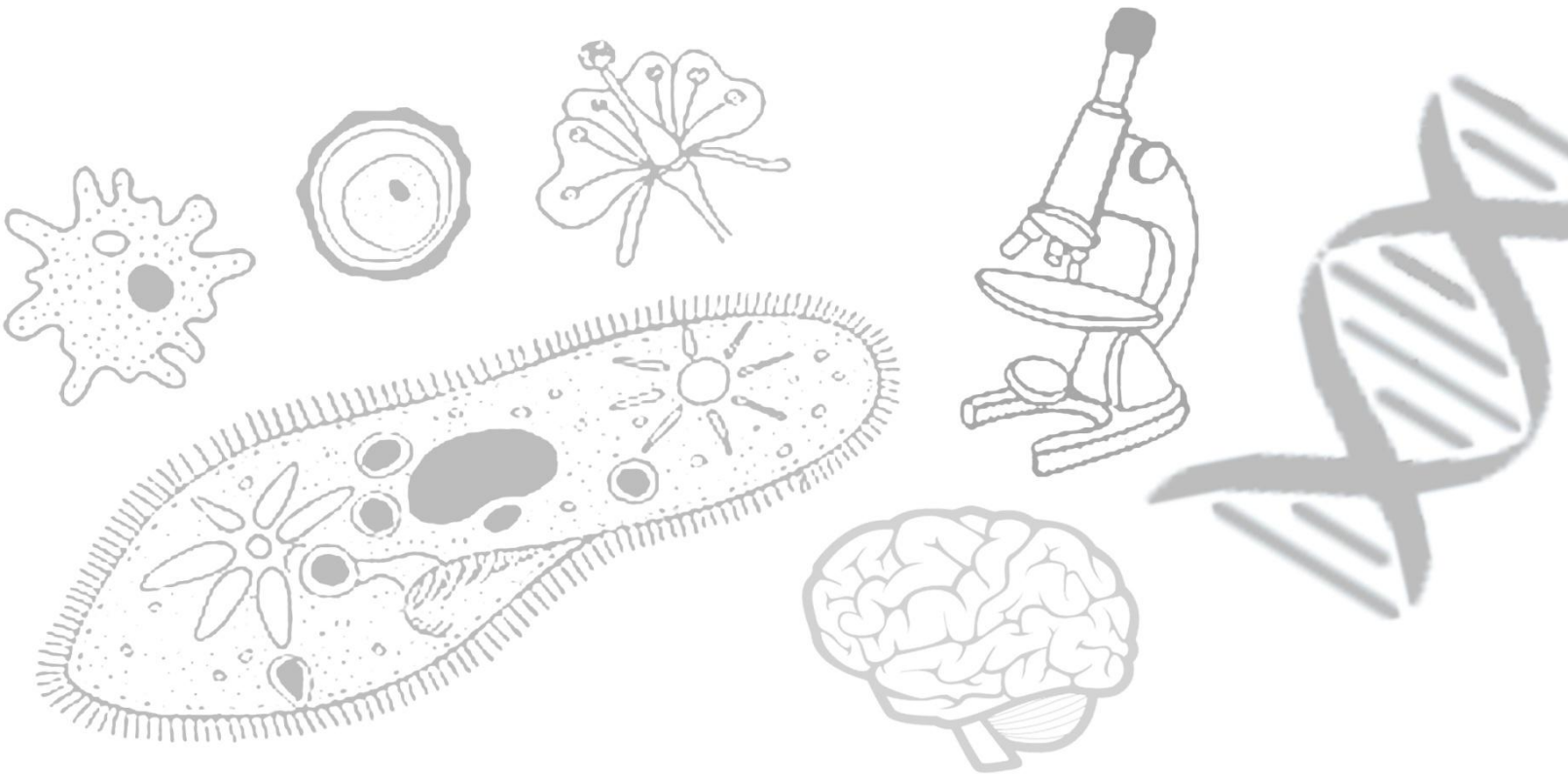
Chapter Notes

BIOLOGY



Modes of Excretion, Human Excretory System

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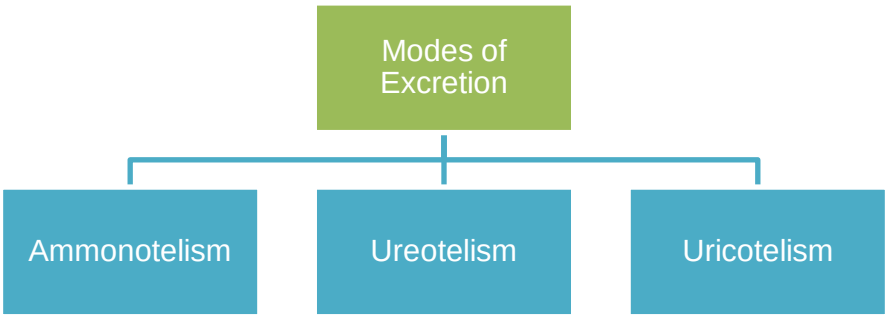
Modes of Excretion

- **Excretion** is the process by which living organisms get rid of the waste substances either totally or partially accumulated during metabolic activities.
- **Nitrogenous waste products** are substances which contain nitrogen and are produced during the metabolism of proteins and amino acids.
- **Major forms of nitrogenous wastes** excreted by animals are **ammonia**, **urea** and **uric acid**.
- Depending on the nature of the nitrogenous compound being excreted, animals exhibit three modes of excretion:



Ammonotelism

- Excretion of **ammonia** is called **ammonotelism**.
- Animals excreting ammonia as a major excretory product are called **ammonotelic animals**.
- **Formation of ammonia:**
  - By oxidative deamination of excess of amino acids.
- **Nature of ammonia:**
  - It is the basic metabolic waste of proteins.
  - It is highly toxic; hence, it cannot be retained in the body for a long time.
  - It is highly soluble in water.
  - It can diffuse across the body surface easily.

DID YOU KNOW ?

About 300–500 ml of water is required for the excretion of one gram of ammonia.

- **Ammonotelic animals:**
  - Protozoans, sponges, jelly fish, crustaceans, aquatic insects, bony fish and aquatic amphibians are ammonotelic animals.
  - In sponges and coelenterates, ammonia is excreted from the general body surface.
  - In fish, ammonia is excreted by the gills.

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Ureotelism

- Excretion of **urea** is called **ureotelism**.
- Terrestrial adaptation necessitated the evolution of ureotelic animals.
- Animals excreting urea as the major nitrogenous waste are called **ureotelic animals**.
- **Formation of urea:**
  - Urea is synthesised in liver cells by the **ornithine cycle** or **urea cycle**.

DID YOU KNOW ?

The ornithine or urea cycle is also known as the Krebs–Henseleit cycle after Hans Adolf Krebs and Kurt Henseleit discovered the process of urea formation and published their discovery.

  - Two molecules of ammonia combine with one molecule of CO_2 to form one molecule of urea.

$$2NH_3 + CO_2 \rightarrow \underset{\text{Urea}}{CO-NH_2} + H_2O$$

- **Nature of Urea:**
  - Urea is less soluble in water than ammonia.
  - It is less toxic than ammonia.
  - It can be retained in the body for some time and can be excreted slowly.
  - Urea is always excreted partially and some amount is retained in the kidneys for osmoregulation.

DID YOU KNOW ?

❖ One gm of urea requires about 50 ml of water for its excretion.

- **Ureotelic animals:**
  - It is observed in terrestrial and semi-terrestrial animals.
  - Frogs, toads, mammals, cartilaginous fish, turtle, aquatic reptiles and mammals are ureotelic animals.

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Uricotelism

- Excretion of **uric acid** as a nitrogenous waste is called **uricotelism**.
- Animals excreting uric acid as the major nitrogenous waste are called **uricotelic animals**.
- **Formation of uric acid:**
  - It is formed from ammonia, adenine and guanine (purines).
  - Its formation requires energy.
  - In humans, purines are first converted into xanthine which then changes into uric acid.
  - In insects, uric acid is formed in Malpighian tubules.
- **Nature of uric acid:**
  - It is the least soluble in water.
  - It is less toxic as compared to ammonia and urea.
  - It is excreted as a solid waste in the form of pellet or paste with a minimum loss of water.

DID YOU KNOW ?

One gm of uric acid requires only 10 ml of water for its excretion.

Aminotelism

- **Amino acids** are excreted without any metabolism.
- All echinoderms and certain molluscs are **aminotelic animals**.

Guanotelism

- **Guanine** is the main nitrogenous waste.
- Spiders, scorpions, lizards and certain birds such as gannets, cormorants and pelicans are **guanotelic**.

Gannets

Cormorant

Pelican

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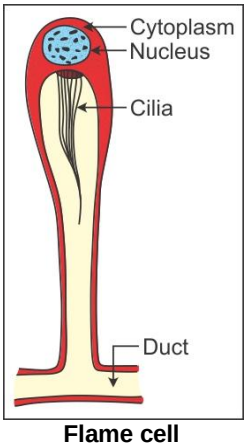
Organs of Excretion

- Organs which are associated with excretion are called **excretory organs**.
- The animal kingdom presents a variety of excretory structures.

Animal group	Excretory structures
1. Protozoans	• In protozoans, nitrogenous wastes are excreted with the help of the **contractile vacuole**. • Contractile vacuoles are spherical; they collect excess fluid from the protoplasm which empties into the surrounding medium periodically.
2. Sponges	• Ammonia is excreted through the body surface by the water current.
3. Coelenterates	• Waste is excreted by the simple diffusion through the body surface.
4. Platyhelminthes	• Protonephridia or flame cells.  **Flame cell** • The lumen of each flame cell has a bunch of constantly beating cilia. • They are mainly concerned with osmoregulation.
5. Annelids	• Nephridia remove nitrogenous waste and water from the coelomic fluid. • The waste is either discharged or sent to the alimentary canal. • They help in the maintenance of ionic and fluid balance.
6. Arthropods	• Green glands in prawns. • Maxillary glands in scorpion. • Malpighian tubules in insects.
7. Molluscs	• Renal organ or kidney. • It discharges the excretory fluid into the mantle cavity. • From the mantle cavity, the excretory fluid is thrown out with the water current.
8. Echinoderms	• Ammonia is excreted by diffusion through the thin walls of tube feet and dermal branchiae.

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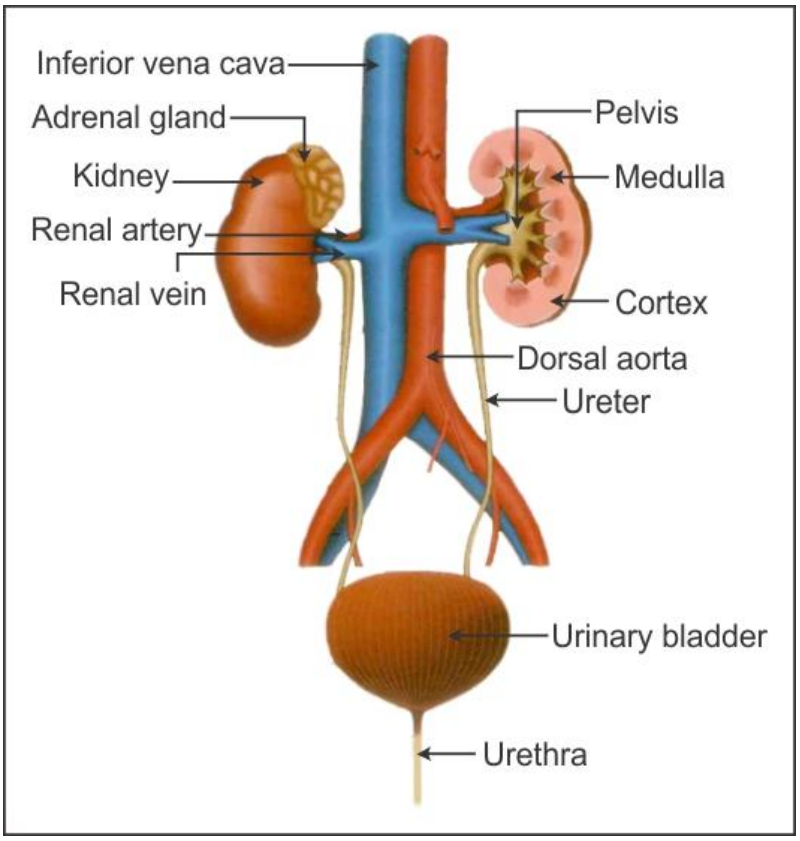
Human Excretory System

- **The human urinary system consists of**
  - Pair of kidneys
  - Pair of ureters
  - Urinary bladder
  - Urethra



Human Urinary System

Parts of the Human Excretory System	Description
1. Pair of kidneys	• Dark red, bean-shaped. • Kidneys are located on either side of the vertebral column, between the levels of the last thoracic and third lumbar vertebra close to the dorsal inner wall of the abdominal cavity. • The kidneys are attached to the abdominal wall by peritoneum called **mesorchium**. • Each kidney measures 10–12 cm in length, 5–7 cm in width and 2–3 cm in thickness. • Each kidney on an average **weighs 120–135 gm** in **adult females** and **150–170 gm** in **adult males**. • The outer layer of the kidney is tough and called **capsule**.

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	• The right kidney is slightly lower in position because of the presence of the liver. • The renal artery supplies oxygenated blood to the kidneys. • The renal vein takes away deoxygenated blood from the kidneys.
2. Pair of ureters	• Ureters are tube-like structures which arise from the notch, i.e. **hilum** of each kidney. • The ureters connect behind with the urinary bladder. • Each ureter is 28–30 cm long. • The ureters carry the urine produced to the urinary bladder. • At its distal end, valves are present which prevent the backflow of the urine into the ureters when the bladder contracts.
3. Urinary bladder	• Muscular sac-like structure. • It stores urine temporarily. • Its opening is guarded by muscular sphincters. • The sphincters open at the time of micturition (urination).
4. Urethra	• Short muscular tube which expels urine out of the body. • In males, the urethra is long. • In females it is very short. • In males, the urethra transports urine and semen. • The opening is guarded by sphincters which open at the time of urination.

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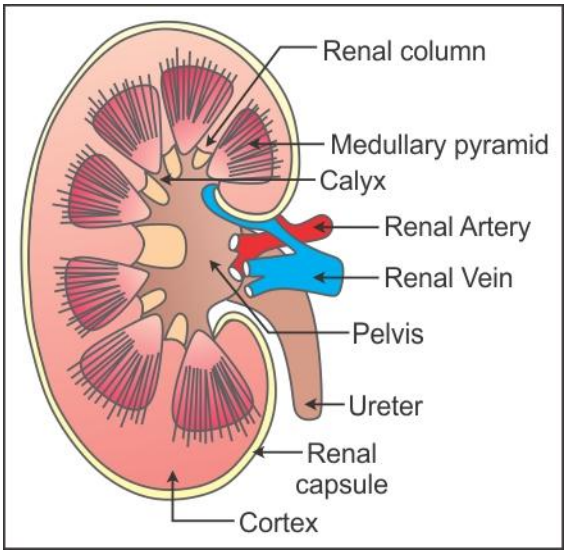
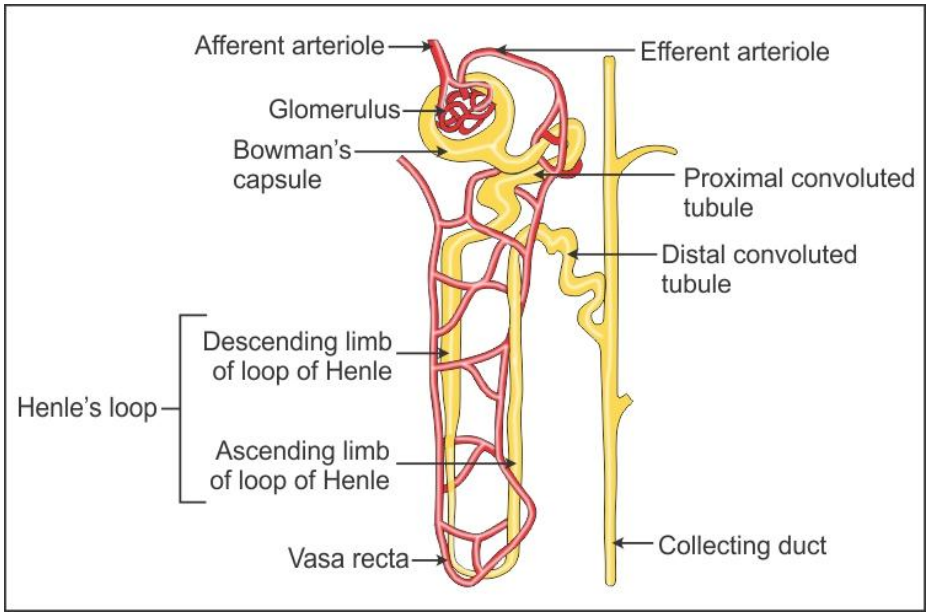
Internal Structure of the Kidney (L. S.)



L. S. of the Kidney

- The inner concave surface of the kidney has a notch called **hilum**. Ureters, blood vessels and nerves enter the kidney through the hilum.
- The hilum extends into a flat, funnel-shaped region called the **pelvis**.
- The longitudinal section of the kidney shows two regions—an outer dark **cortex** and an inner lighter **medulla**.
- The medulla is composed of conical **renal pyramids** or **medullary pyramids**.
- Medullary pyramids project into calyces.
- The cortex extends in between the renal pyramids. These extensions are called **columns of Bertini**.
- The apex of each pyramid, i.e. **papilla**, projects into the pelvis.

Uriniferous Tubule



Uriniferous Tubule

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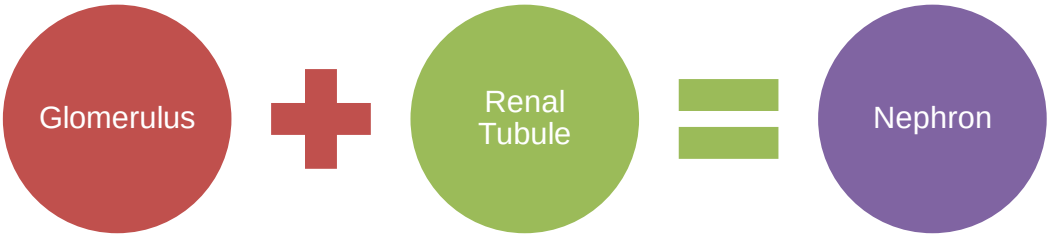
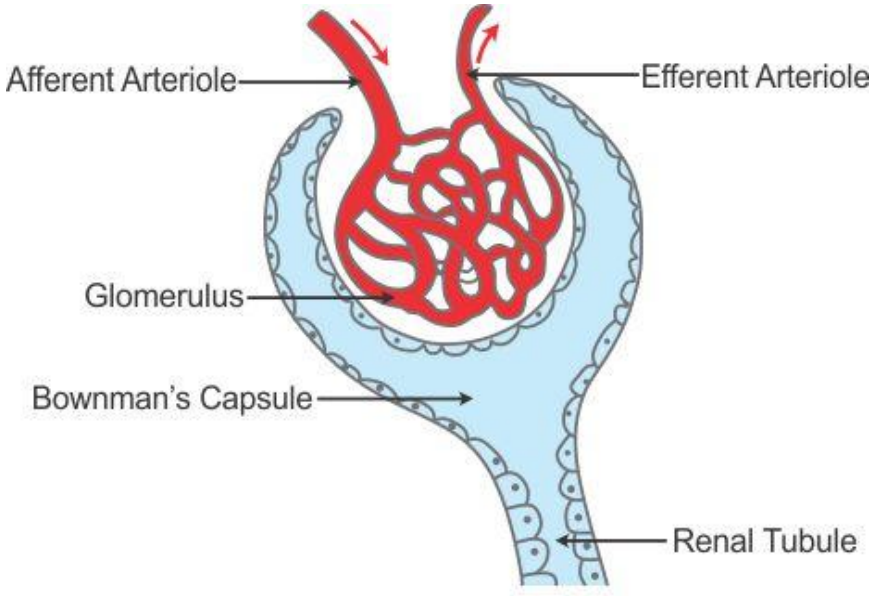
- A kidney is composed of an enormous number of **uriniferous tubules**.
- They are also known as **nephrons** or **renal tubules** or **kidney tubules**.
- Uriniferous tubules are the structural and functional units of the kidney.
- Each kidney is formed of about 1 million nephrons.
- Nephrons are held together by a connective tissue.
- There are two types of nephrons:
- Each nephron is made of a glomerulus and a renal tubule.





Malpighian Tubule

A. Glomerulus:

- It is a **tuft of anastomosing blood capillaries** formed by the fine branches of the **afferent arteriole**.
- These capillaries of the glomerulus again unite to form the **efferent arteriole**.
- The afferent arteriole is wider than the efferent arteriole.
- The afferent arteriole brings blood into the glomerulus, while the efferent arteriole collects blood from the glomerulus.

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B. Renal Tubule:

- The renal tubule comprises the following regions:

Bowman's Capsule	Proximal Convoluted Tubule (PCT)	Loop of Henle	Distal Convoluted Tubule (DCT)
• The Bowman's capsule lies in the **cortex**. • It is a thin double-walled, cup-like depression. It is the blind end of the nephron. • The glomerulus is located in the concave depression of the Bowman's capsule. • The Bowman's capsule and the glomerulus together are called **Malpighian Capsule** or **Renal Capsule**. • The outer layer of the Bowman's capsule is made of flattened epithelial cells. • The inner layer is in close contact with the glomerulus and bears special cells called **podocytes**. • Podocytes have many feet-like processes called pedicels and minute slit-like pores called **slit pores**.	• PCT lies in the **cortex**. • It is also known as the **first convoluted tubule**. • The Bowman's capsule continues into the PCT. • It is lined with a layer of columnar epithelial cells. • The columnar cells are with numerous microvilli to increase the surface area of absorption.	• It lies in the **medulla**. • It is U-shaped. • It is not convoluted. • It has a descending limb and an ascending limb. • Each limb has a thick region towards the cortex and a thin region towards the medulla. • Thick regions are lined with columnar epithelial cells. • Thin regions are lined with flat epithelial cells.	• It lies in the **cortex**. • Its short terminal part is called a **collecting tubule**. • The collecting tubule opens into the **collecting duct**. • DCT in lined with ciliated columnar epithelial cells. • The **collecting duct** receives the contents of many renal tubules.

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- The **collecting duct** is a larger duct which receives collecting tubules of several nephrons.
- Collecting ducts pass into the renal medulla and join with each other to form the **ducts of Bellini**.
- The ducts of Bellini run through the renal pyramids and open into calyces.
- All calyces open into the pelvis.
- From the pelvis, urine is carried to the urinary bladder through the ureters.

Types of Nephrons

Cortical Nephron	Juxtamedullary Nephron
• 85% of nephrons are cortical nephrons.	• 15% of nephrons are juxtamedullary nephrons.
• The Malpighian body, PCT and DCT of these nephrons are situated in the cortex.	• Glomeruli lie at the centre of the cortex and medulla.
• Loop of Henle is too short and extends very little into the medulla.	• Loop of Henle is long and lies in the medulla.
• These nephrons control the plasma volume when water supply is normal and no water conservation is required.	• The efferent arteriole emerging from the glomerulus forms a fine capillary network around the renal tubule called the **peritubular capillary network**.
• Vasa recta is highly reduced or absent.	• A minute vessel of this network runs parallel to the loop of Henle forming U-shaped vasa recta.
-	• Plasma volume is controlled when water supply is very less and conservation of water is required.

Blood Supply to the Kidneys

Dorsal aorta → renal artery → afferent arteriole → glomerulus → efferent arteriole → secondary capillary network (vasa recta) → renal vein → posterior vena cava

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