of nephrons constitutes the kidney.
- During development in fishes a pronephros is replaced by mesonephros (opisthonephros), which opens into the nephric duct called the opisthonephric duct.



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- Fish kidney consists of a large number (hundreds to 10,000) of tubular nephrons or uriniferous tubules each of which produces urine.
- Each nephron is made up of or consists of renal corpuscle or malpighian capsule and the tubule.
- A typical nephron of freshwater teleosts is called glomerular nephron and generally consists.
- A renal corpuscle containing a well developed vascularized glomerulus.



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A ciliated neck region connecting the corpuscle with the tubule.

In the marine teleosts, the distal segment is probably absent.

In the freshwater teleosts, the kidney has a large number of renal corpuscles each containing a highly vascular glomerulus, hence called glomerular nephron.



Mechanisms of excretion/ function

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The primary function of the kidney tubule is to remove excess of water, salts, waste material and foreign substances from the blood.

For this blood, is filtered under high pressure through the glomerulus and the Bowman's capsule which work as ultra filters.

Glomerulus is composed of a leaky capillary endothelium, a fine porous basement membrane and the epithelium of the Bowman's capsule.



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During ultrafiltration under arterial blood pressure, inorganic ions, organic molecules, glucose, urea, amino acids are filtered into the tubule.

The kidney of freshwater fishes is often larger in relation to body weight than that of marine fishes

In both groups the kidney excretes wastes from the body, but that of freshwater fishes also excretes large amounts of water, counteracting the water absorbed through the skin.



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- Kidney in freshwater fishes also serves as an excretory organ for nitrogenous compounds such as creatine and uric acid.
- Thus copious urine, 5-12% of body weight/day is produced in freshwater fishes.
- In marine teleosts, the kidney performs the function of removing magnesium and sulphate ions along with Na, Cl, K and Ca.
- Trimethyl amine oxide (TMAO) is also excreted but only traces of ammonia and urea.



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The gills perform the function of main organs of excretion removing ammonia and urea along with carbon dioxide.

Marine fishes excrete common marine salts via the salt excreting glands located on the lamellae of the gills while in the freshwater fishes it is through kidney.

Freshwater fishes drink very little water and take in little water in their food.



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In many higher crustaceans (decapods) the excretory glands are located in the head.

They are called antennal glands or maxillary glands, depending on whether they open at the base of the antennae or at the maxillae.

The two glands are probably never functional together in the same animal, though one may replace the other in the course of development.



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If the tubule adjacent to the excretory pore is green, the gland is called a green gland or **nephridia**.

Crustaceans excrete through **nephridia** or **green glands**. Nephridia are invertebrate organs which occur in pairs and function similar to kidneys.

They remove metabolic wastes from an animal's body.



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They serve 2 functions, osmoregulatory and excretory.

A **metanephridium** is a type of excretory gland or nephridium found in many types of invertebrates such as Annelids , Arthropods and Molluscs.

Most insects and spiders have a excretory system called **Malpighian tubes** which collects liquid wastes in the gut.



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Wastes are crystallized and then excreted to reduce weight for flight.

Malpighian tubules filter the uric acid and other nitrogenous waste out of the blood in the hemocoel, and dump these materials into the hindgut, from which they are expelled as feces.

Most aquatic arthropods and some terrestrial ones also have organs called nephridia ("little kidneys"), which extract other wastes for excretion as urine.



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Mollusca

- The anatomical form of the renal gland varies from one class of molluscs to another, but a common plan is clearly evident.
- Like most other molluscs, the excretory organs of bivalves are nephridia.
- There are two nephridia, each consisting of a long, glandular tube, which opens into the body cavity just beneath the heart, and a bladder.
- Blood is forced through the walls of the heart into the pericardium. From there it passes into the kidneys where wastes are removed, producing urine.



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Chapter 4. Osmoregulation

Definitions

Most *marine invertebrates* have body fluids with the same osmotic pressure as the sea water; they are isosmotic or isosmotic.

One way is to change the osmotic concentration of its body fluids to conform with that of the medium, thus remaining isosmotic with the medium; such an animal is an osmo-conformer.



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The other way is to maintain or regulate its osmotic concentration in spite of external concentration changes; such an animal is called an *osmoregulator*.

Fresh-water animals have body fluids that are osmotically more concentrated than the medium; these animals are *hyperosmotic*.

Some aquatic animals can tolerate wide variations in the concentration of the water in which they live; they are called euryhaline animals.



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A marine animal that can penetrate into brackish water and survive is euryhaline.

An extremely euryhaline animal may even be able to tolerate shorter or longer periods in fresh water.

There is no sharp separation between euryhaline and stenohaline animals.



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Osmoregulation

Osmoregulation is a physiological activity for proper maintenance of water and salt balance of the body tissues in fishes, whether they live in fresh, marine or brackish waters.



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Osmoregulatory problem in freshwater fishes

Animals such as invertebrates, fishes, amphibians, reptiles and mammals that live in freshwater are osmoregulators.

Their body fluids ($1/3^{\text{rd}}$ of the concentration of seawater) have a greater concentration than their surrounding environment (**hyperosmotic**).

Skin has low permeability to water and salt ions, hence very little water is allowed to enter the body or salt to diffuse out through it.



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To counter the continuous inflow of water through gills, freshwater fishes produce a large amount of dilute urine.



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Osmoregulatory problem in marine fishes

Marine fishes experience just the opposite effect in comparison to freshwater fishes because their internal salt content is less than that of the surrounding water.

Marine teleosts are **hypoosmotic** (body fluids 1/3 of that seawater) and live in a medium ing high concentration of salts.

marine fish has an internal osmotic concentration lower than that of the surrounding seawater, so it tends to lose water and gain salt.



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It actively excretes salt out from the gills.

Marine fishes are faced with the problem of continuous loss of water and gain salts.

As marine fish drinks seawater and Na and Cl ions are actively absorbed through the gut.

Many species are reported to drink water >25% of their body weight/day, of which 80% is absorbed.



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This excess of salt ions is excreted out into the water by the special cells in the gills, oral membrane and inner surface of the operculum.



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Osmoregulatory problem in chondrichthyes or elasmobranchs

The chondrichthyes maintain osmotic concentration of blood nearly at the same level as that of seawater (**isoosmotic**) and are not in danger of dehydration and do not drink seawater

This is achieved by retaining nitrogen containing compounds, mainly urea and trimethylamine oxide (TMAO) in the blood, which is slightly hyperosmotic to seawater.



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The gills of chondrichthyes are impermeable to urea so that it is retained in the blood in large quantity to raise the osmotic concentration of blood to a slightly higher level than seawater.

The osmotic balance in these fishes is maintained by retention of high level of urea in the blood.

Whereas, freshwater sharks have a lowered concentration of urea in the blood.



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Rectal gland is a structure found in marine elasmobranchs which helps in osmoregulation by excreting NaCl.



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Migratory fish are hyperosmotic to their environment during some periods and hypoosmotic at other times.

To complete their life cycle, amphihaline fishes show remarkable adaptation in being able to migrate from the sea to freshwater bodies or vice versa.

They have to survive in 2 different environments for the sake of their progeny.



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One lives in seawater, grows there and after becoming reproductively mature starts migrating to breed in riverine or land locked freshwater.

The young born in freshwater migrate into seawater and live there until they are in turn mature and ready to spawn in freshwater.

These fish eg. Salmon and hilsa are known as amphihaline potemotocous.



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The young salmon, which is born in freshwater spends several years in these surroundings and undergoes important morphological, biochemical and physiological modifications before undertaking downstream migration to marine feeding grounds.