Morfologie živočichů - MB170P46

Pavel Němec

VI. VYLUČOVACÍ SYSTÉM

Vylučovací soustava

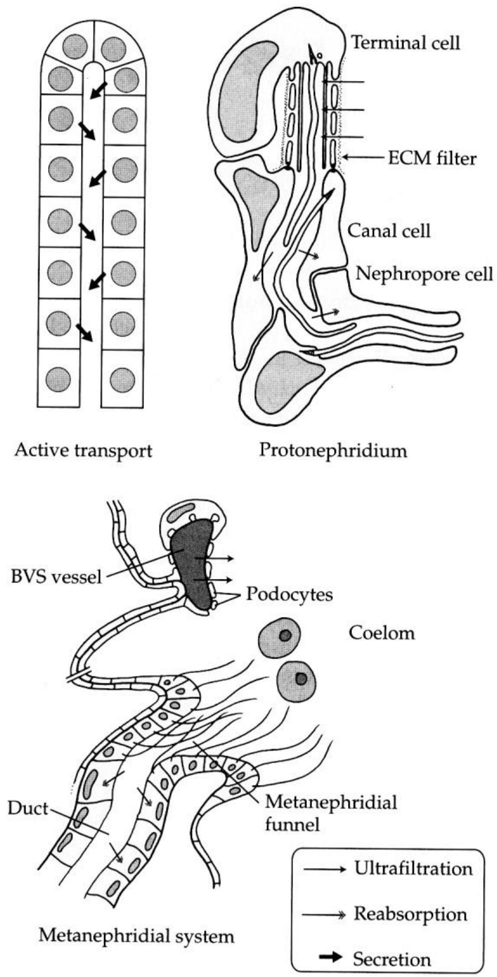


Fig. 9.1. Schematic representation of main principles in excretion. In active transport excretes are secreted by cells into a lumen of an epithelially lined tube. In a protonephridium, filtration occurs through the ECM covering slits or pores in the terminal cell (arrows). The filtrate flows through a canal system, in which reabsorption of water and ions is possible (double-headed arrows). In metanephridial systems, filtration occurs from a blood-vascular system vessel through podocytes into the coelom. Modification takes place in the canal following the metanephridial funnel. Figures partly after Bartolomaeus and Ax (1992).

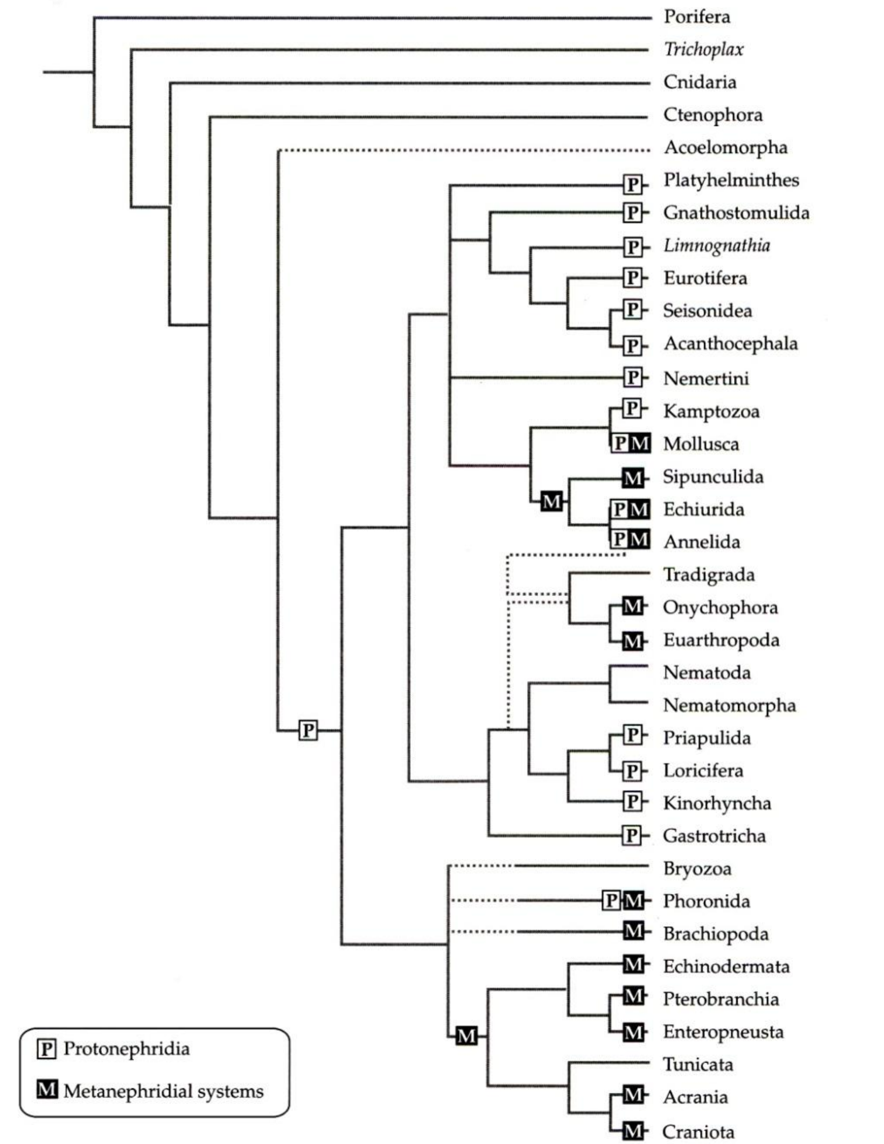


Fig. 9.14. Distribution of protonephridia and metanephridial systems on the phylogeneic tree and reconstruction of the presence of these systems in some ancestors.

Metanefridie vznikly konvergentně alspoň 3x:
u měkkýšů;
u předka krožkovců, sumýšovců a rypohlavců;
a u druhoústých.

Protonefridie

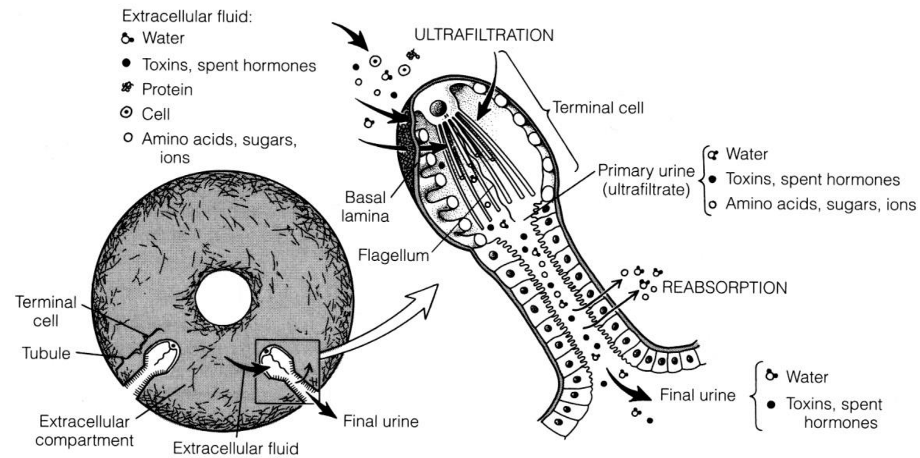


FIGURE 9-19 Bilaterian excretion: protonephridia. As in metanephridial systems, protonephridial excretion is a two-step process involving ultrafiltration and modification (reabsorption and secretion) to form final urine. In protonephridia, ultrafiltration occurs across the wall of a terminal cell, which resembles a single podocyte attached to the inner end of the nephridial tubule. The flagellum (or flagella) on the terminal cell is believed to create the pressure difference for ultrafiltration. As ultrafiltrate (primary urine) enters the tubule, it is modified by reabsorption to final urine, which is transported to the exterior by cilia on the tubule lining.

Obr. 5.292 Schéma stavby protonefridie (část stěny odstraněna).

Terminální buňka
(syn. solenocyt, plaménková buňka)

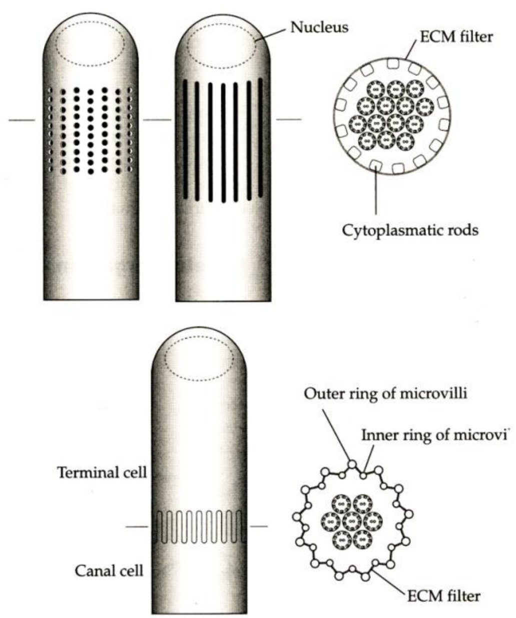


Fig. 9.2. Schematic representation of different designs in terminal cells. On top are cells with pores or slits; cross section at indicated level shows the filter composed of ECM covering the pores or slits. Below is a weir, where the filtration area is composed of microvilli from the terminal and the canal cell cross section is from the level indicated.

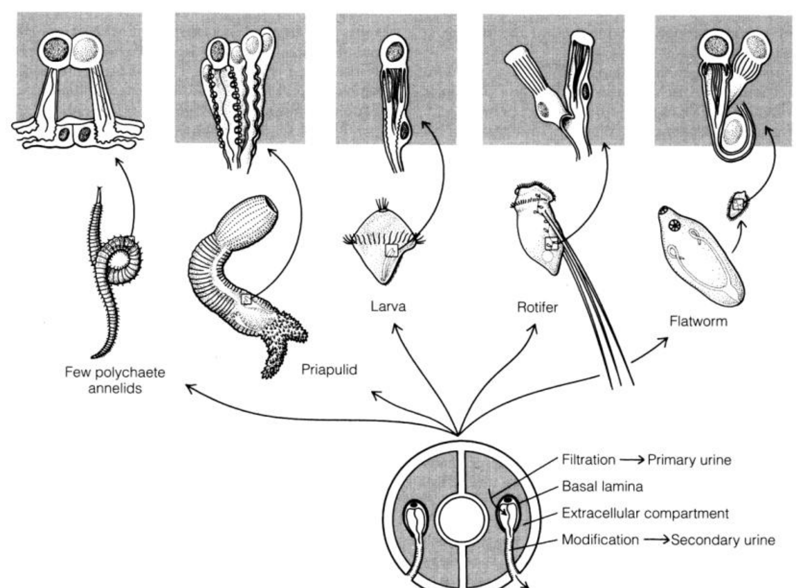
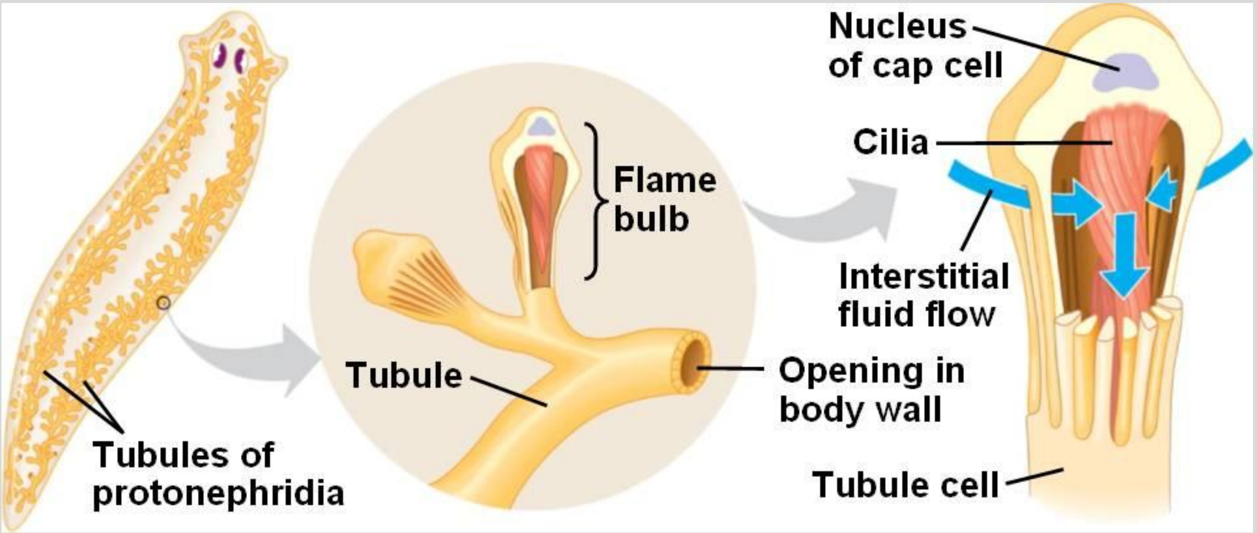
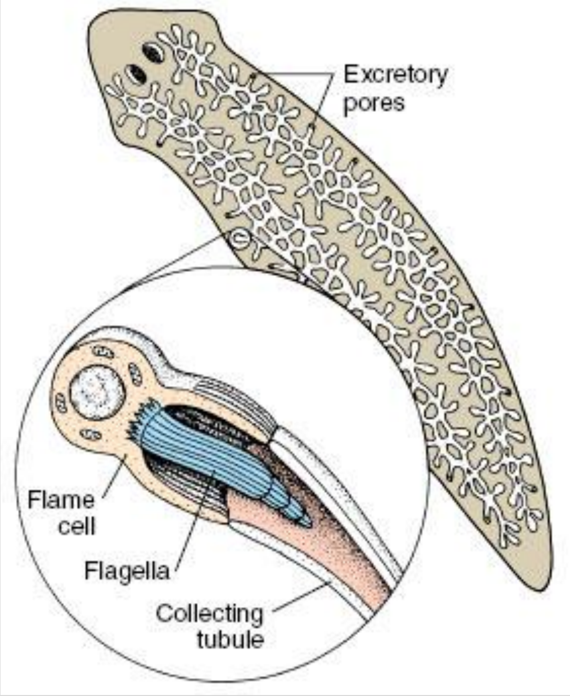
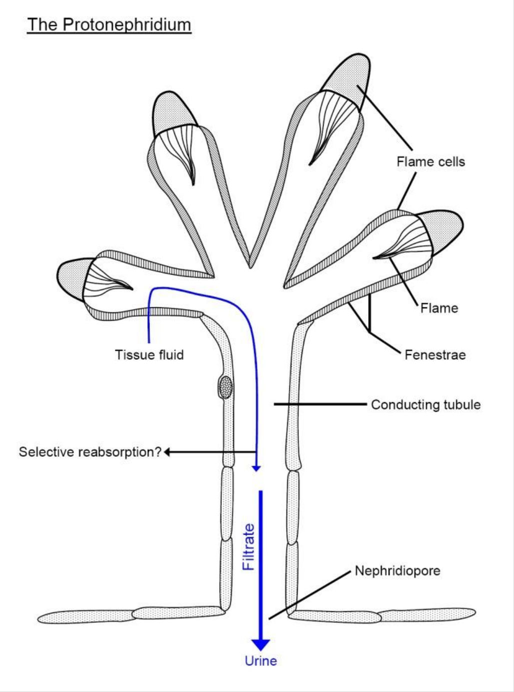


FIGURE 9-20 Bilaterian excretion: body design and the occurrence of protonephridia. Bilaterians that lack a hemal system, a coelomic system, or both have protonephridia instead of a metanephridial system. Typically these are small animals that rely on simple diffusion for internal transport. Protonephridia also occur in a few large animals such as priapulids that have *one* fluid-filled body cavity, usually an unpartitioned coelom or hemocoel. *(From Ruppert, E. E., and Smith, P. R. 1988. The functional organization of filtration nephridia. Biol. Rev. 63:231–258. Reprinted with the permission of Cambridge University Press.)*

Protonefridie







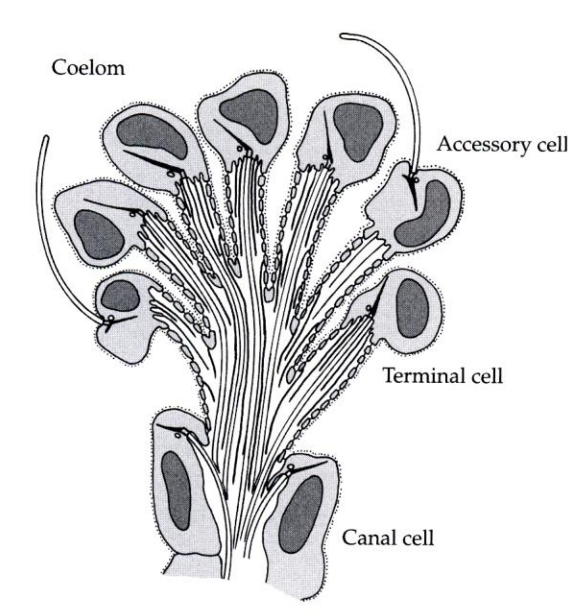
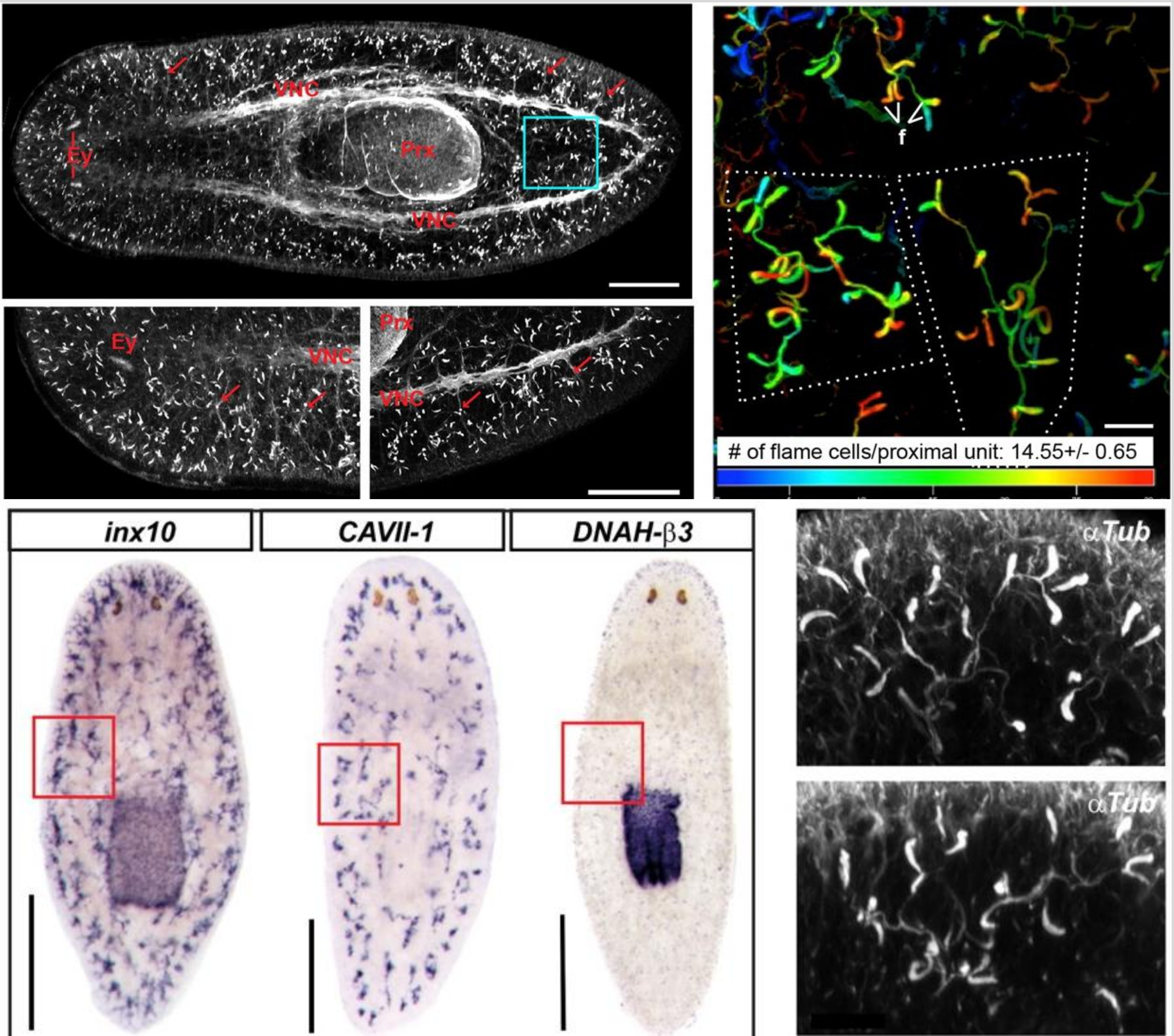


Fig. 9.11. The terminal complex in the actinotrocha (Phoronida) is composed of terminal and accessory cells. After Bartolomaeus (1989c).

Chapadlovky (*Phoronida*)

Protonefridie



Ploštěnka

Schmidtea mediterranea

Metanefridie

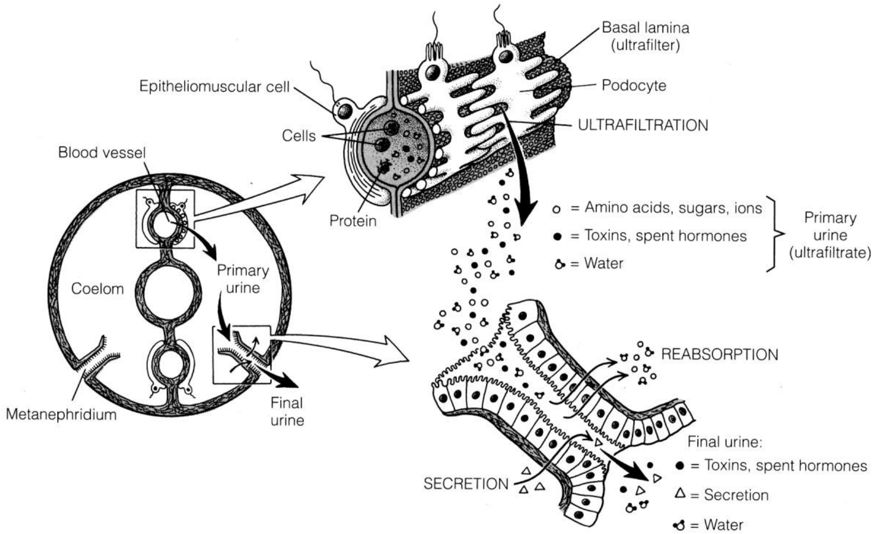
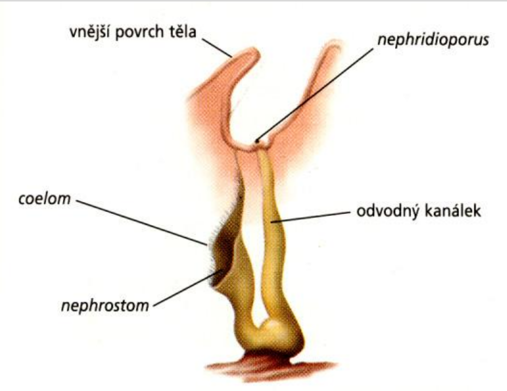


FIGURE 9-17 Bilaterian excretion: metanephridial system. A metanephridial excretory system consists of an ultrafiltration site on a blood vessel (indicated by podocytes), a coelom, and a tubule (metanephridium) that leads to the exterior. Muscular contraction of the blood vessel pressurizes the blood, forcing a cell- and protein-free ultrafiltrate (primary urine) across the podocyte layer and basal lamina (ultrafilter) into the coelom. Coelomic cells, including gametes, probably reabsorb nutrients from the primary urine, but the ciliated metanephridia are the chief sites for selective reabsorption and secretion, where the primary urine is converted to final urine. Urine is released from the nephridiopore.



Obr. 5.293 Schéma stavby metanefridie, která je z větší části derivátem ektodermu (podobně jako u protonefridie), avšak nefrostom je tvořen mezodermem stěny célomu.

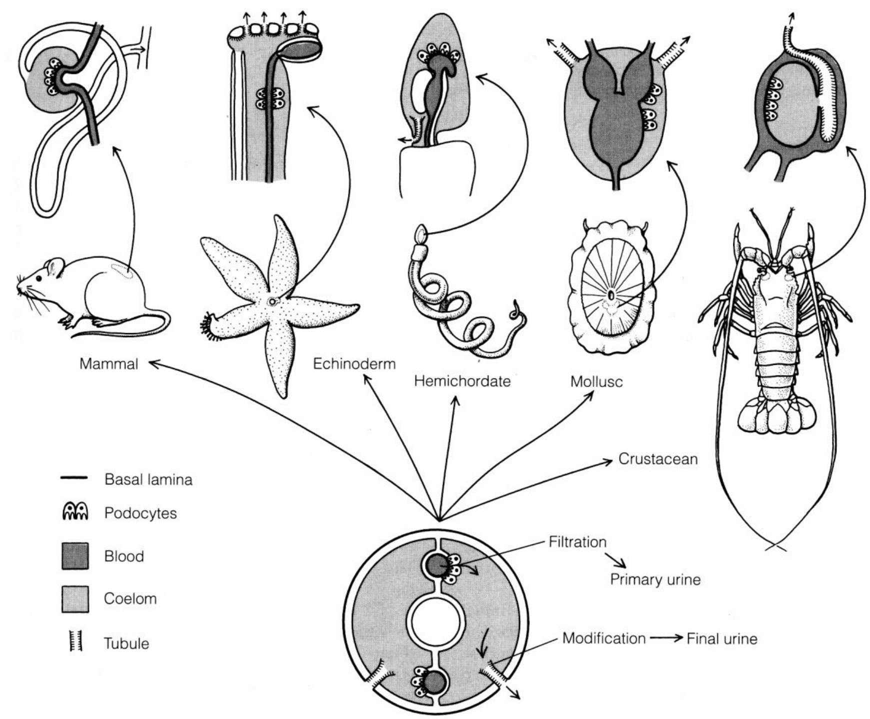
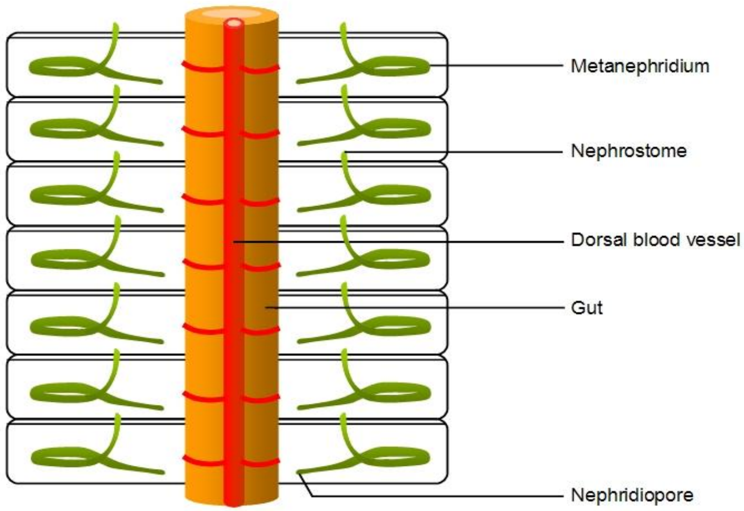
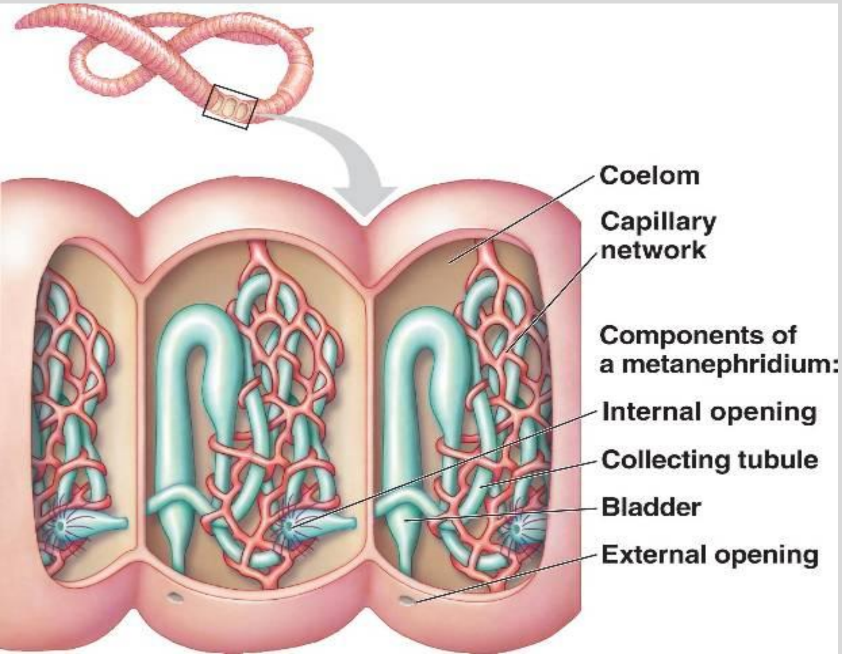


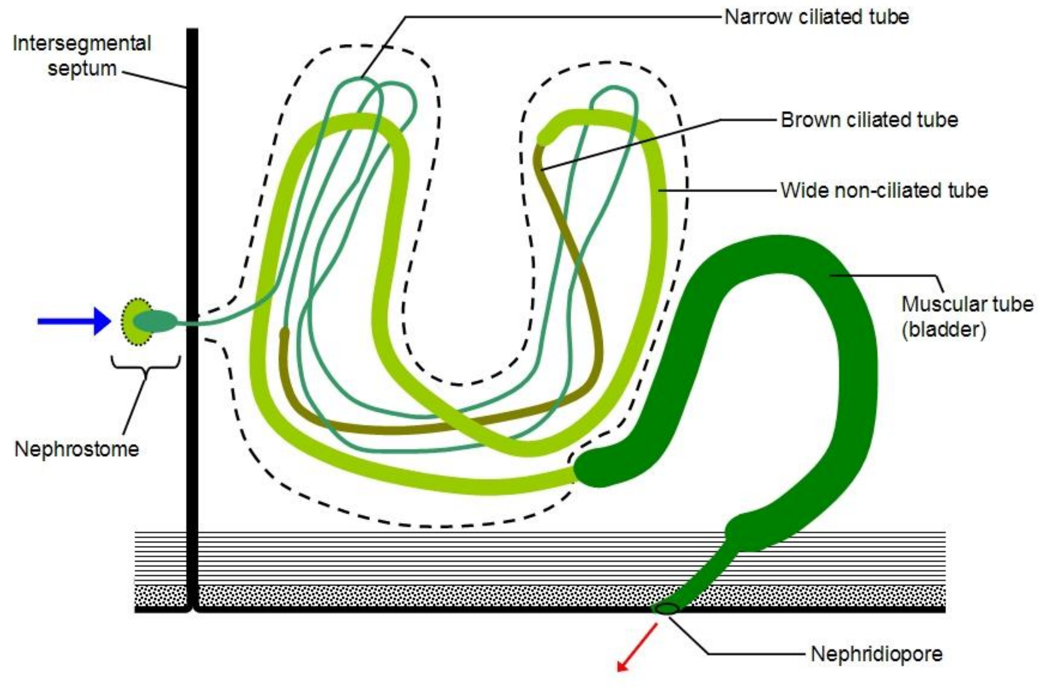
FIGURE 9-18 Bilaterian excretion: body design and the occurrence of metanephridial systems. Metanephridial systems usually occur in large bilaterians with both coelomic and hemal compartments. *(From Ruppert, E. E., and Smith, P. R. 1988. The functional organization of filtration nephridia. Biol. Rev. 63:231–258. Reprinted with the permission of Cambridge University Press.)*

Metanefridie – Oligochoeta



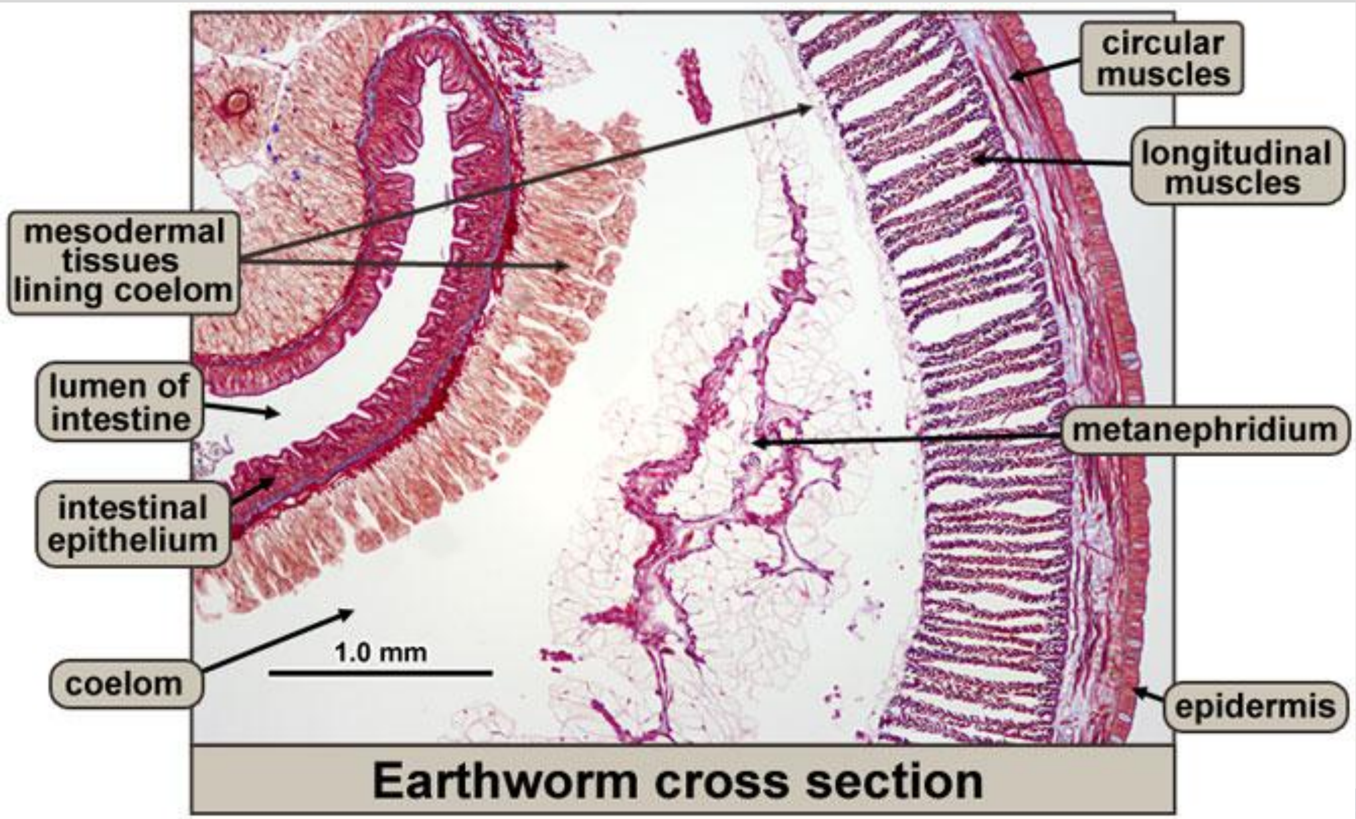
Dorsal dissection of 7 segments of *Lumbricus terrestris* showing the arrangement of the nephridia.

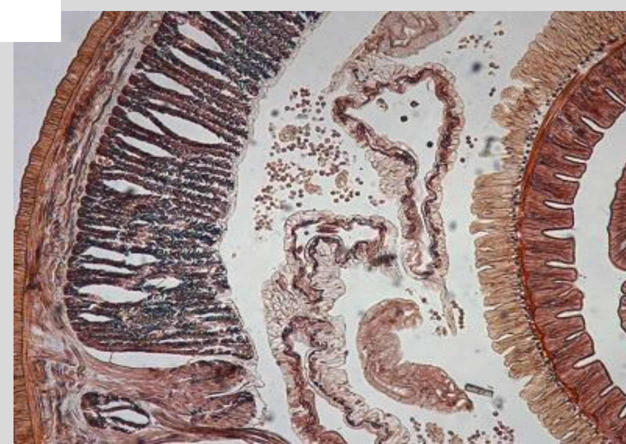




The nephridium of Lumbricus terrestris; coelomic fluid is drawn in (blue arrow) through the nephrostome and urine emerges (red arrow) through the nephridiopore.

Metanefridie – Oligochoeta





Mnohoštětinatci (Polychaeta) – aneb vše je možné

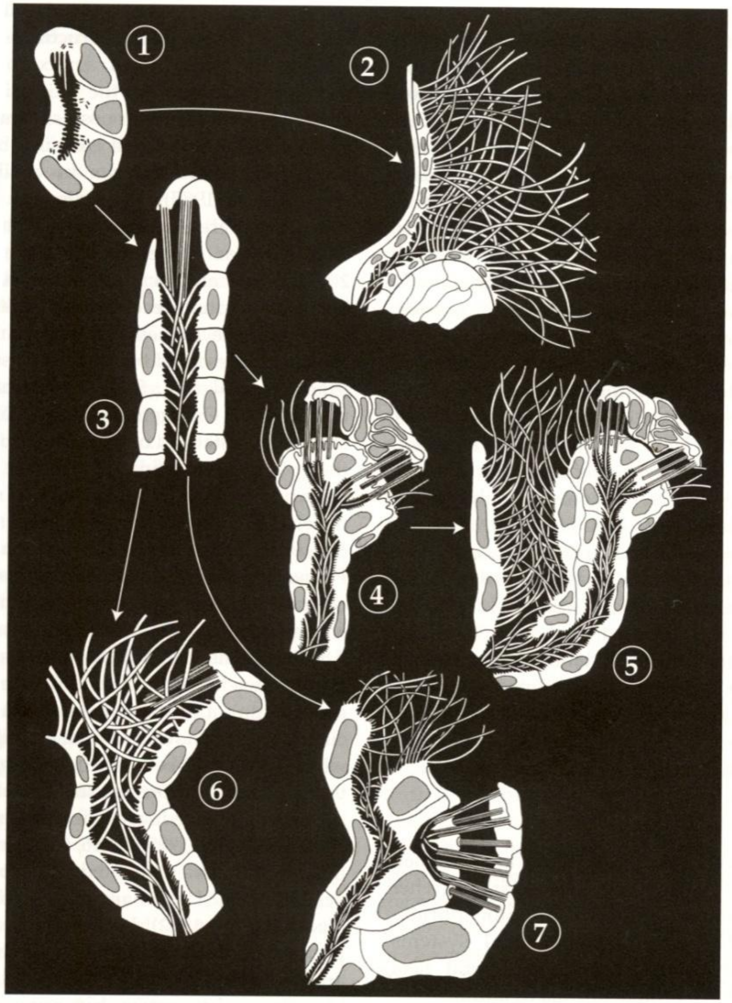
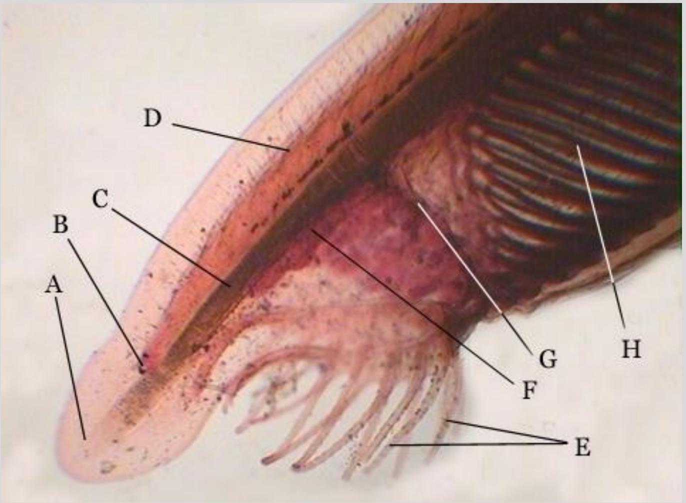


Fig. 9.7. Correspondence of protonephridial and metanephridial systems in polychaetes. In all cases, development starts with an anlage composed of few cells (1). During further development, this either directly opens to the coelom with a metanephridial funnel (2) or terminal cells develop in the proximal part (3). The filtration region of such protonephridia is within the coelom (4). These protonephridia may remain present throughout life, but during reproduction temporary metanephridial funnels open from the canal region into the coelom (5), examples are *Phyllodoce* and *Eulalia*. Protonephridia can also be replaced by the metanephridial funnel opening in the proximal region of the duct and subsequently degenerate (6), for example in *Pholoe* and *Harmothoe*. In *Tomopteris*, protonephridia direct into a small blind lumen and are probably nonfunctional, a metanephridial funnel is present close to this region (7). Compiled using figures from Bartolomaeus (1993a) and Bartolomaeus and Quast (2005).

Kopinatec (Branchiostoma)



90 párů branchiálních nefridií

jde o **modifikovaná metanefridie** – specializované buňky **cyrtopodocyty**

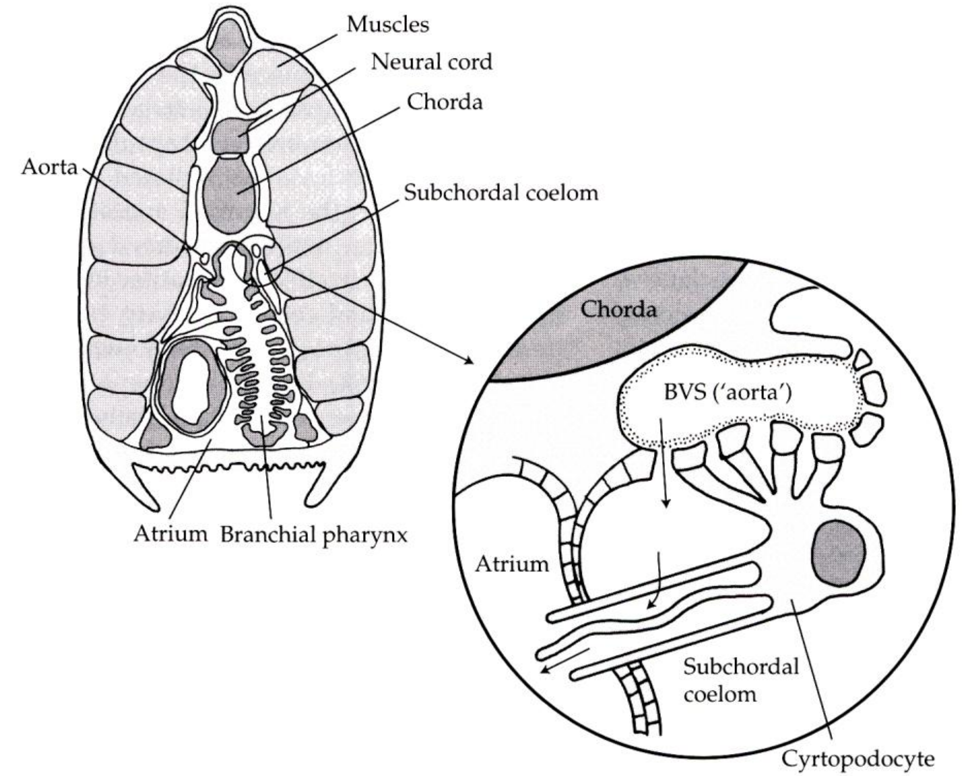
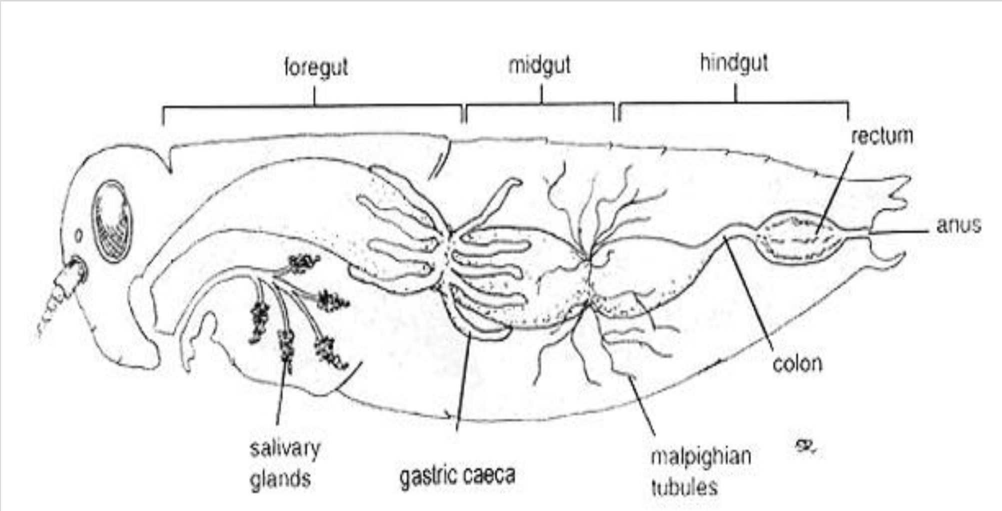


Fig. 9.12. Cyrtopodocytes in *Branchiostoma* (Acrania) are specialized coelom epithelium cells that connect the blood vascular system and the atrium through the subchordal coelom. One part is formed like podocytes, the other contains a cilium and circumciliary microvilli. Cross section after Ruppert (1997).

Malpigiho trubice hmyzu



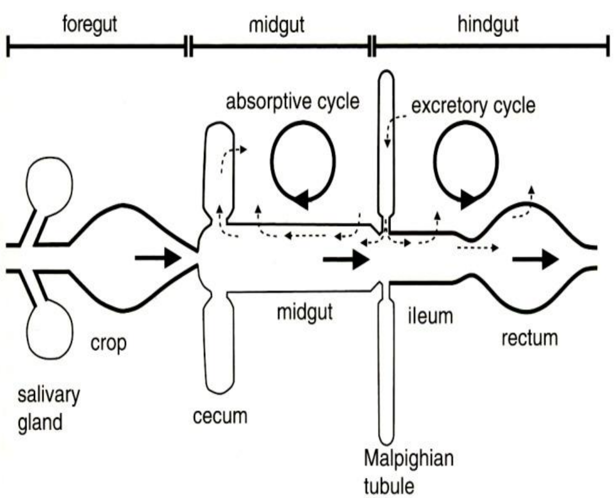
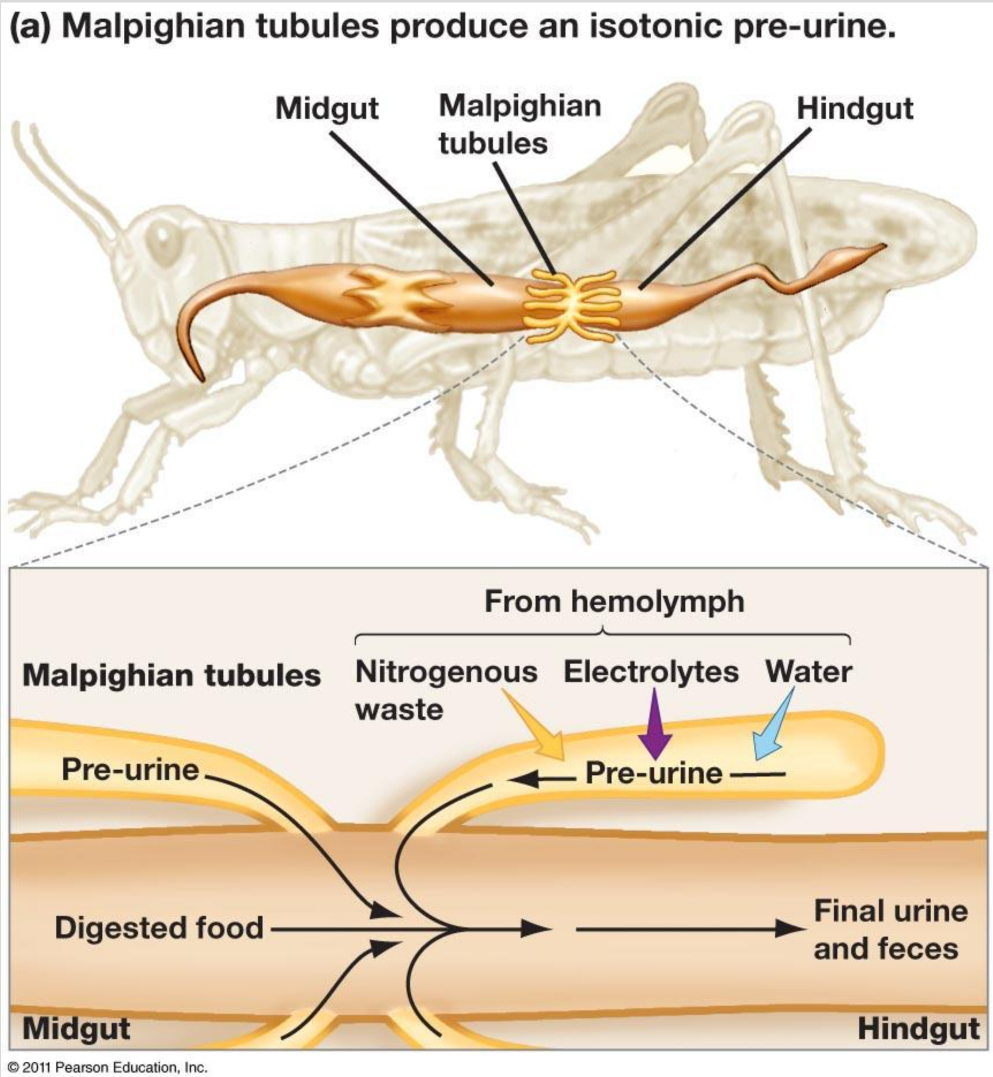


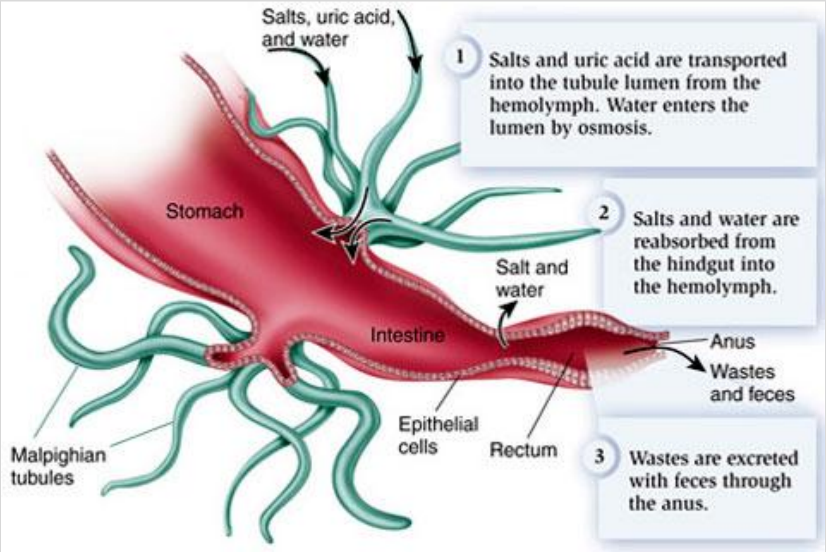
Figure 18.1 Overview of the insect alimentary canal, showing the absorptive and excretory cycles of water movement (Berridge, 1970). Heavy arrows show the path of food through the alimentary canal, and dotted lines show cycles of fluid movement. Heavier lines denote the cuticle lining of the foregut and hindgut.

Hmyz (Insecta)
Stonožkovci (Myriapoda)
Pavoukovci (Arachnida)
Želvušky (Tardigrada)

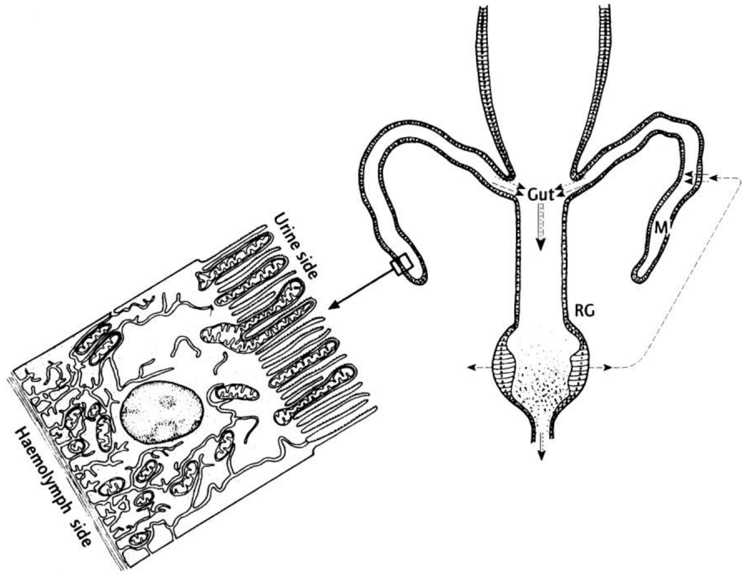
Počet: 2-250
Délka: 2-100 mm
Průměr: 30-100 µm
Plocha u švába 500 mm^2,
včetně zřasení 5000 mm^2

Malpigiho trubice hmyzu





Malpigiho trubice hmyzu



ig. 12.13 Malpighian tubules (M) and rectal gland
RG) of insects. → = food; → = water and some ions
otice that the spatial organization of Malpighian
ubules and rectal gland is such that water and ions can
ycle); → = uric acid (after Potts & Parry, 1964). The
ltrastructure of the Malpighian tube is also shown
fter Oschman & Berridge, 1971). Notice that it is rich
mitochondria, suggesting that it is involved in active
ansport.

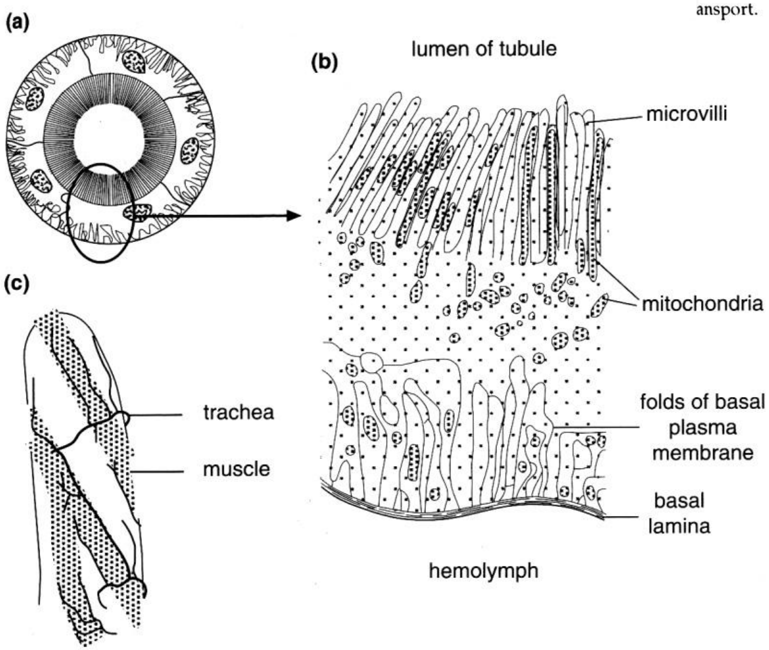
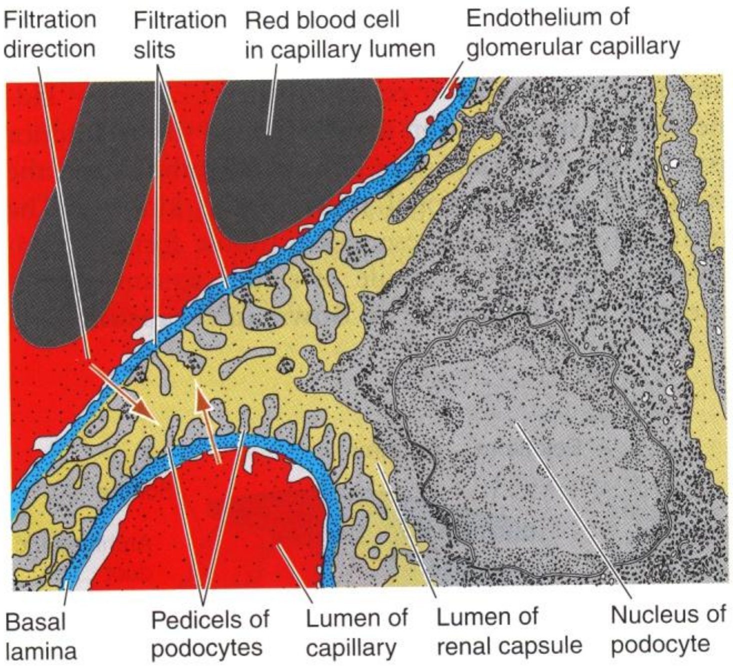


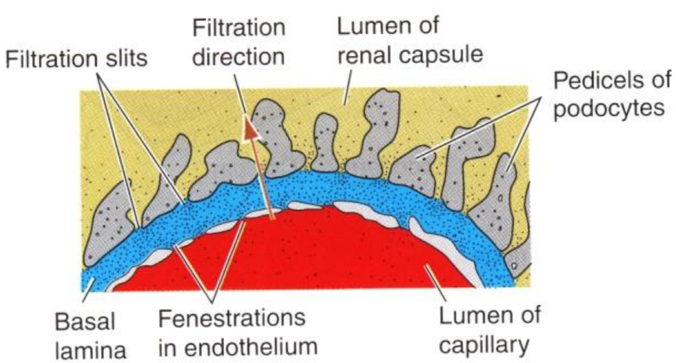
Figure 18.2 Structure of a typical Malpighian tubule. (a) Cross-section of a tubule. (b) Detail of part of one cell. (c) End of a Malpighian tubule of *Apis* showing the spiral muscle strands and the tracheal supply (after Wigglesworth, 1965).

Otevřený cévní systém - tlak hemolymfy stejný jako v trubicích, nefunguje proto tlaková mikrofiltrace. K+ ionty jsou aktivně transportovány do lumen Malpigiho trubic, voda a metabolity v ní rozpuštěné poté následují osmotický tlak.

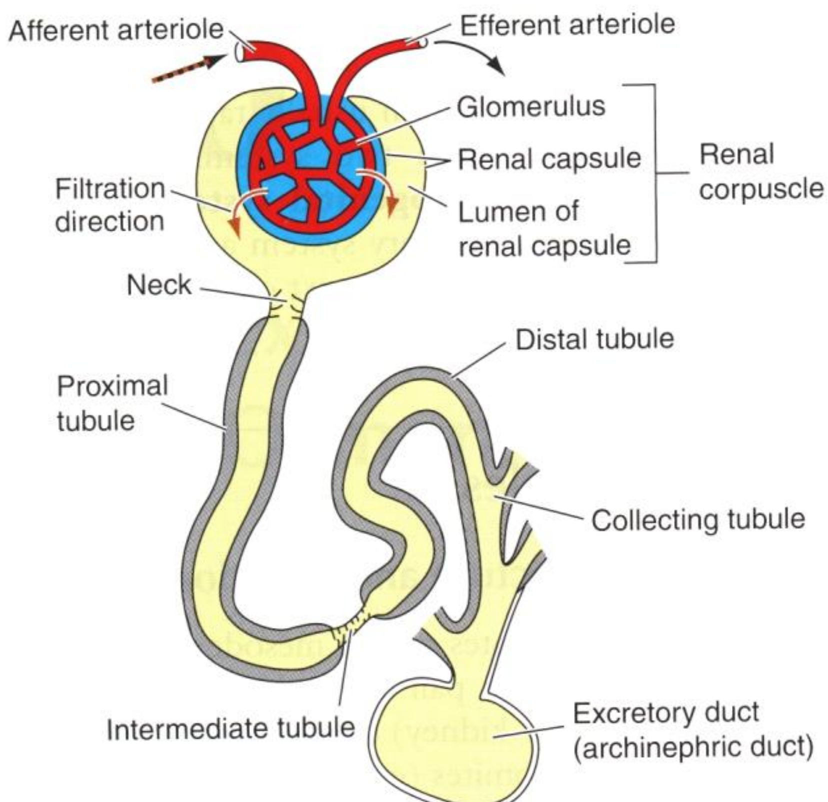
Nefron obratlovců = zdokonalená metanefridie



B. Glomerular capillary/renal capsule interface

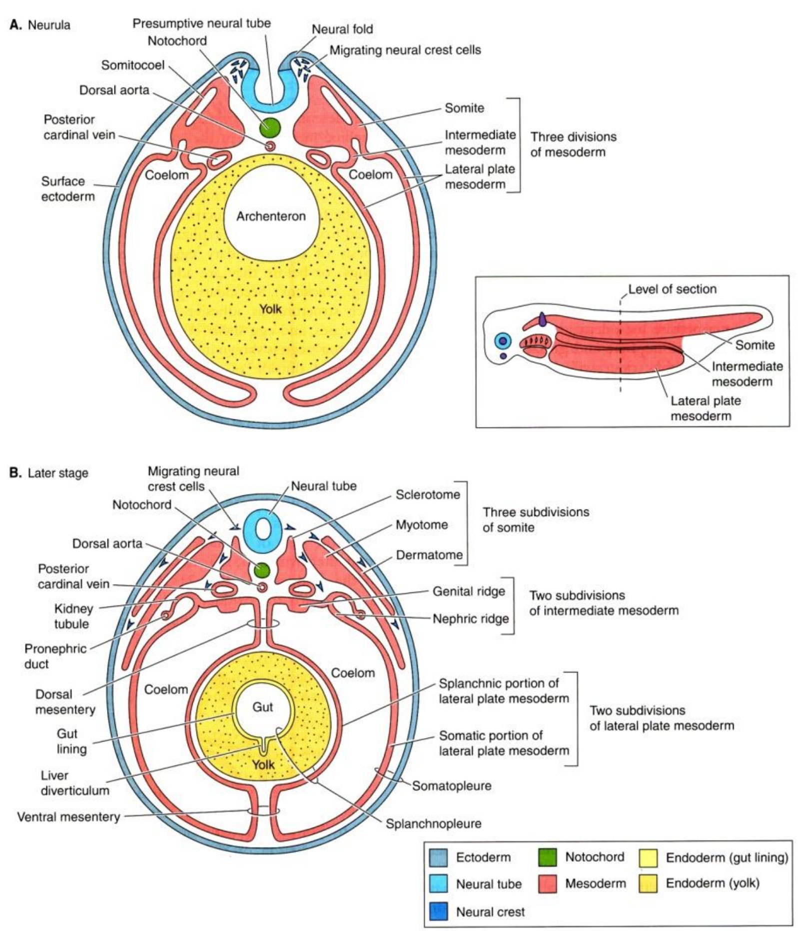


C. Enlargement of the interface



A. Parts of a nephron

Embryonální vývoj vylučovací soustavy



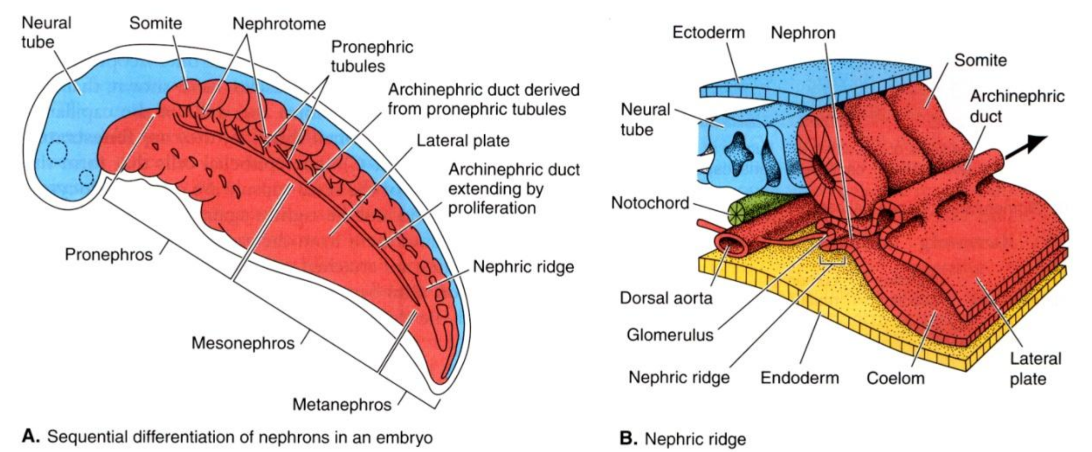
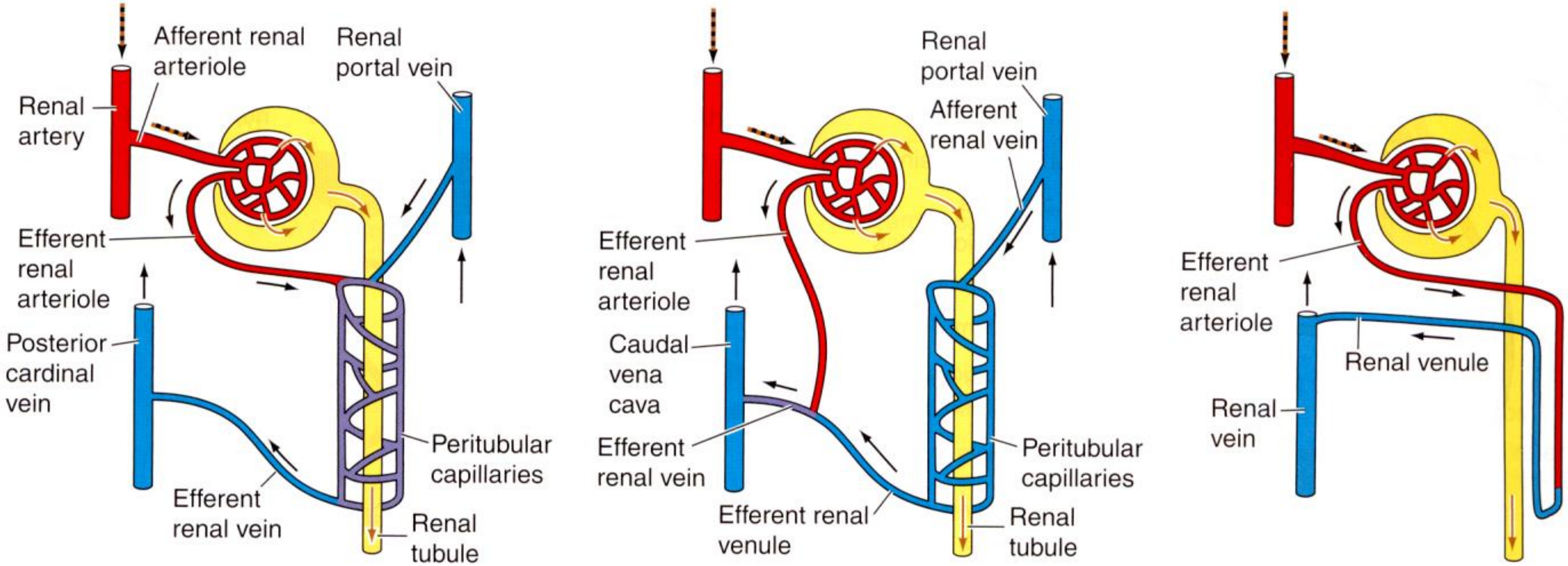


FIGURE 20-1

The embryonic development of the nephrons. *A*, A lateral view of an amniote embryo, showing the sequential differentiation (from anterior to posterior) of nephrons in the nephric ridge. The nephric ridge lies between the somites and the lateral plate mesoderm. *B*, A stereodiagram of the nephric ridge and adjacent structures. *(A, After Pough et al.; B, after Williams et al.)*

Cévní zásobení nefronu



A. Chondrichthyans and reptiles (including birds) **B.** Osteichthyan fishes and lissamphibians **C.** Mammals

FIGURE 20-3
The blood supply to the nephrons of various vertebrates. *A*, Chondrichthyans, reptiles and birds. *B*, Osteichthyan fishes and lissamphibians. *C*, Mammals. *(From Walker and Homberger.)*

Ontogeneze a evoluce nefronu

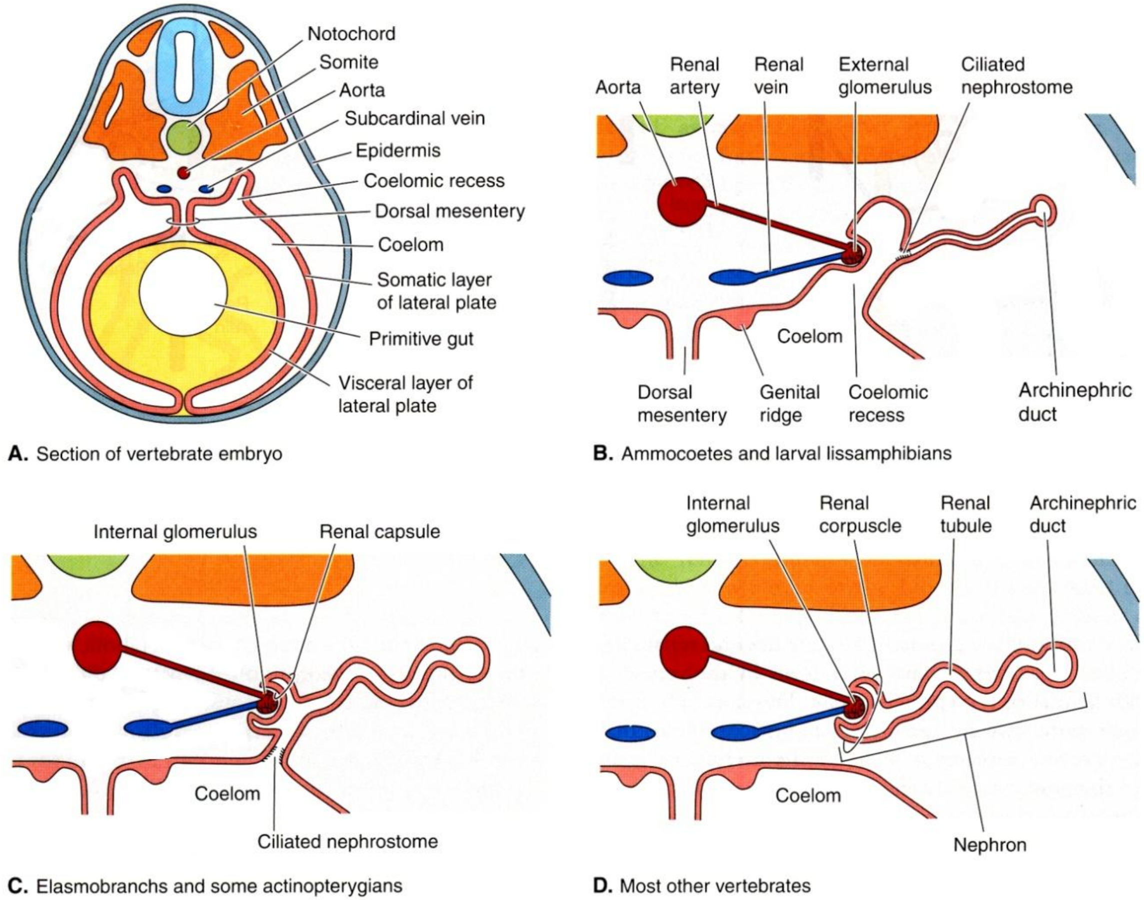
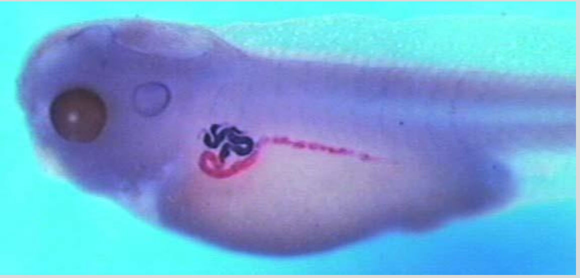


FIGURE 20-4

A, Cross section of a primitive vertebrate embryo, showing the coelomic recess that contributes to the formation of the renal capsule. *B–D*, The probable sequence in the evolutionary development of the renal capsule. *B*, External glomeruli as seen in the ammocoete larva of the lamprey and some larval lissamphibians. *C*, The internal glomeruli of elasmobranchs and some actinopterygians retain a connection to the coelom. *D*, The internal glomeruli of most other vertebrates. *(From Walker and Homberger.)*

Evoluce ledvin



Pronefros – hlavová ledvina

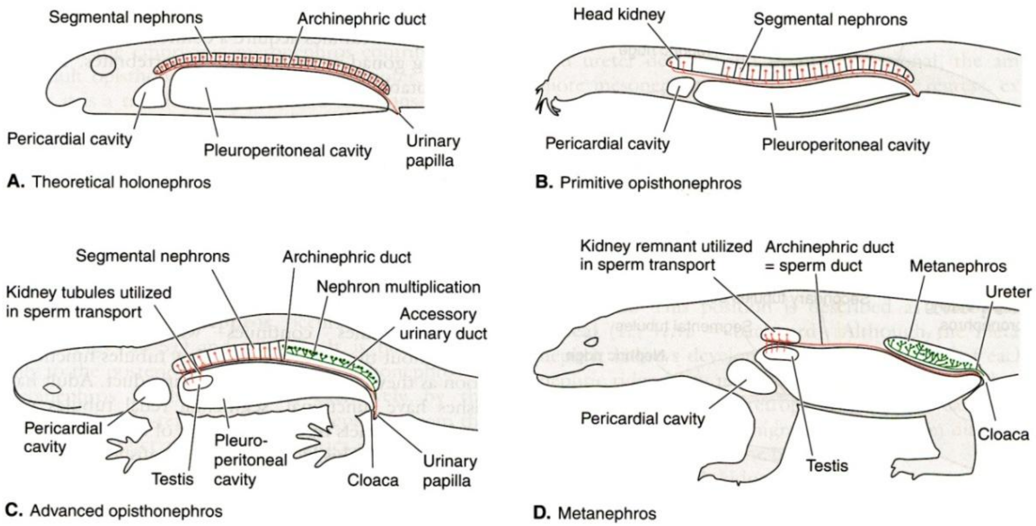
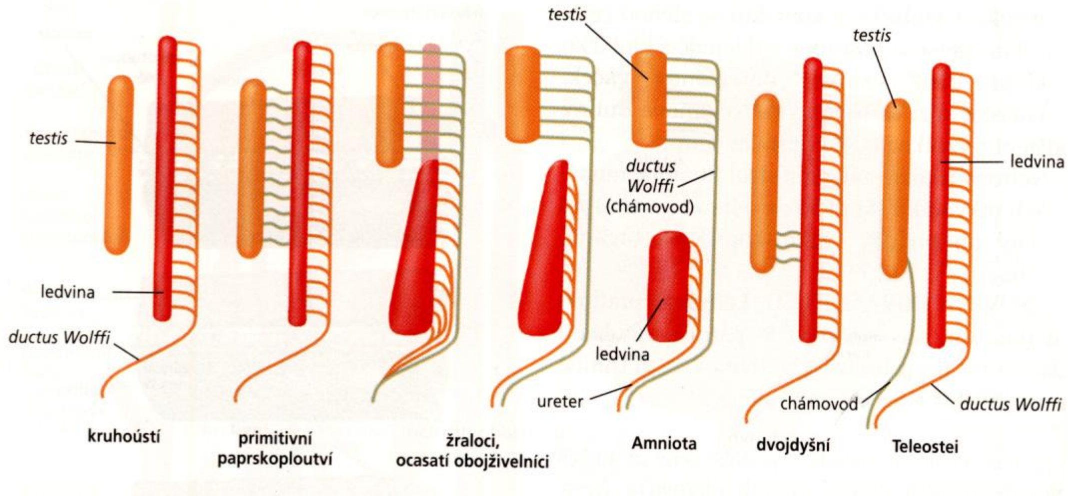


FIGURE 20-5
Lateral views of the evolution of the kidney and its ducts in adult craniates. *A,* The theoretical holonephros. *B,* The primitive opisthonephros found in a hagfish. *C,* The advanced opisthonephros characteristic of most fishes and amphibians. *D,* The metanephros of amniotes.



Ontogenetický vývoj vylučovacího ústrojí – Amniota

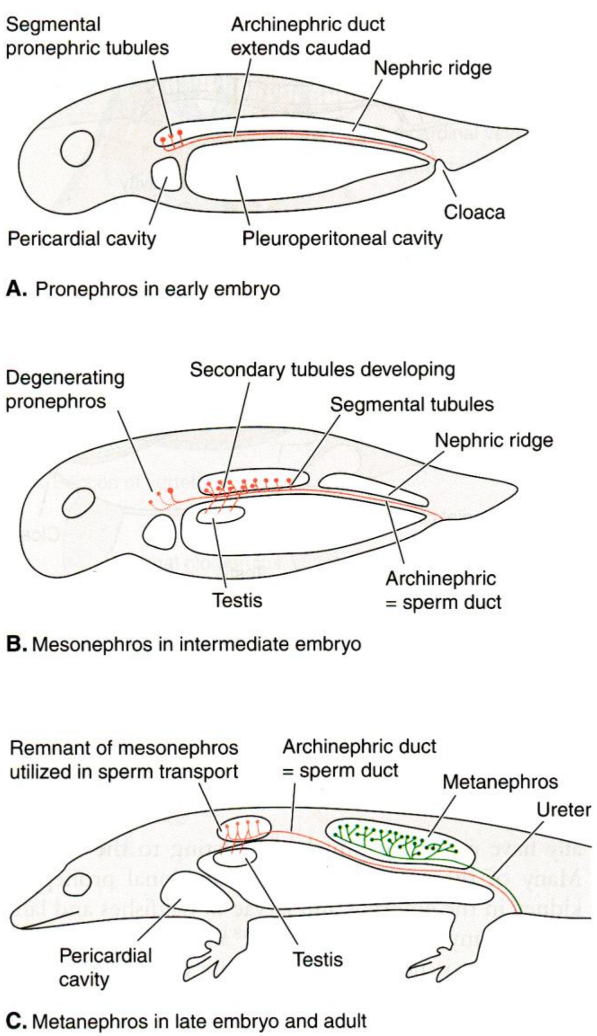


FIGURE 20-6

A–C, Lateral views of the sequence of kidneys that occurs during the embryonic development of an amniote.

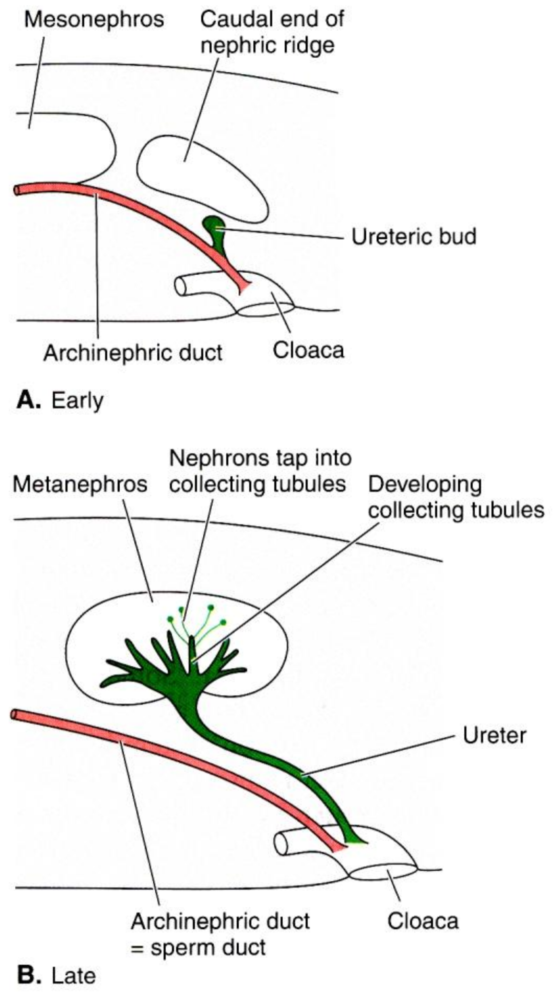
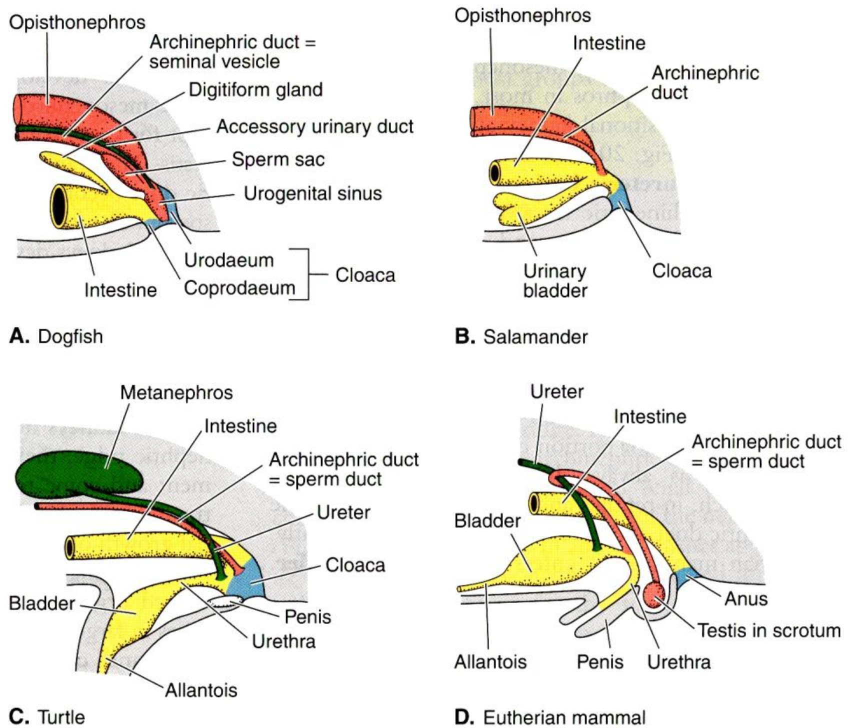


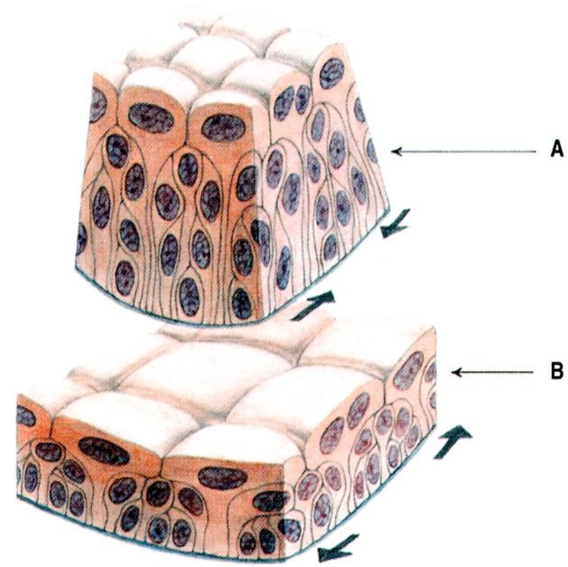
FIGURE 20-7

A and *B,* Lateral views showing how a ureteric bud induces the formation of nephrons in the metanephric region of the nephric ridge.

Kloaka a močový měchýř

FIGURE 20-8
Lateral views of the cloacal region of representative male vertebrates, showing the relationship to each other of terminations of the intestine, urinary ducts, and associated structures. The way the cloaca becomes divided in eutherian mammals so as to continue the opening of the intestine and urinary ducts to the surface is considered in the next chapter. *A,* A dogfish. *B,* A salamander. *C,* A turtle. *D,* A eutherian mammal.





Obr. 9. EPITHEL PŘECHODNÍ – výstelka močového měchýře
A na stěně prázdného (smrštěného) orgánu
B při náplni orgánu a napjaté stěně

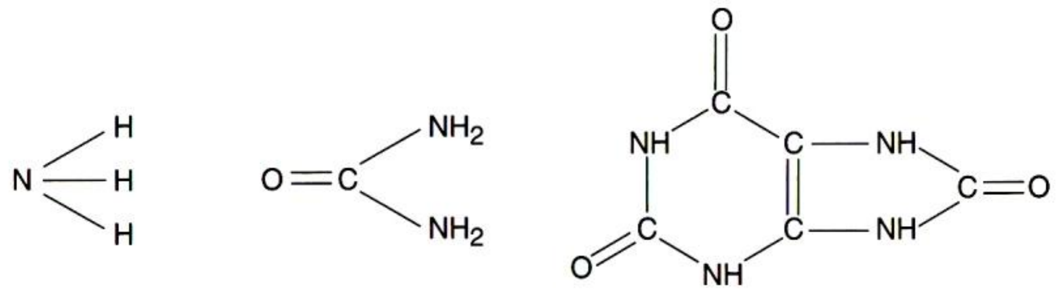
Osmoregulace

TABLE 20-1 Osmotic Concentration of Inorganic Salts and Urea in Plasma*

	Habitat	Osmotic Concentration (mOsm/L)	Urea (mOsm/L)
Sea water		≈1000	
Hagfish *(Myxine)*	Marine	1152	
Lamprey *(Petromyzon)*	Marine	317	9
Dogfish *(Squalus)*	Marine	1000	354
Freshwater ray *(Potamotrygon)*	Fresh water	308	1+
Goldfish *(Carassius)*	Fresh water	259	
Toadfish *(Opsanus)*	Marine	392	
Eel *(Anguilla)*	Marine	371	
Eel *(Anguilla)*	Fresh water	323	
Coelacanth *(Latimeria)*	Marine	1181	355
Frog *(Rana)*	Fresh water	200	1+

*The amount of urea included in the osmotic concentration is shown separately if it is 1 milliosmol per liter or greater and therefore osmotically significant. (Data from K. Schmidt-Nielsen.)

Osmoregulace – vylučování dusíku



A. Ammonia **B.** Urea **C.** Uric acid

TABLE 20-2 Major Form of Nitrogen Excretion

Animal	Environment	Type of Nitrogen Excretion
Teleost	Fresh water	Ammonia, some urea
Teleost	Marine	Ammonia, some urea
Elasmobranch	Marine	Urea
Larval amphibian	Fresh water	Ammonia, some urea
Adult amphibian	Terrestrial	Urea, some ammonia
Reptile	Terrestrial	Uric acid
Bird	Terrestrial	Uric acid, urea in some species
Mammal	Terrestrial	Urea, small amounts of ammonia, and sometimes uric acid

Struktura nefronu u obratlovců

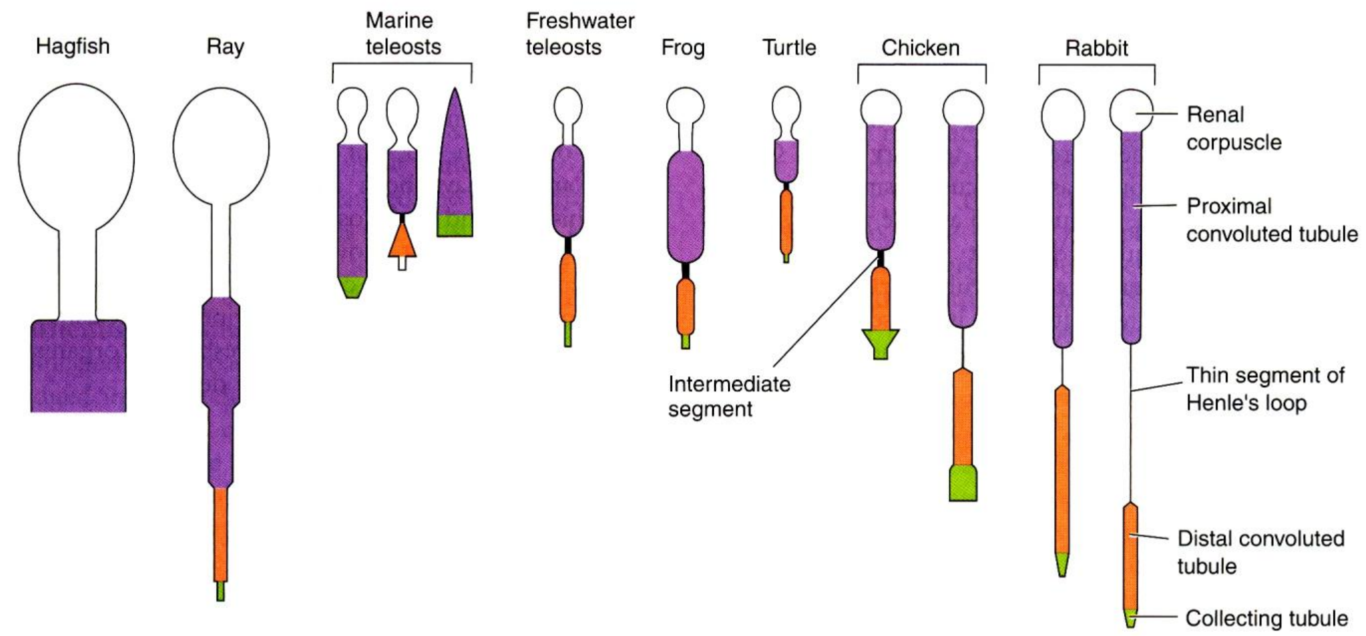
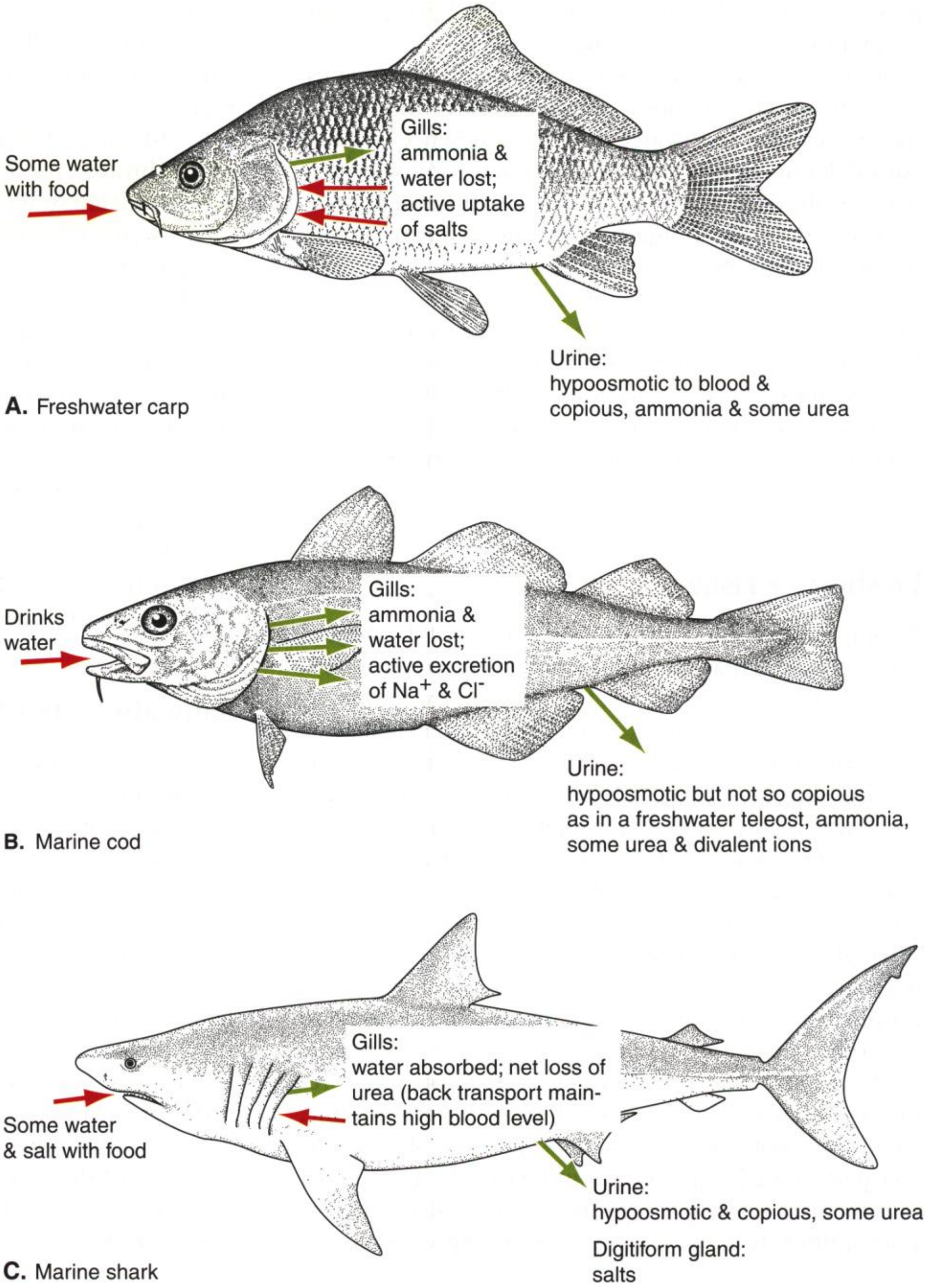
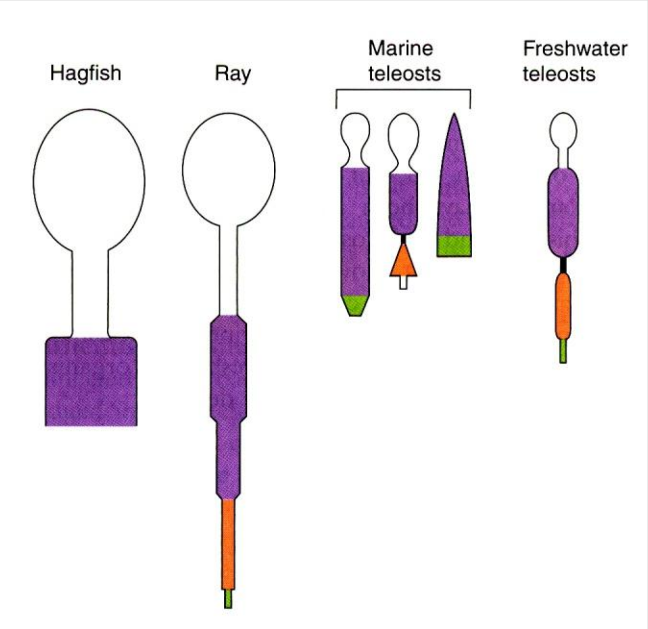


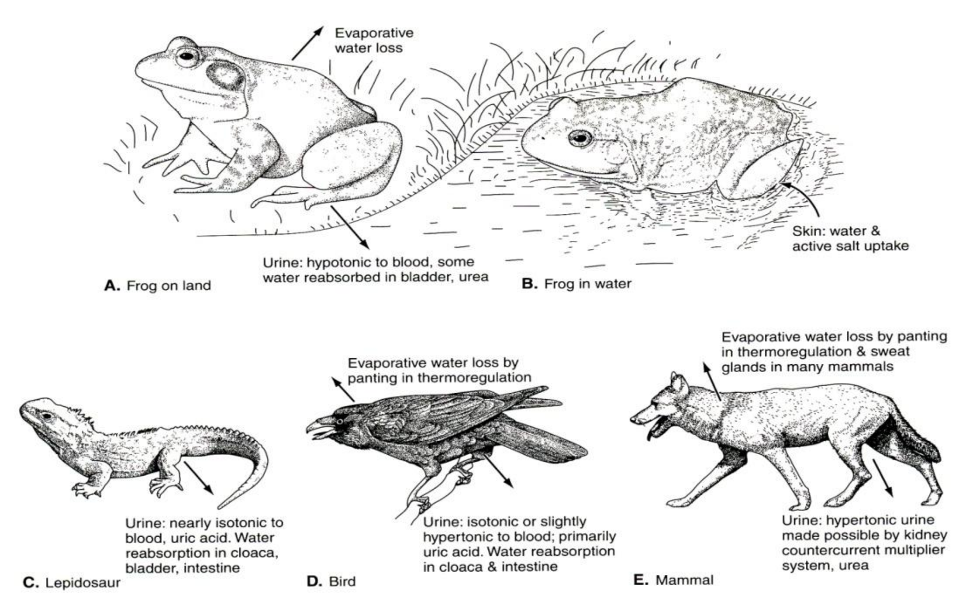
FIGURE 20-10
Nephron structure in representative craniates. The thin and intermediate segments are ciliated. *(After Prosser.)*

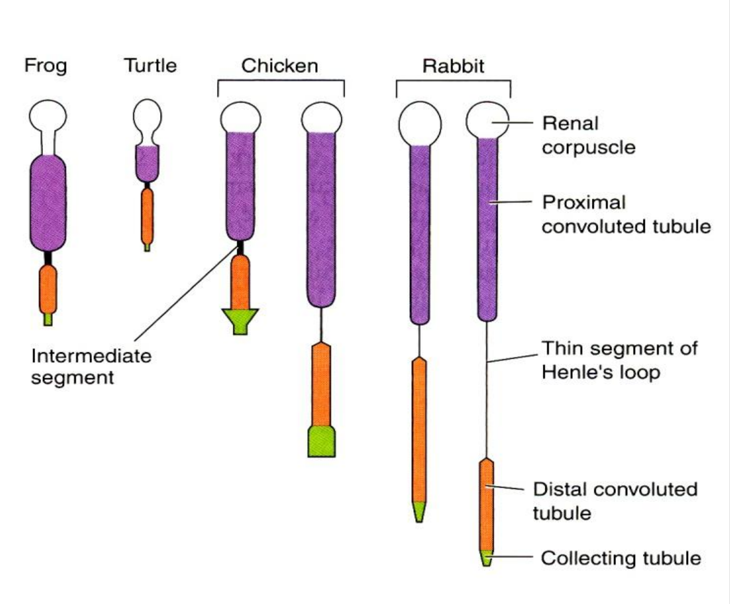
Osmoregulace



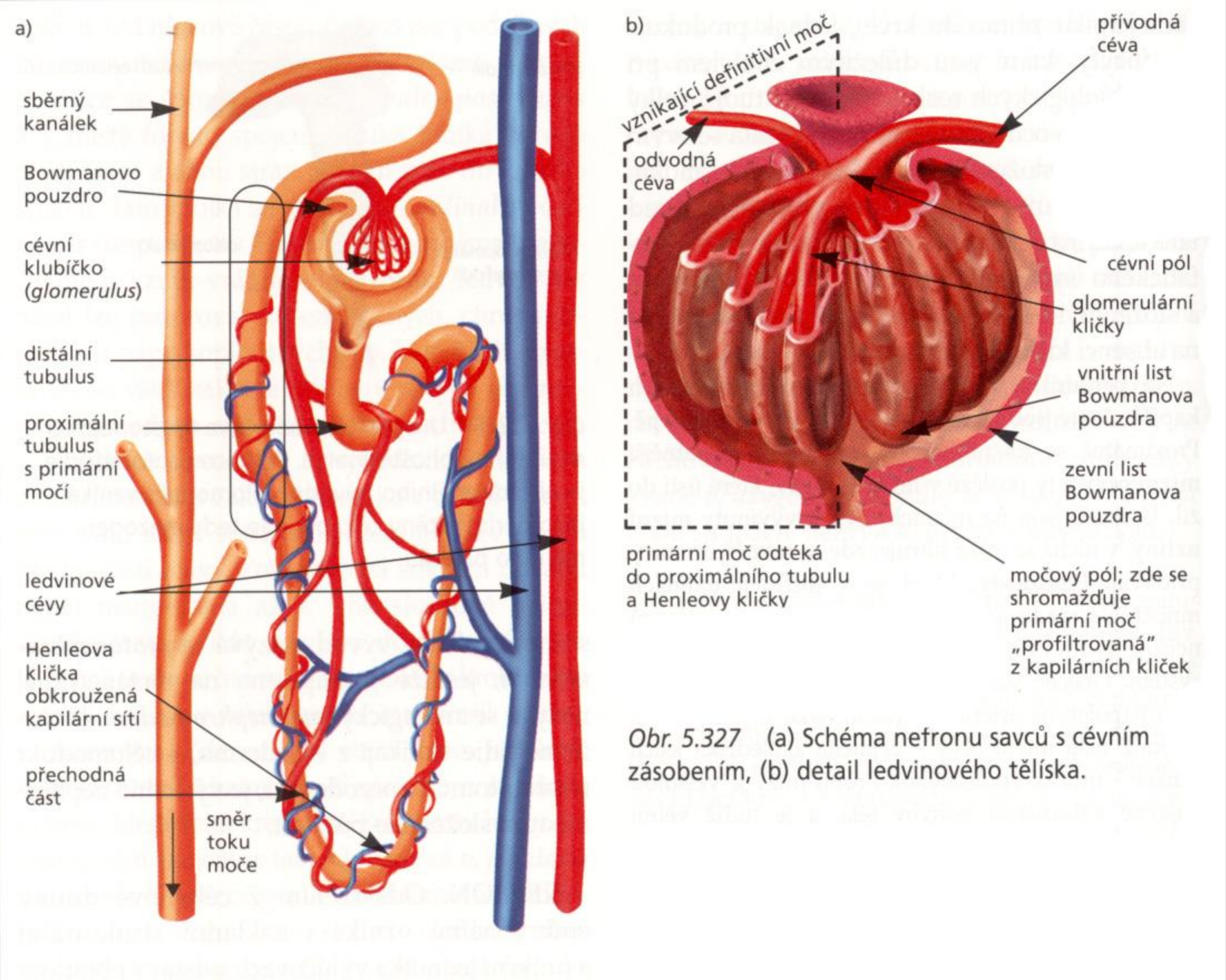


Osmoregulace





Nefron savců



Obr. 5.327 (a) Schéma nefronu savců s cévním zásobením, (b) detail ledvinového tělíska.

Nefron savců

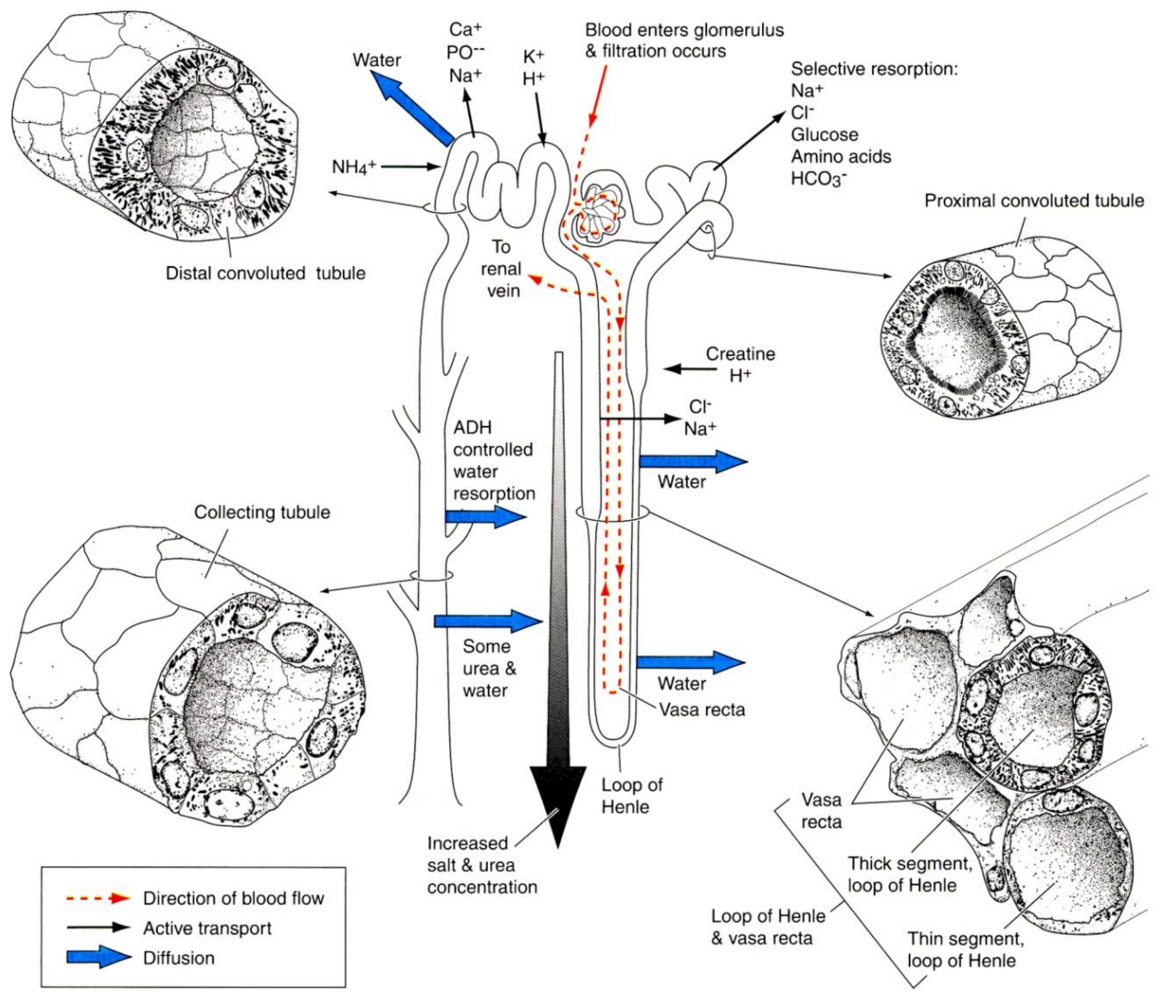
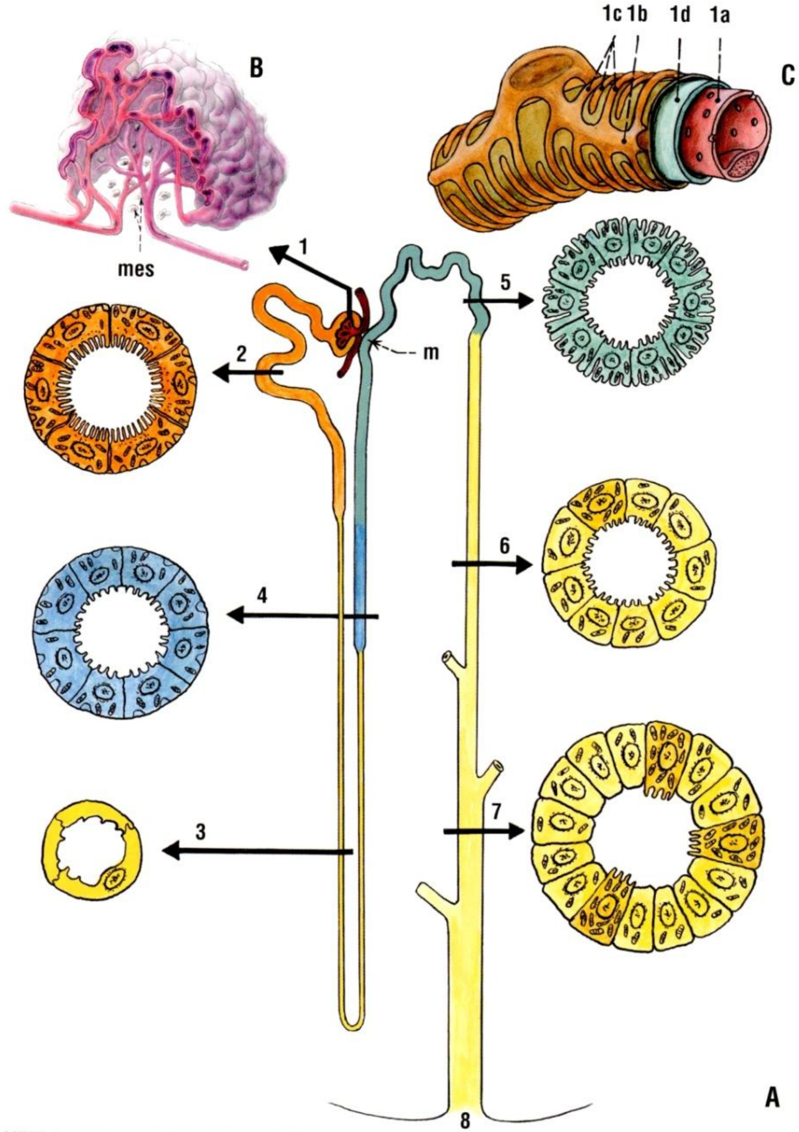
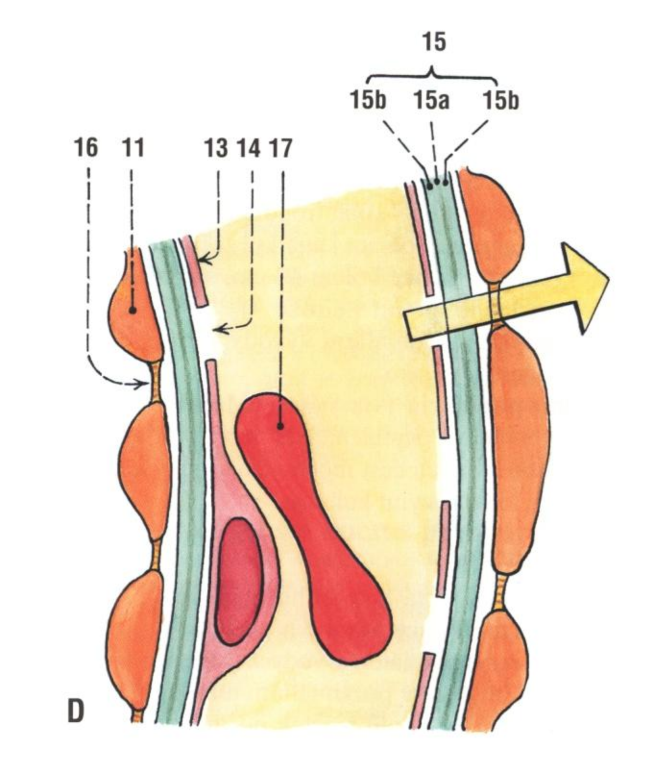


FIGURE 20-14
A mammalian nephron. Dashed red arrows represent blood flow. The regions where materials are exchanged by active transport (*narrow black arrows*) or by passive diffusion (*wide blue arrows*) are shown. The combined result of kidney action is the production of a hypertonic urine. *(Modified from Williams et al.)*

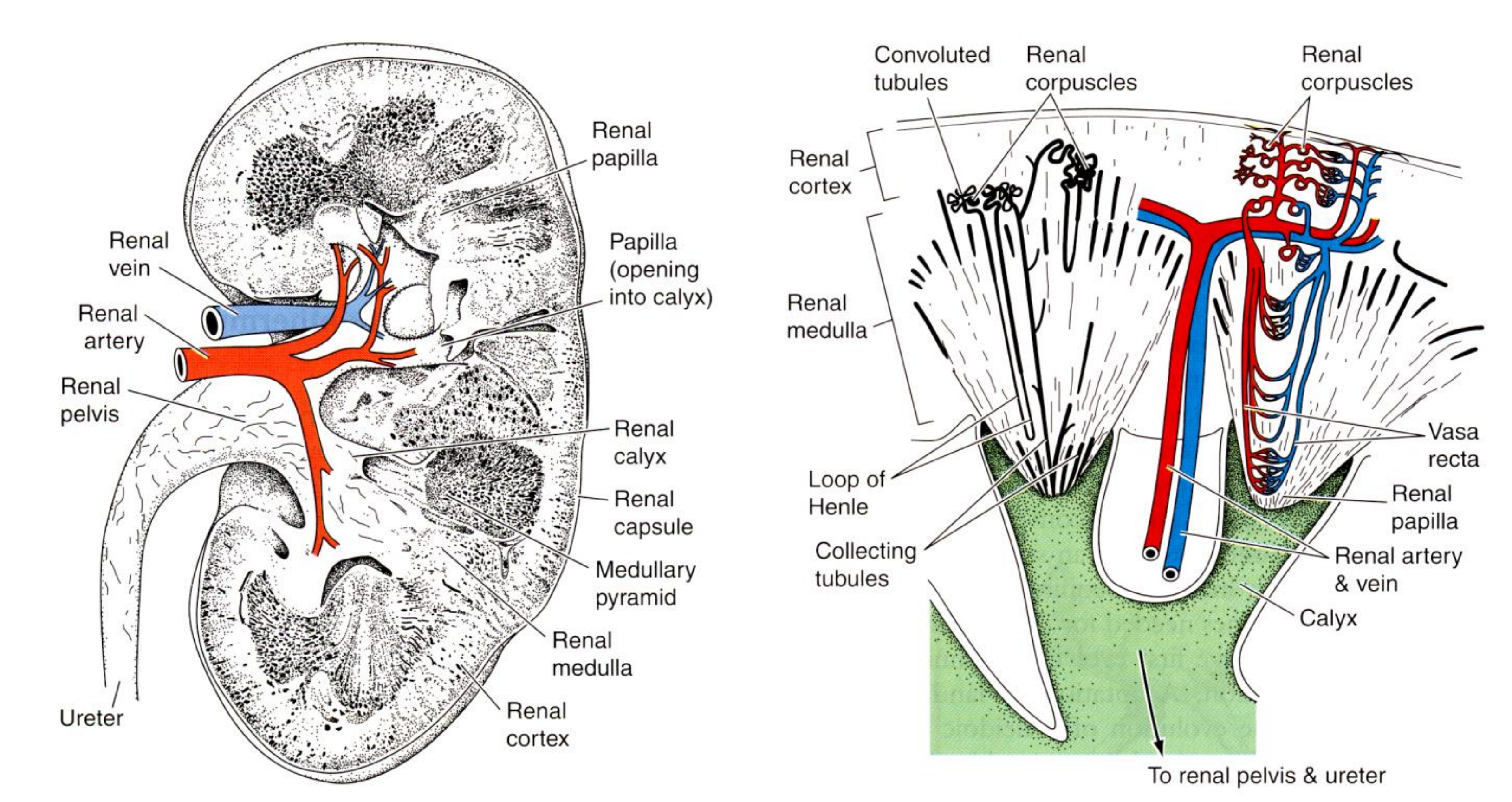
Nefron savců



Obr. 181. SCHÉMA NEFRONU A DETAILY JEHO STAVBY
A SCHÉMA NEFRONU A PRŮŘEZY JEHO SLOŽEK
B SCHÉMA ÚPRAVY KAPILÁR GLOMERULU (adaptováno podle Žlábka, 1957)
C DETAIL KAPILÁRY GLOMERULU S PODOCYTEM
1 corpusculum renale s glomerulem
1a fenestrovaná kapilára glomerulu
1b výběžek podocytu
1c pedikly podocytu
1d splývající bazální membrány endothelu kapiláry a podocytů
2 proximální tubulus s pars contorta a pars recta
3 Henleova klička – tenké sestupné raménko, přecházející v tenký úsek vzestupného raménka
4 Henleova klička – vzestupné raménko, jeho tlustý úsek
5 distální tubulus s pars recta a pars contorta
6 tubulus colligens
7 ductus papillaris
8 foramen papillare
mes – mesangiové buňky
m – místo macula densa na přechodu přímé a stočené části distálního tubulu



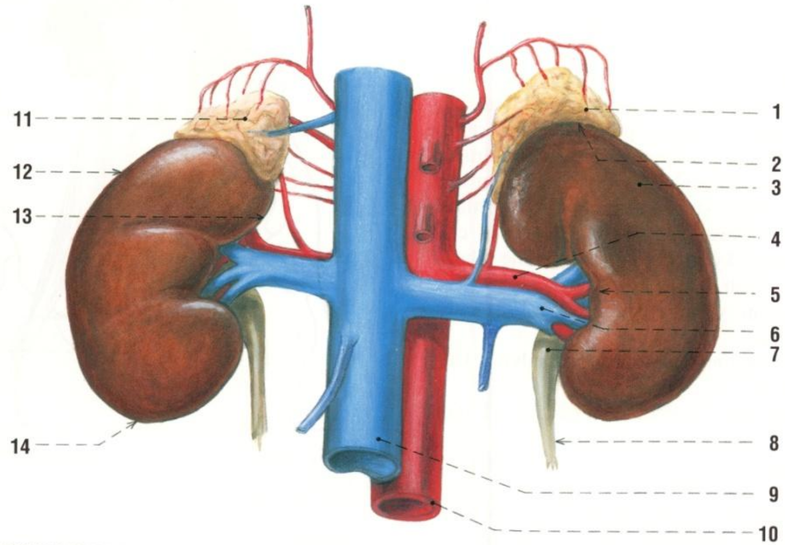
Struktura savčí ledviny



A. Section through a mammalian kidney

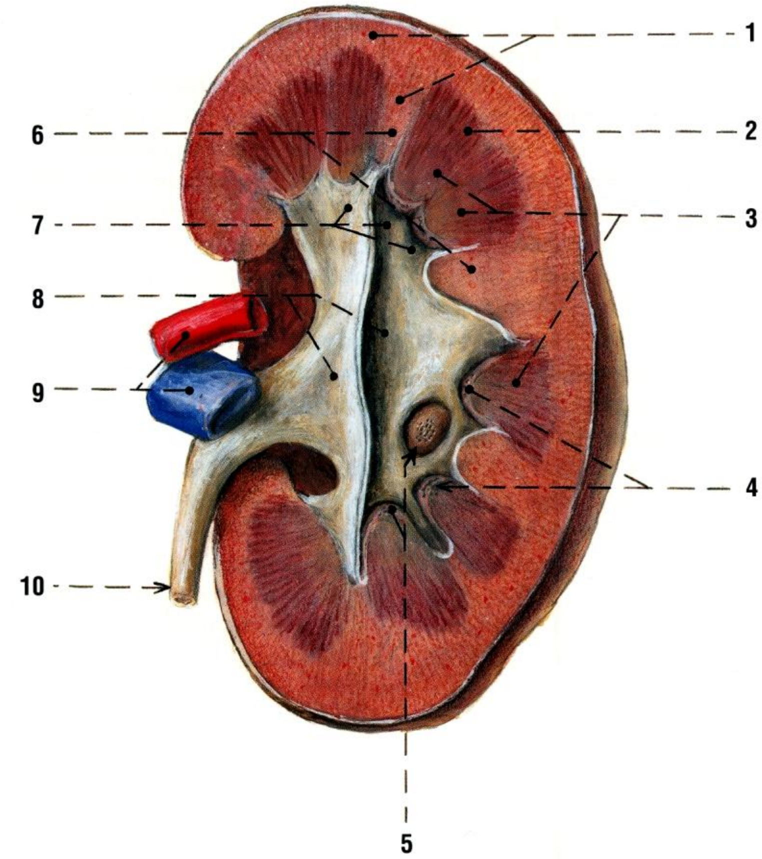
B. Mammalian kidney tubules in relationship to circulation

Struktura savčí ledviny



Obr. 179. LEDVINY S NADLEDVINAMI a jejich cévy

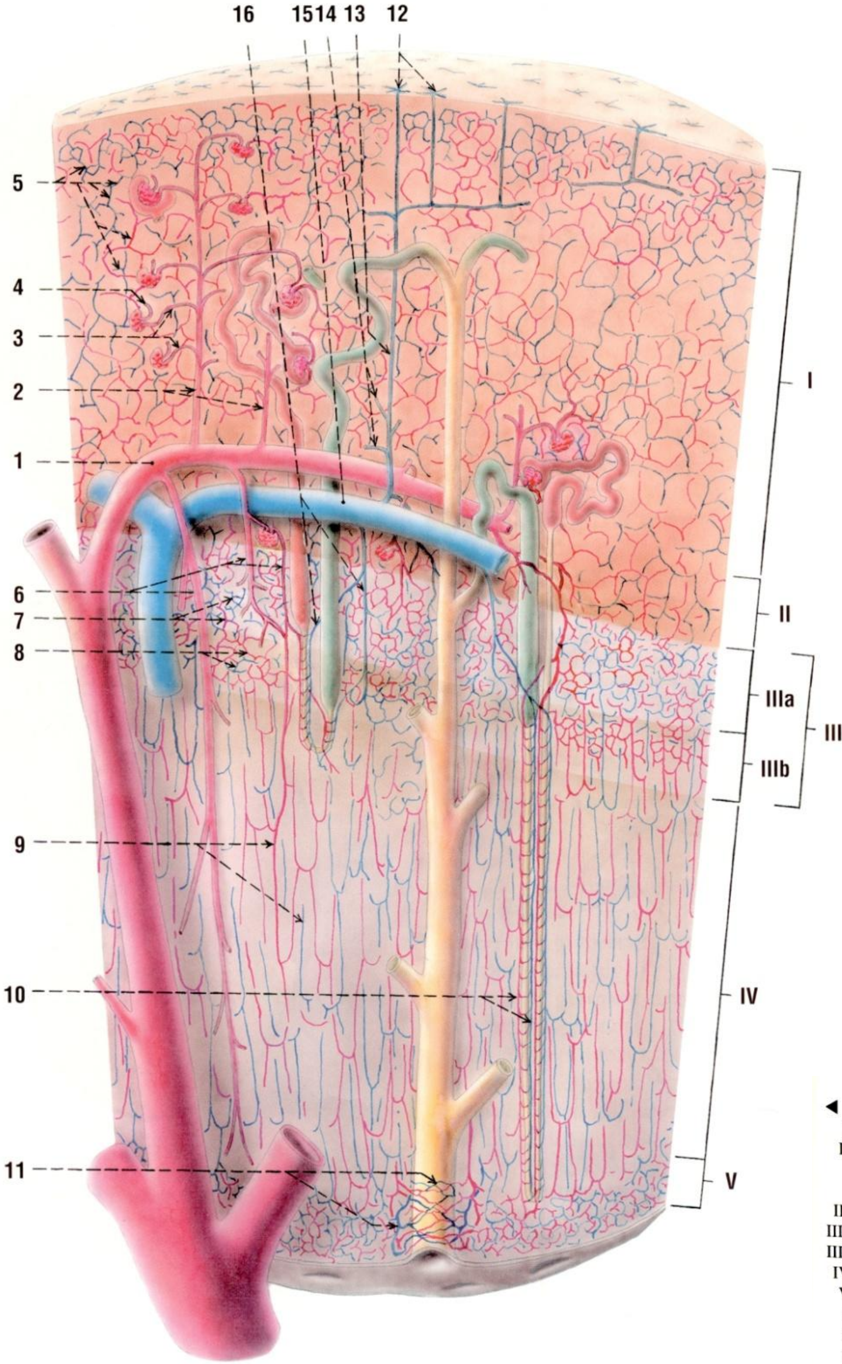
1 levá nadledvina
2 extremitas superior levé ledviny
3 facies anterior levé ledviny
4 a. renalis sinistra
5 sinus renalis
6 v. renalis sinistra
7 pelvis renalis
8 ureter sinister
9 v. cava inferior
10 aorta abdominalis
11 pravá nadledvina
12 margo lateralis pravé ledviny
13 margo medialis pravé ledviny
14 extremitas inferior pravé ledviny



Obr. 180. FRONTÁLNÍ ŘEZ LEDVINOU; pelvis renalis zčásti otevřená řezem, proříznuto několik kalichů

1 cortex renalis
2 medulla renalis
3 pyramides renales
4 papillae renales
5 area cribrosa, na ní foramina papillaria
6 columnae renales
7 calices renales
8 pelvis renalis
9 a. et v. renalis
10 ureter

Struktura savčí ledviny



v ledvině člověka 0,9 – 1,6 milionu ledvinových tělísek

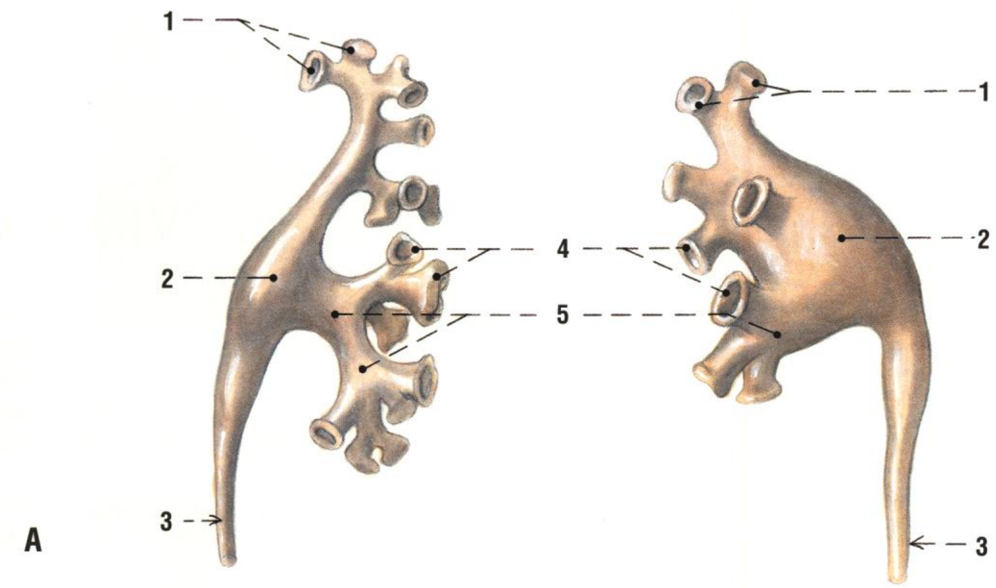
ledvinový kanálek dlouhý až 46 mm

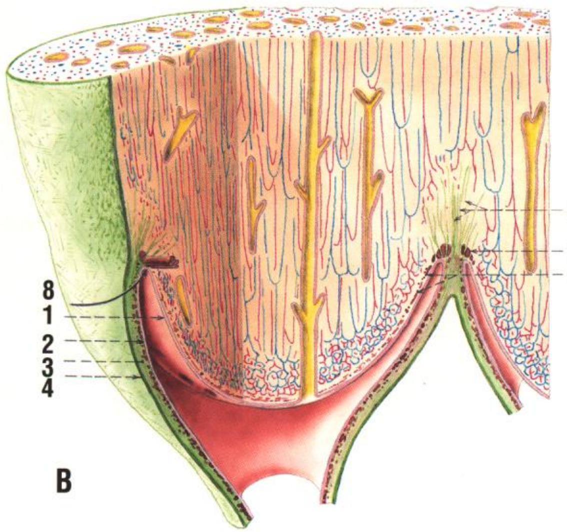
do každého odvodného kanálku ústí 5-10 nefronů

◀ Obr. 184. SCHÉMA VĚTVENÍ CÉV V LEDVINĚ a úprava cév u kortikálních a juxtamedulárních glomerulů

I cortex
II subcortex, v něm jeden z juxtamedulárních glomerulů se spojkou mezi arteriola afferens a arteriola efferens (paraglomerulus)
III zevní dřeň
IIIa zevní dřeň – zevní proužek
IIIb zevní dřeň – vnitřní proužek
IV vnitřní dřeň
V oblast papily
1 a. arcuata
2 a. interlobularis
3 arteriolae glomerulares afferentes
4 arteriola glomerularis efferens
5 peritubulární kapilární pleteň
6 arteriolae rectae (medullares)
7 kapilární pleteně v zevním proužku s hustými oky kolem kanálků
8 kapilární pleteně ve vnitřním proužku s prodlužujícími se oky
9 kapilární pleteně s výrazně podlouhlými oky ve vnitřní dřeni
10 husté kapilární pleteně kolem tenkých ramének Henleových kliček
11 kapilární pleteň kolem ústí ductus papillaris
12 venulae stellatae
13 v. interlobularis
14 žíly sbírající se z peritubulární kapilární pleteně
15 v. arcuata
16 venulae rectae medullares

Struktura savčí ledviny





Obr. 194. LEDVINOVÉ KALICHY A LEDVINOVÁ PÁNVIČKA; pohled zpředu

A KALICHY A PÁNVIČKA

vlevo – TYP DENDRITICKÝ (levá strana)

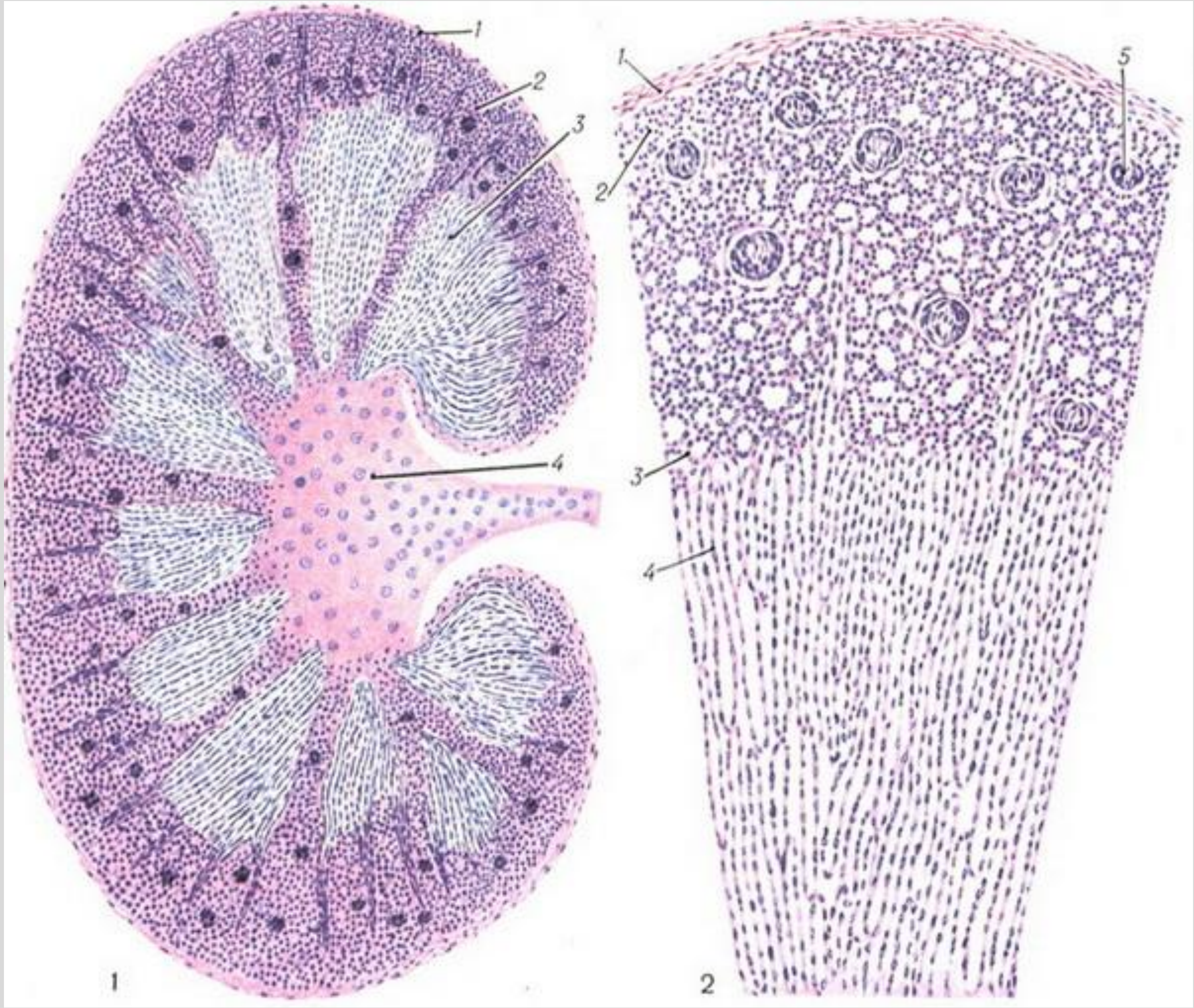
vpravo – TYP AMPULÁRNÍ (pravá strana)

1 calices renales
2 pelvis renalis
3 ureter
4 calices renales minores
5 calices renales majores

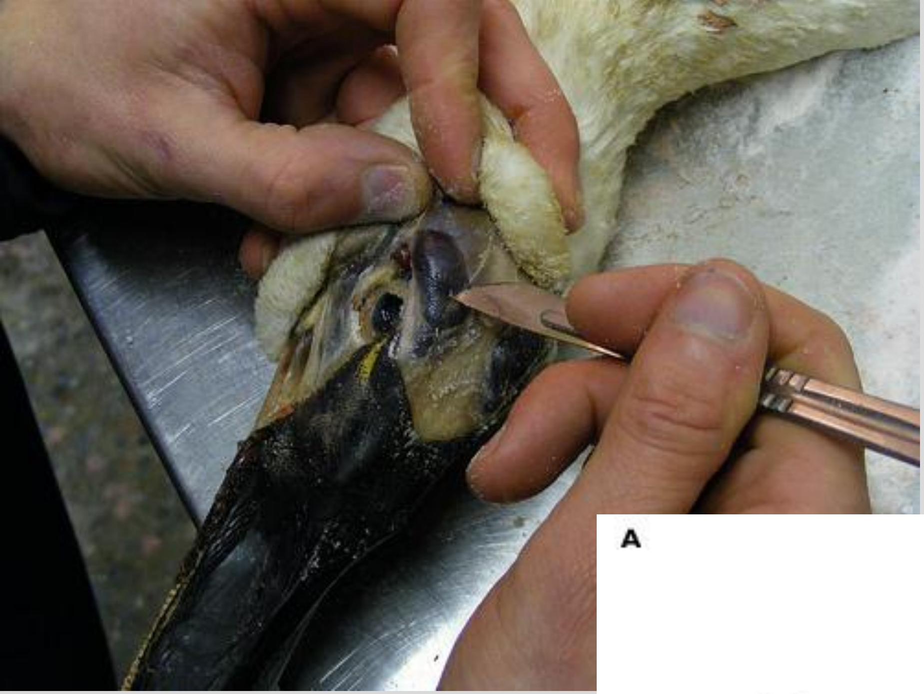
B DETAIL PŘIPOJENÍ KALICHU NA PAPILU; schéma

1 epithel na povrchu papily (epithel jednovrstevný cylindrický)
2 epithel kalichu (přechodní epithel)
3 vazivově-svalová stěna kalichu
4 vazivová adventicie kalichu
5 fixační vazivová vlákna pronikající ze stěny kalichu do nitra papily
6 cirkulární hladká svalovina ve formě svěrače papily
7 podélná a cirkulární hladká svalovina v papile
8 kritické místo na styku epithelů papily a kalichu, v místě průniku vazivových vláken do nitra papily, kde může dojít k protržení tkáně ledviny při městnání moče v kalichu

Struktura savčí ledviny



Solné žlázy



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The salt glands of birds are located just above the eyes (arrows).