



Pavel Němec

III. TRÁVÍCÍ & VZLUČOVACÍ SYSTEM

Členění a embryonální původ trávicího traktu

**Trávicí trubice –
endodermální původ**

**Proctodeum a
stomodeum –
ektodermální původ**

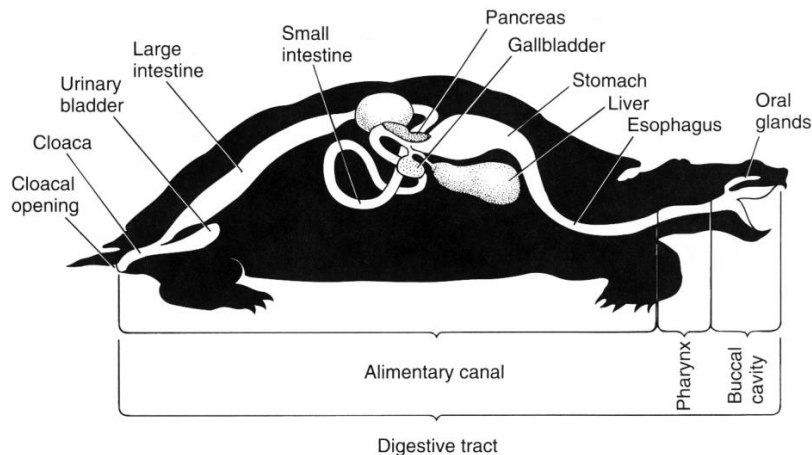
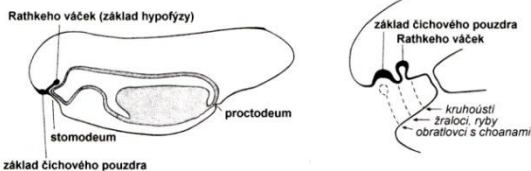
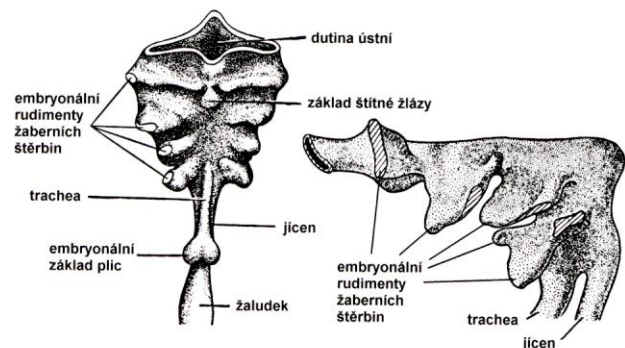
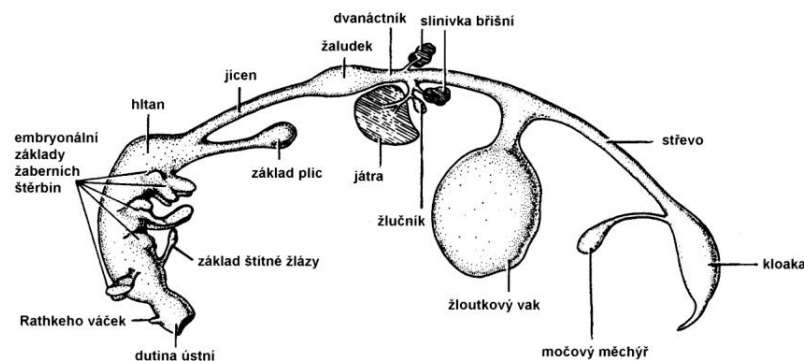


FIGURE 13.1 Vertebrate digestive system. The digestive system consists of the digestive tract plus associated glands of digestion. The digestive tract includes the buccal cavity, pharynx, and alimentary canal. The alimentary canal is divided into esophagus, stomach, intestines, and cloaca.



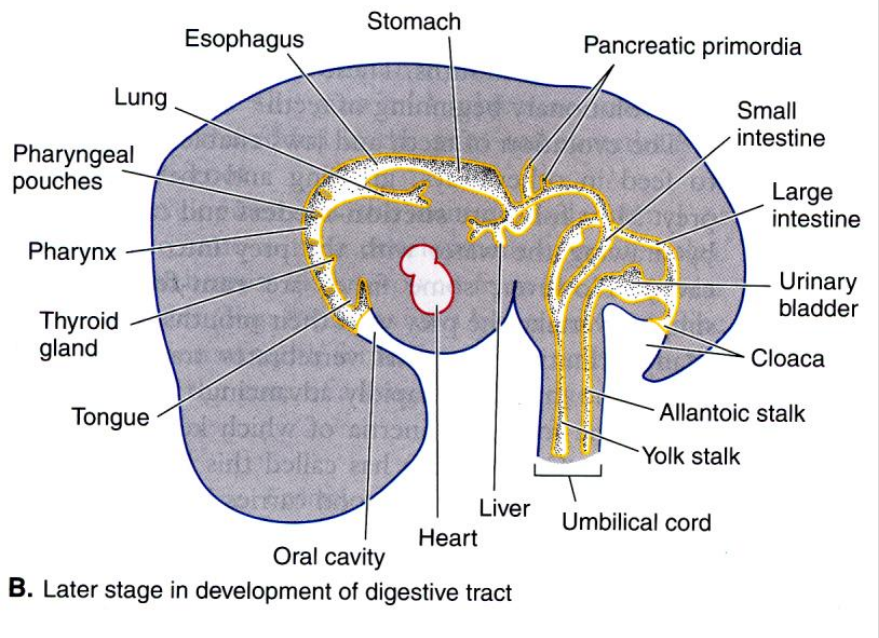
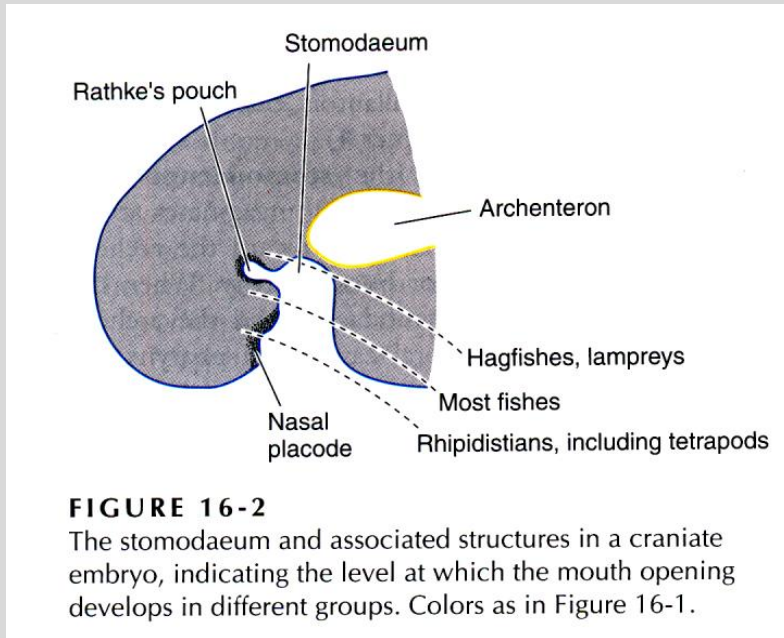
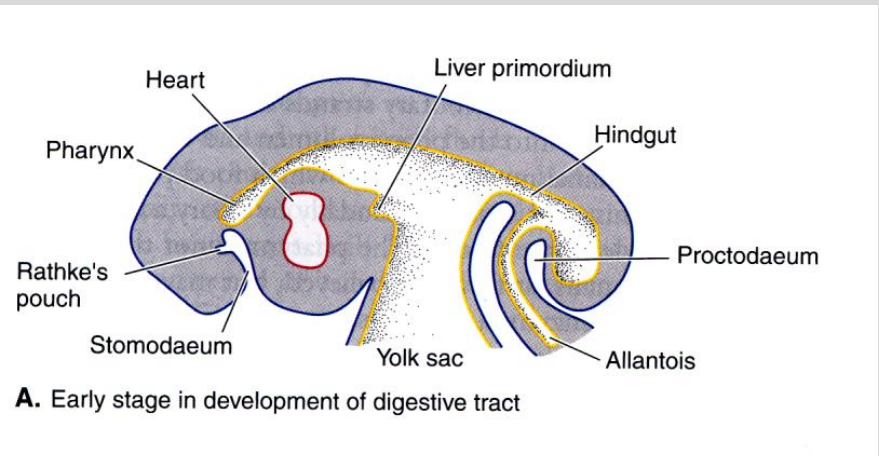
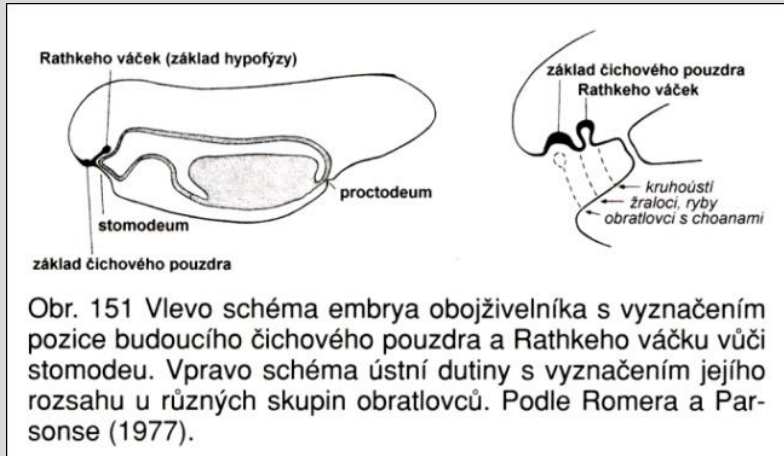
Obr. 151 Vlevo schéma embrya obojživelníka s vyznačením pozice budoucího čichového pouzdra a Rathkeho váčku vůči stomodeu. Vpravo schéma ústní dutiny s vyznačením jejího rozsahu u různých skupin obratlovců. Podle Romera a Parsonse (1977).

Obr. 154 Schéma embryonální trávicí soustavy suchozemského obratlovce v konečném stadiu trávení žlutkového vaku. Z Romera a Parsonse (1977).



Obr. 155 Pohled na přední část trávicí trubice embrya savce (člověk) z ventrální (vlevo) a laterální strany (vpravo) se základem plic a žaberních štěrbin. Podle Areye, z Romera a Parsonse (1977).

Embryonální původ trávicího traktu

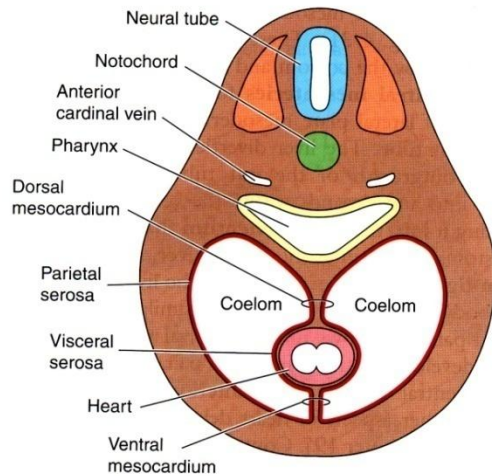


Embryonální původ trávicího traktu

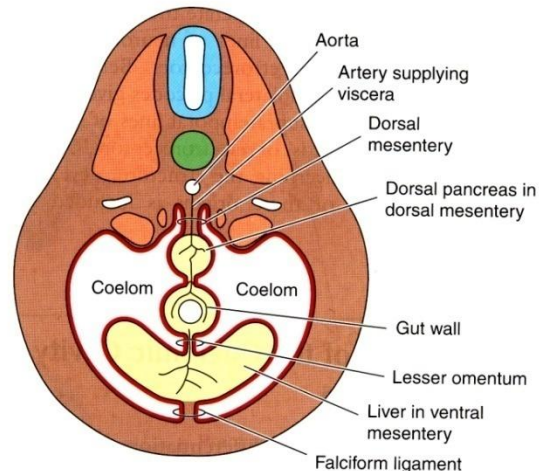
Endoderm prvostřeva:
Výstelka trávicího traktu a jeho derivátů (výstelka plic, sekreční buňky jater, slinivky břišní)

Mesoderm – splanchopleura coelomových váčků:
Svalová a vazivová stěna trávicí trubice a jejich derivátů

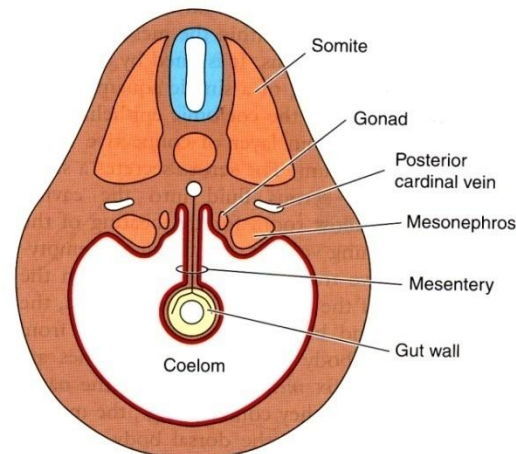
V hlavové a branchiální oblasti jsou svaly ze somitů, vazivo z neurální lišty



A. Transverse section at level of heart



B. Transverse section at level of liver



C. Transverse section at level of intestine

FIGURE 4-31

Structural relationships of coelom, mesenteries, and viscera in transverse sections of idealized vertebrate embryos.

A, The heart develops by fusion of left and right precardiac vessels in the ventral mesentery (mesocardia) cranial to the liver. B, The liver grows into the ventral mesentery, and the dorsal pancreas grows into the dorsal mesentery. C, Much of the ventral mesentery disappears caudal to the liver, and the left and right coelomic spaces become confluent. (Modified from Corliss.)

Embryonální původ štítné žlázy, příštitných žláz, brzlíku

Štítná žláza – glandula thyroidea

Nepárová výchlípka ventrální stěny hltanu, produkuje thyroxin, trijodthyronin, všichni obratlovci, jejím homologem je endostyl kopinatců a pláštěnců.

Brzlík – thymus

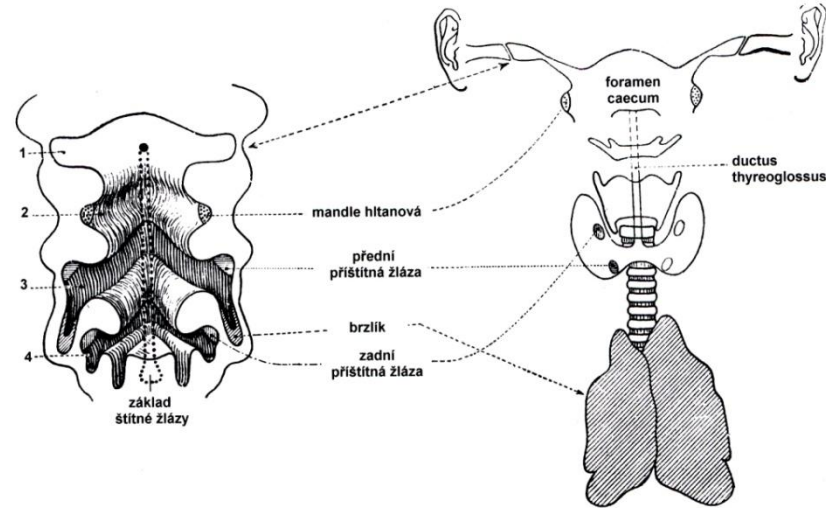
Vznik z žaberních váčků, segmentální původ variabilní mezi obratlovci.

Příštitné žlázy – glandulae parathyroideae

Vznik z epitelu 3 a 4 žaberního váčku za čelistmi, u tetrapodních obratlovců.

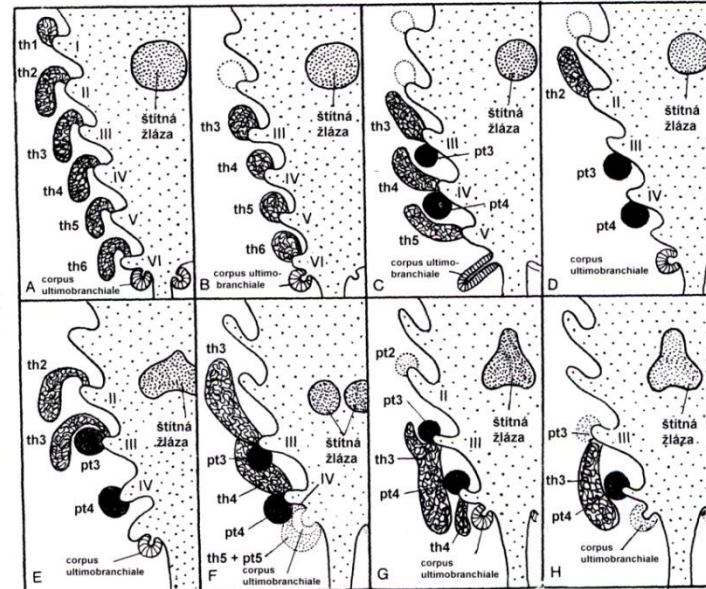
Ultimobramchiální tělíska – corpus ultimobranchiale

Vodní čelistnatci, produkují kalcitonin, který snižuje hladinu vápníku v krvi a podporuje jeho ukládání v kostech.

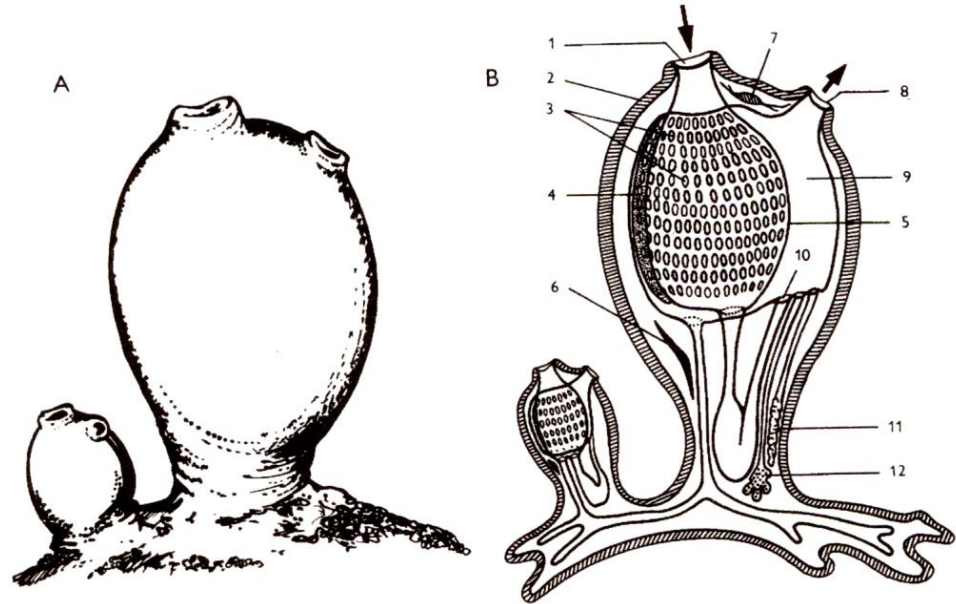
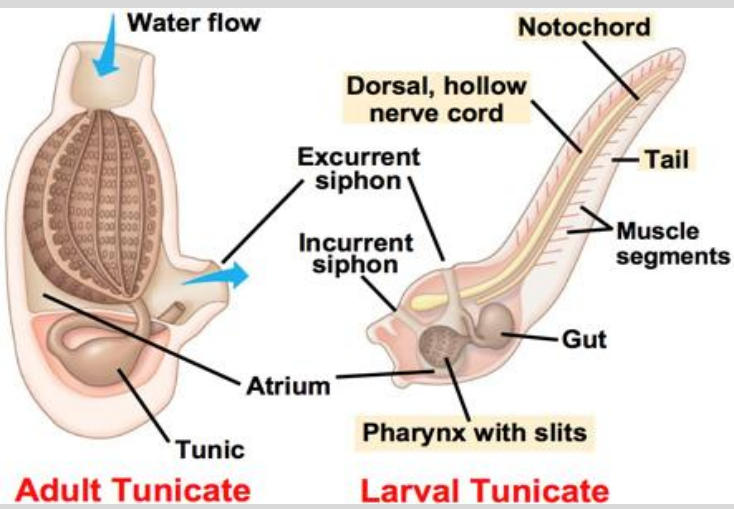


Obr. 159 Ontogenetický vývoj štítné žlázy a dalších orgánů vznikajících z epitelu žaberních výchlípek u člověka. Vlevo horizontální řez hltanem embrya, vpravo situace u dospělého člověka. Číslice označují pořadí žaberních štěrbin za čelistmi (první je spiraculum, které se v definitivním stavu mění u suchozemských tetrapodů na dutinu středního ucha a Eustachovu trubici). Podle Cunninghama, z Borovanského a kol. (1976).

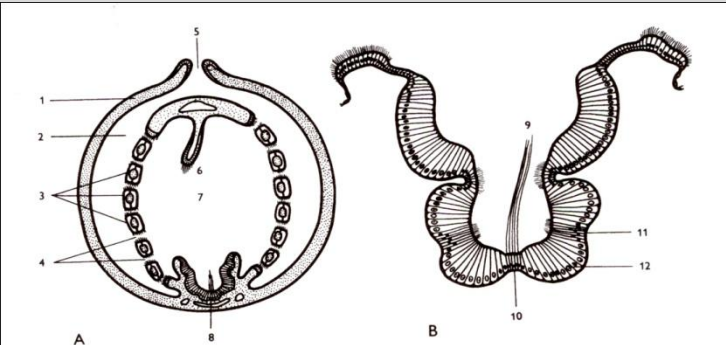
Obr. 158 Schematické znázornění vývoje orgánů vznikajících ze stěn výchlípek na levé části hltanu (dutina hltanu je vyčleněná). A – Chondrichthyes, B – Osteichthyes, C – Caudata, D – Anura, E – Lepidosauria, F – Aves, G – Carnivora, H – Insectivora. Zkratky: pt – příštitné žlázy, th – brzlík. Římské číslice označují pořadí žaberních oblouků za čelistmi. Pro orientaci zakreslena rovněž štítná žláza. Podle Maurera, z Grodzinského a kol. (1976).



Hltan (Pharynx) – Pláštěnci (Tunicata)

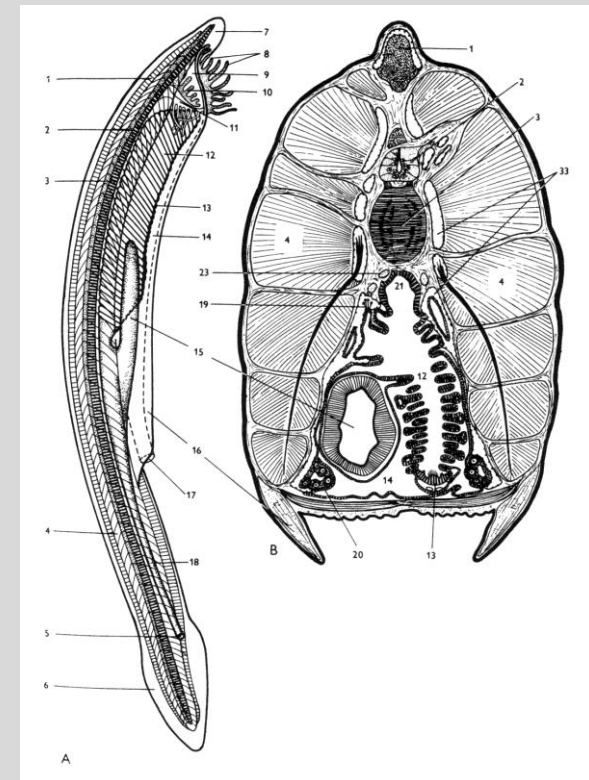
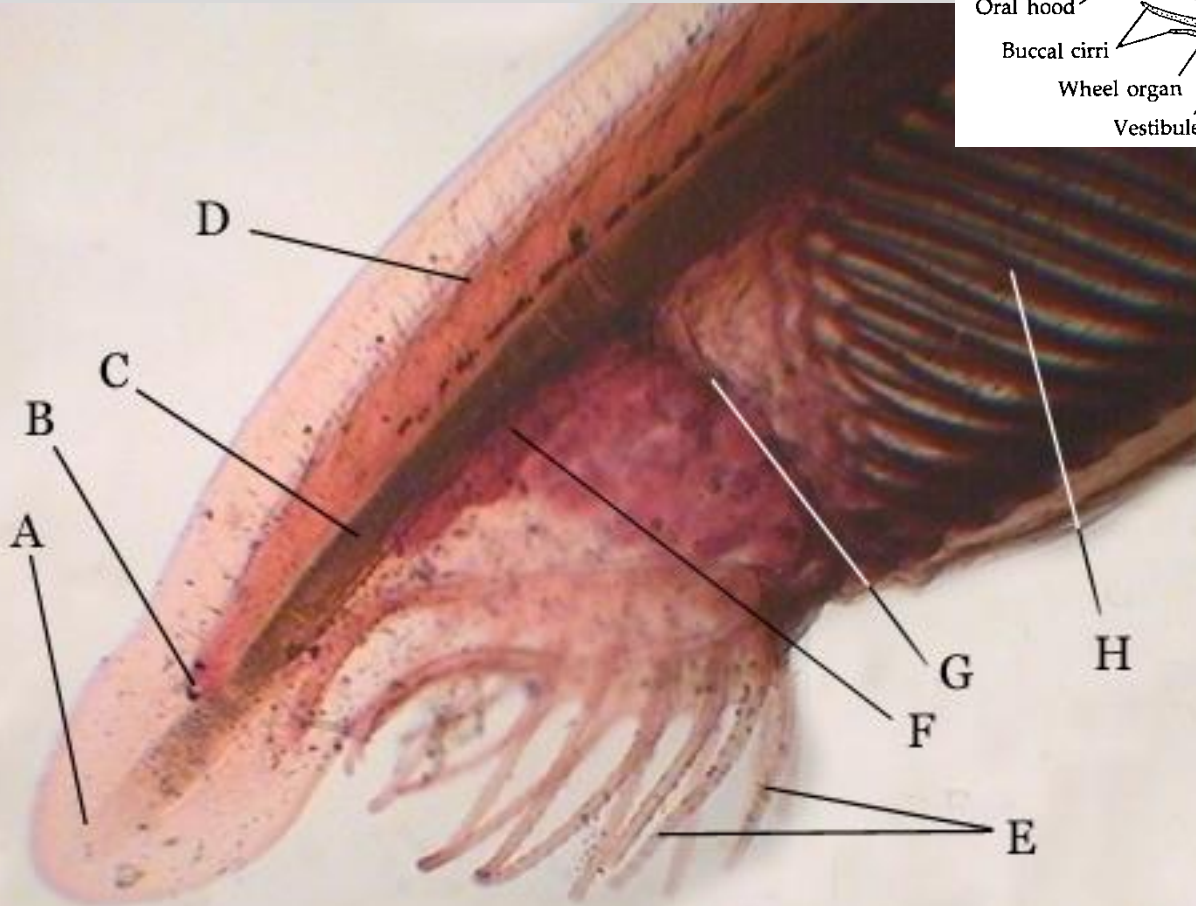
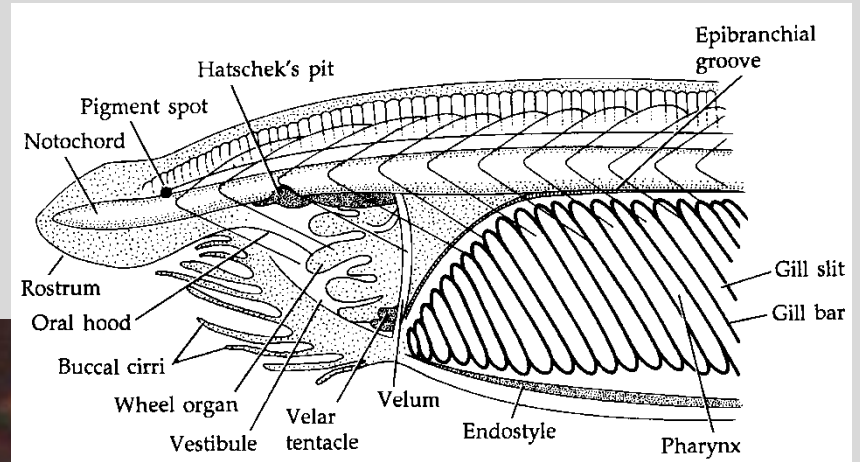
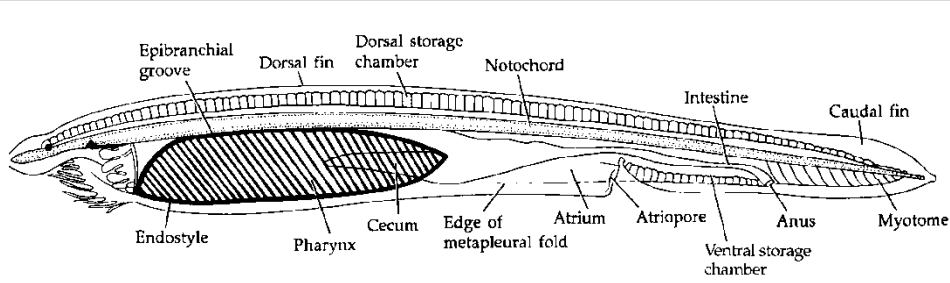


Obr. 12 Vzhled a morfologie dospělých sumek. A – dva jedinci rodu *Halocynthia*, B – schéma jejich anatomie. 1 – přijímací otvor, 2 – tělní stěna a plášť, 3 – žaberní štěrby, 4 – endostyl, 5 – hltan, 6 – srdce, 7 – cerebrální ganglion, 8 – vyvrhovací otvor (kloakální sifon), 9 – kloakální dutina obžaberního prostoru, 10 – vyústění střeva (řitní otvor), 11 – varle, 12 – vaječník.

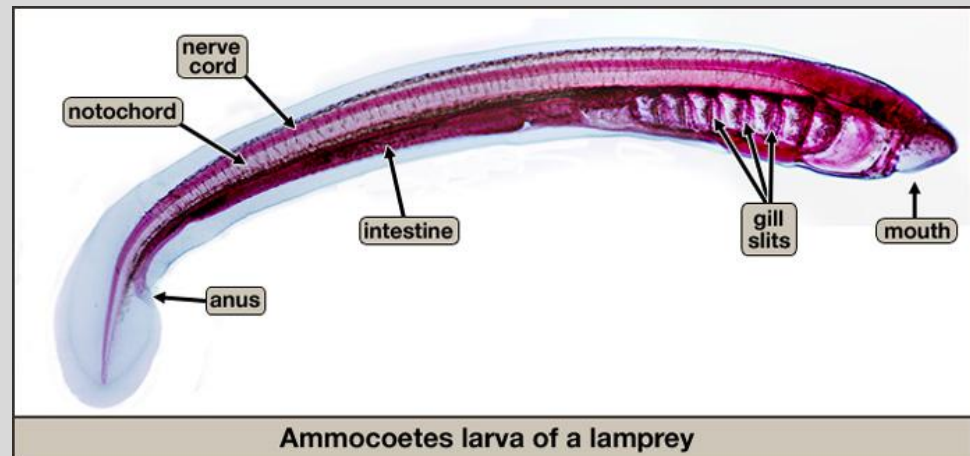
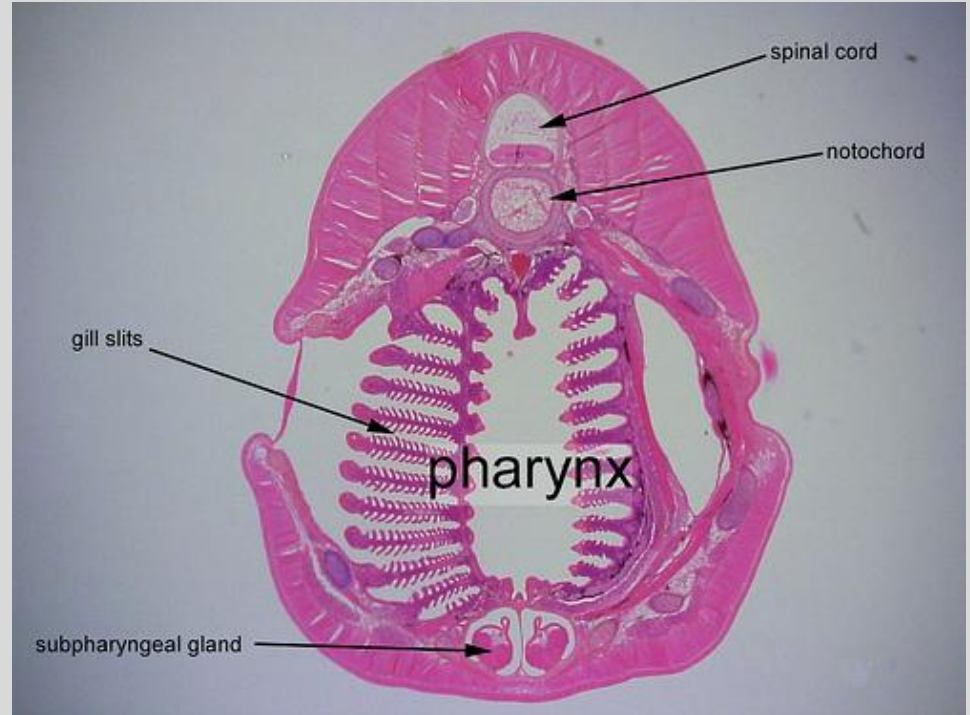


Obr. 9 Šikmý řez krajinou hltanu přes vyvrhovací otvor (A) a příčný řez endostylem (B) pláštěnců (Urochordata). 1 – tělní stěna, 2 – obžaberní prostor, 3 – žaberní přepážky, 4 – žaberní štěrby, 5 – vyvrhovací otvor (*atrioporus*), 6 – epibranchiální lišta, 7 – dutina hltanu, 8 – hypobranchiální rýha (endostyl), 9 – bičíky endostylu, 10 – bičíkaté buňky, 11 – postranní obrvené buňky, 12 – žláznové buňky.

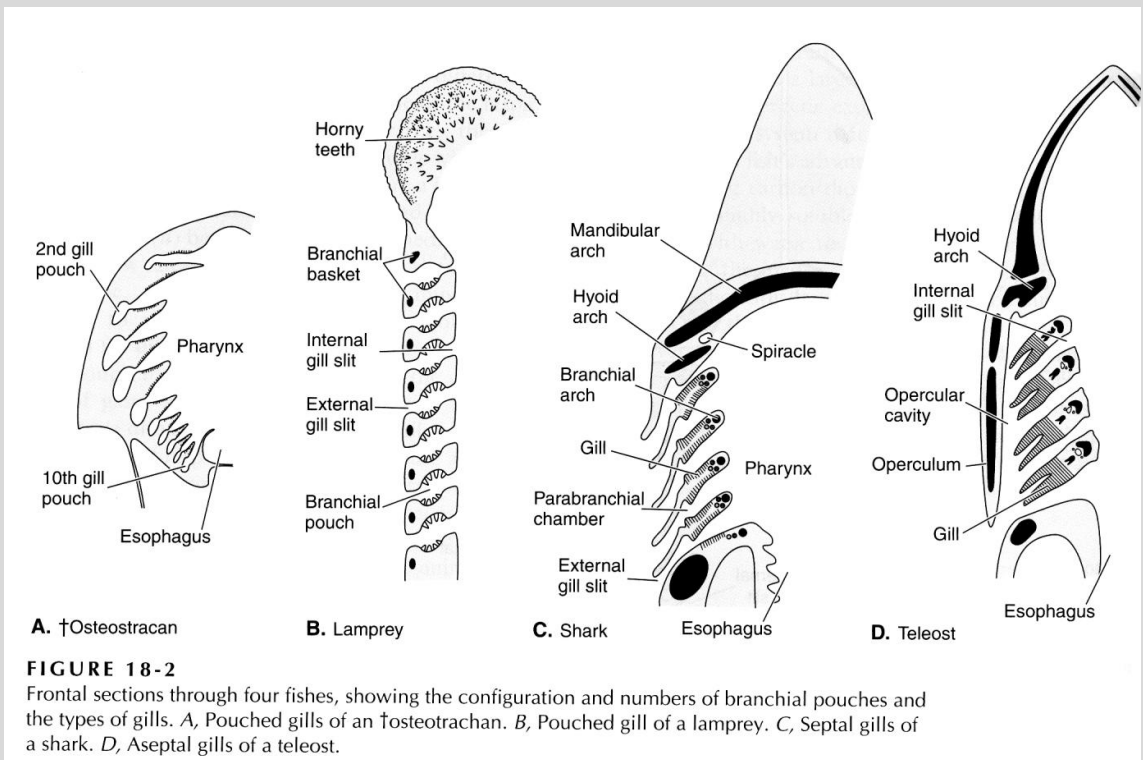
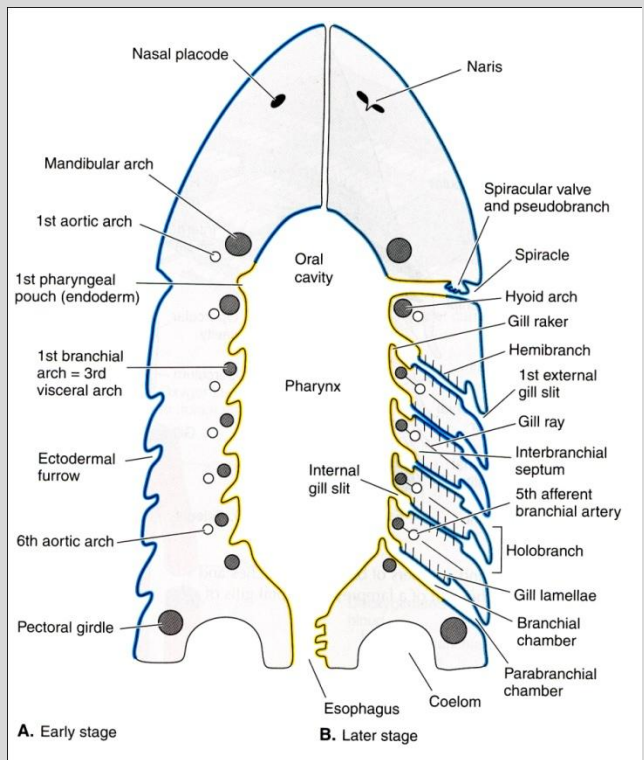
Hltan (Pharynx) – kopinatec (Branchiostoma)



Hltan (Pharynx) – larva mihule



Hitan (Pharynx) – rybovití obratlovci



Jícen (esofagus)

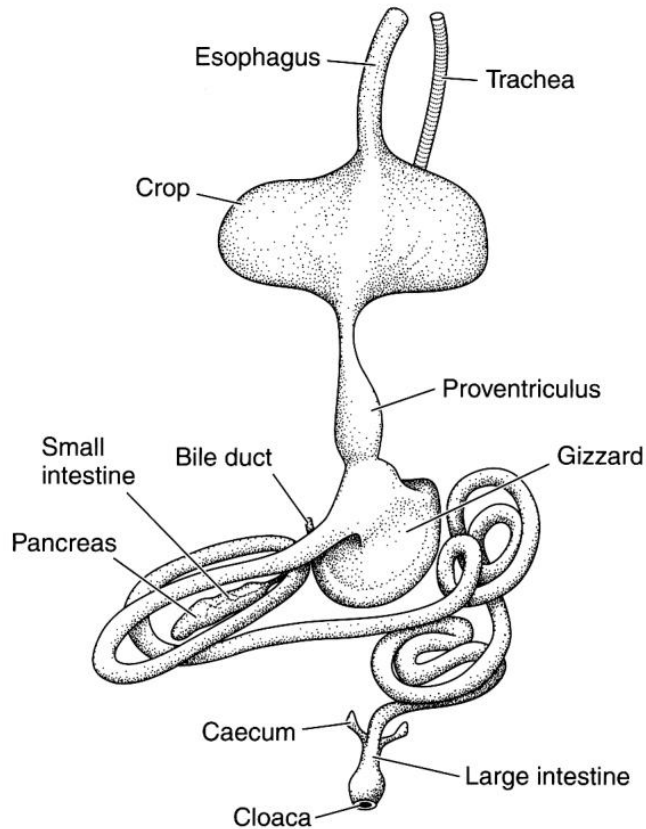


FIGURE 17-5

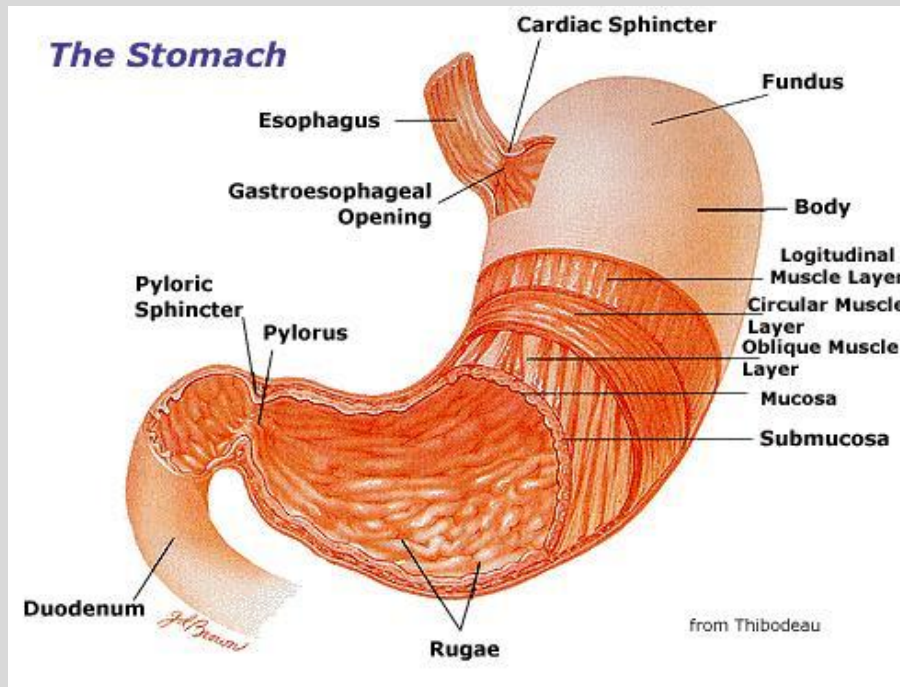
Ventral view of the digestive tract of a pigeon. The liver and pancreas have not been included, but the point of entrance of the bile duct is shown.

Ptáci – sodní část jícnu přeměněna ve vole (ingluvies) – slouží ke skladování a změkčení potravy , někdy i k bakteriální fermentaci (např. hoatzin)



u zvířat přijímajících tvrdou potravu může výstelka jícnu rohovatět

Žaludek (ventriculus)



Vrstvy:

Sliznice – epitel zprohýbaný tvoří žaludeční jamky do kterých ústí tubulózní žlázy, lamina propria (řídke vazivo obsahující roztroušené buňky hladké svaloviny)

Lamina muscularis mucosae – vrstva hladké svaloviny

Submukóza – řídke podslizniční vazivo s krevními a lymfatickými cévami

Lamina muscularis externa – tři vrstvy hladkého svalstva



Sliznice a podslizniční vazivo tvoří na vyprázdněném žaludku řasy (rugae). SEM



Žaludek (ventriculus)

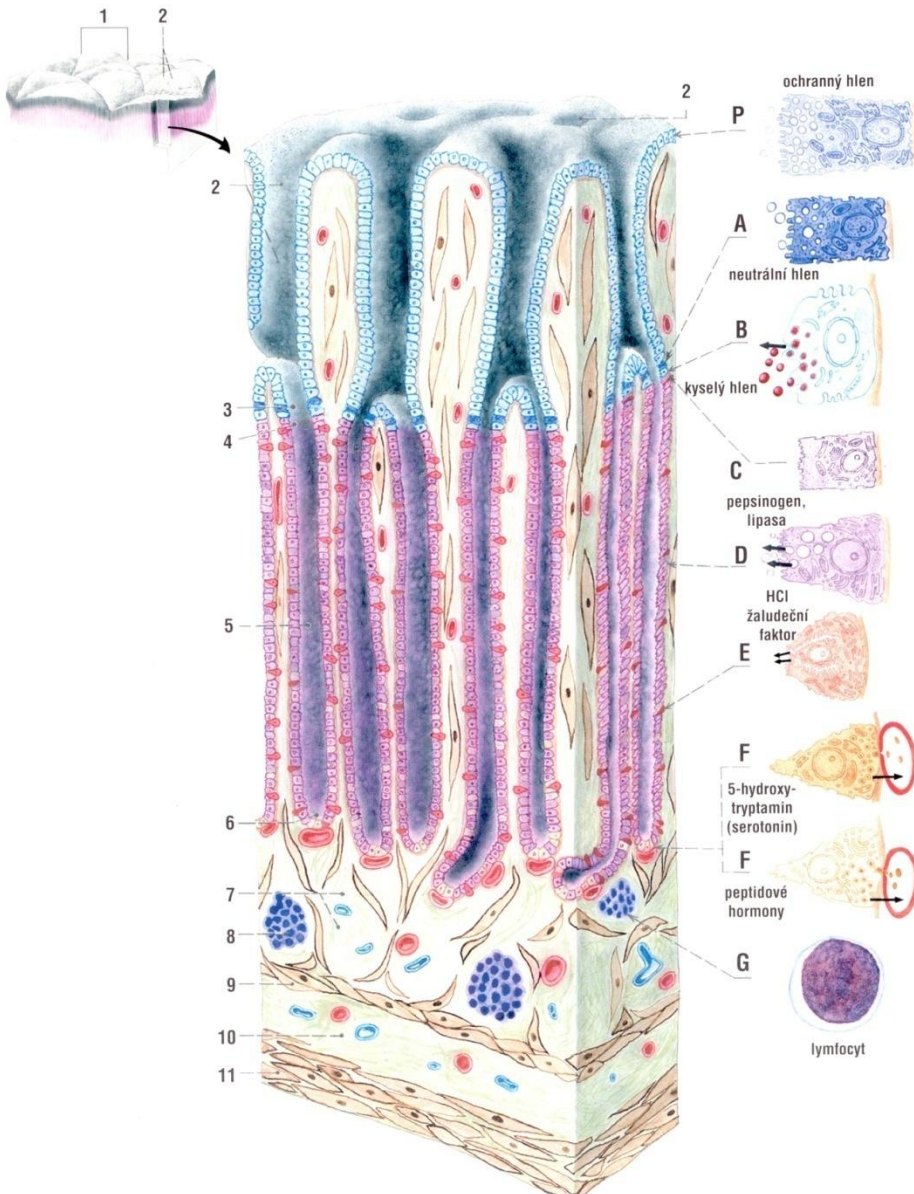
Vrstvy:

Sliznice – epitel zprohýbaný tvoří žaludeční jamky do kterých ústí tubulózní žlázy, lamina propria (řídke vazivo obsahující roztroušené buňky hladké svaloviny)

Lamina muscularis mucosae – vrstva hladké svaloviny

Submukóza – řídké podslizniční vazivo s krevními a lymfatickými cévami

Lamina muscularis externa – tři vrstvy hladkého svalstva

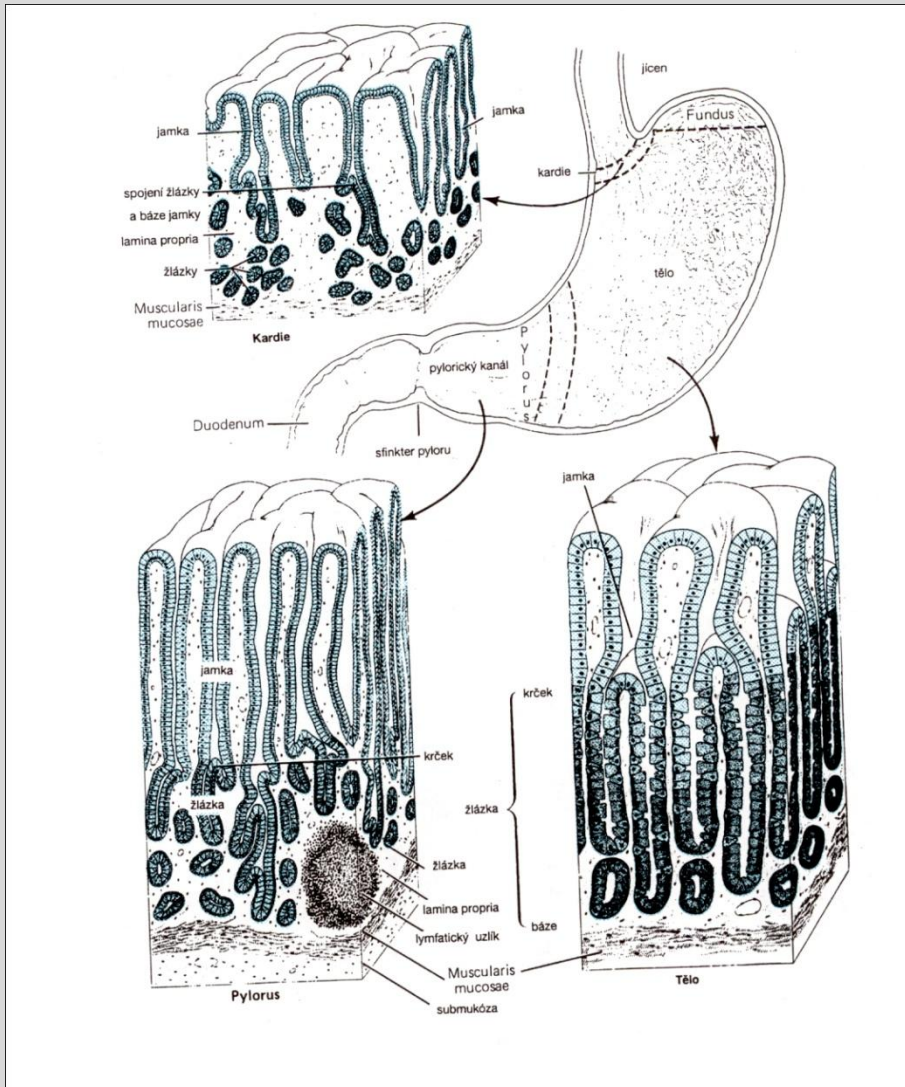


► Obr. 53. STAVBA SLIZNICE ŽALUDKU; žlázy těla žaludku; schematický model (modifikováno podle Gray's anatomy, 38. vyd., Churchill Livingstone, 1995)

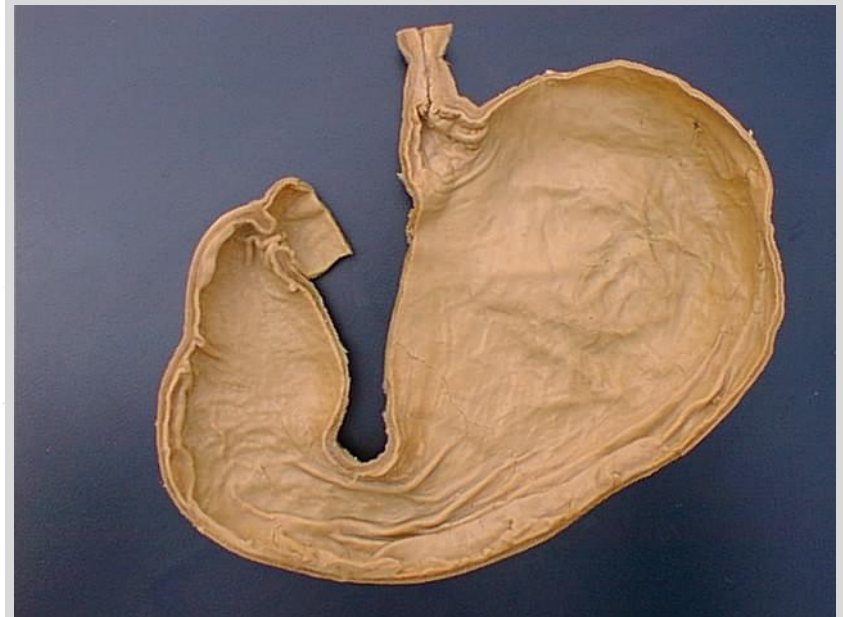
- 1 areae gastricae
- 2 foveolae gastricae, do jejichž dna ústí glandulae gastricae
- 3 isthmus žlázy
- 4 krček žlázy
- 5 tělo žlázy
- 6 dno žlázy
- 7 lamina propria mucosae
- 8 lymfatický uzlík v lamina propria
- 9 lamina muscularis mucosae
- 10 tela submucosae

- 11 tunica muscularis
- P buňka povrchového epitelu
- A hlenová buňka isthmus žlázy
- B hlenová buňka krčku žlázy
- C nediferencovaná (kmenová) buňka
- D hlavní buňka
- E krycí buňka
- F endokrinní buňky
- G lymfocyt mizního uzlíku

Oddíly žaludku a jejich histologická stavba



Pars cardiaca – česlo, žaludeční jamky mělké, v lamina propria jednoduché nebo větvené žlázky s prostorným lumen, produkce hlenu, lysozymu a HCl
Fundus & Corpus – jamky delší, rozvětvené tubulózní žlázky, produkce HCl, pepsinogenu, lipázy, hlenu
Pylorus – vrátník, hluboké žaludeční jamky, krátké stočené žlázy, produkce hlenu, lysozymu, gastrinu a somatostatinu



Žaludek obratlovců



Shark



Teleost



Salamander



Turtle



Snake



Alligator



Bird



Echidna



Kangaroo



Whale



Horse



Hippopotamus

-  Esophagus
-  Cardia
-  Fundus
-  Gizzard
-  Pylorus
-  Nonglandular epithelium



Ruminant



Llama



Deer mouse



Leaf-eating monkey



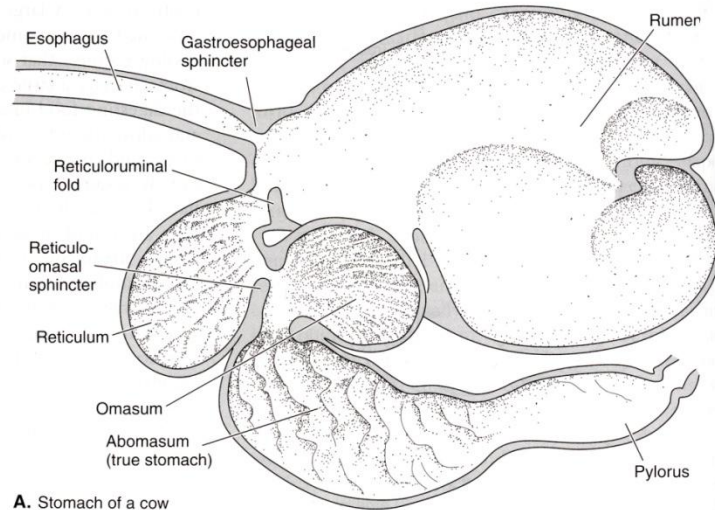
Human

Žaludek chybí u pláštěnců, kopinatců, sliznatek a mihulí, druhotně také u chimér a kaprovitých ryb

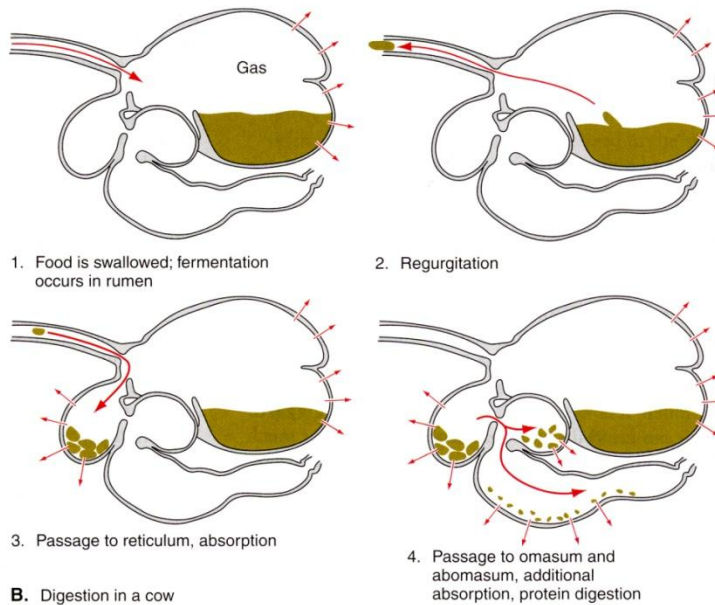
Složení žaludek přežvýkavců

FIGURE 17-6

A, The four chambers of the ruminant "stomach" as represented by a cow. Only the fourth chamber, the abomasum, is comparable with the stomach of other mammals. B, Rumination in a cow. Swallowed food accumulates in the rumen; is regurgitated through the esophagus and remasticated in the mouth, possibly several times; and finally passes through the reticulum and omasum into the abomasum. (Modified after Nickel et al., and Langer.)

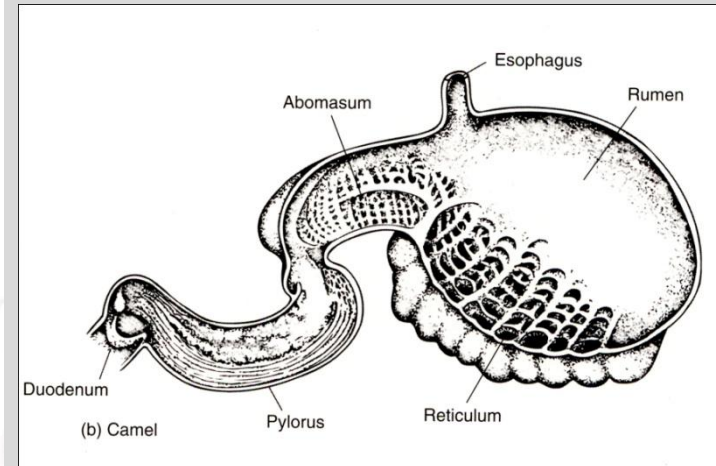


A. Stomach of a cow



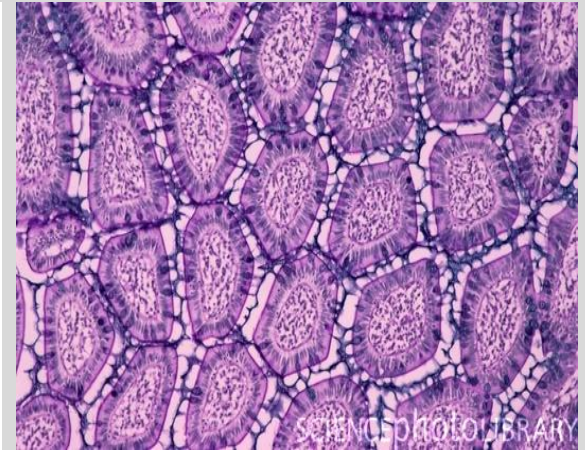
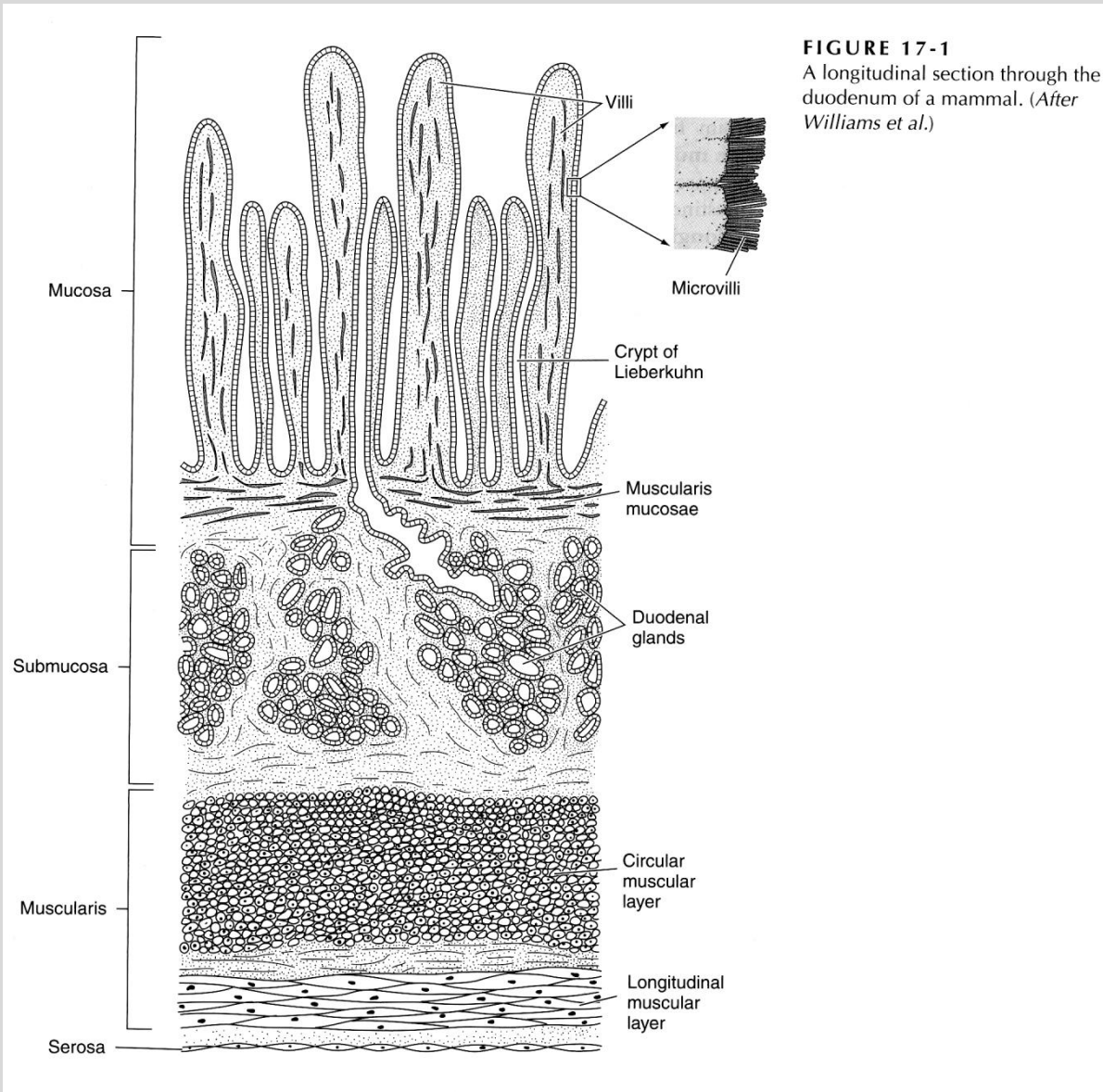
B. Digestion in a cow

Bachor (rumen)
Čepec (reticulum)
Kniha (omasum)
Slez (abomasum)



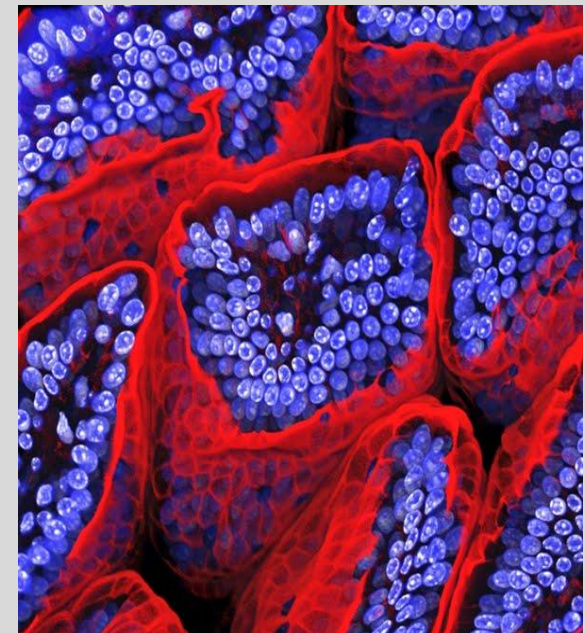
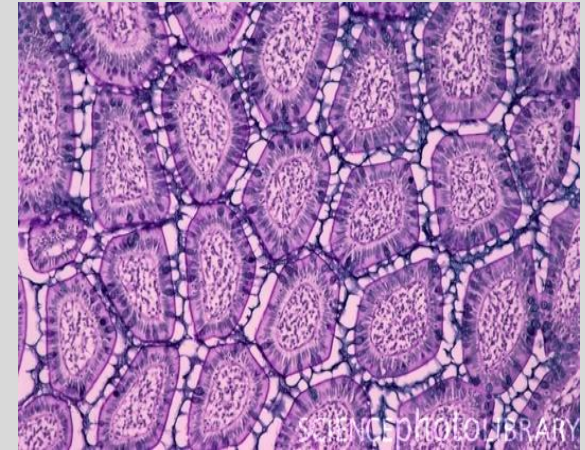
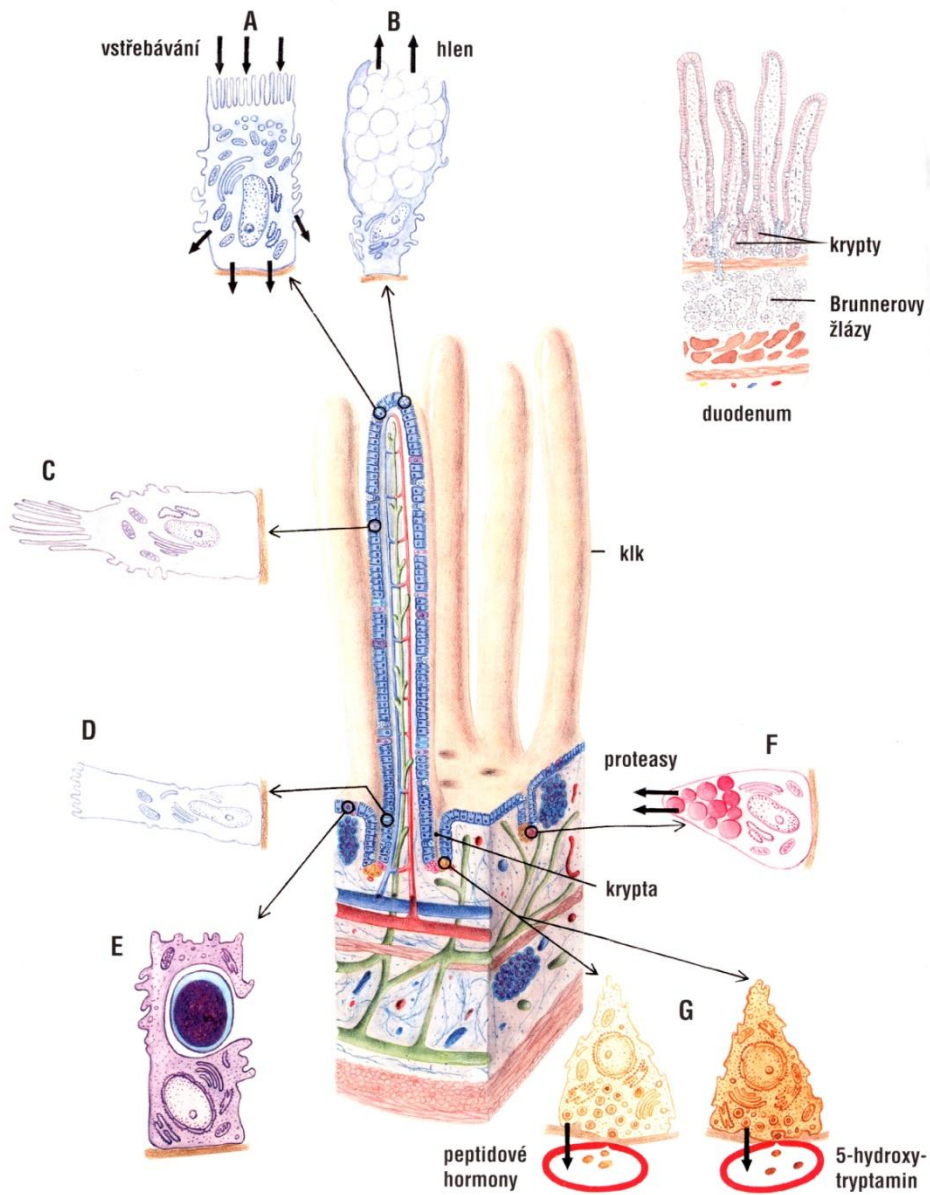
Jednodušší stavba žaludku u velblouda – nepatří mezi přežvýkavce (Ruminantia)

Stavba střeva



Klky tenkého střeva

Stavba střeva



Klyky tenkého střeva

Obr. 61. DETAIL STAVBY SLIZNICE TENKÉHO STŘEVA v jejunoileu; schematický model (modifikováno podle Gray's anatomy, 38. vyd., Churchill Livingstone, 1995)

vpravo nahore – histologický řez duodenem s Brunnerovými žlázami pod lamina muscularis mucosae

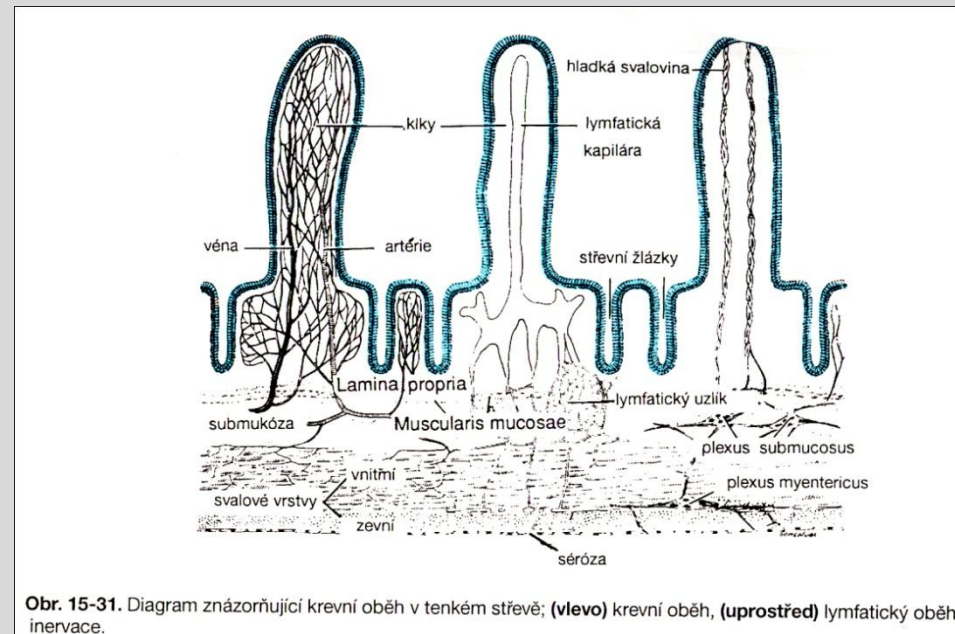
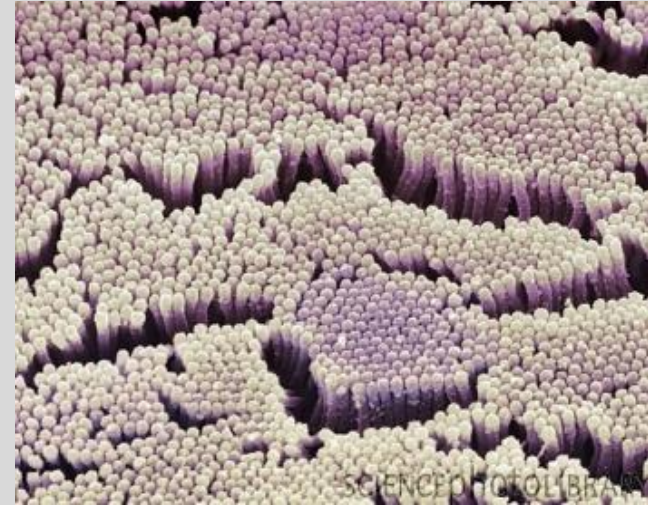
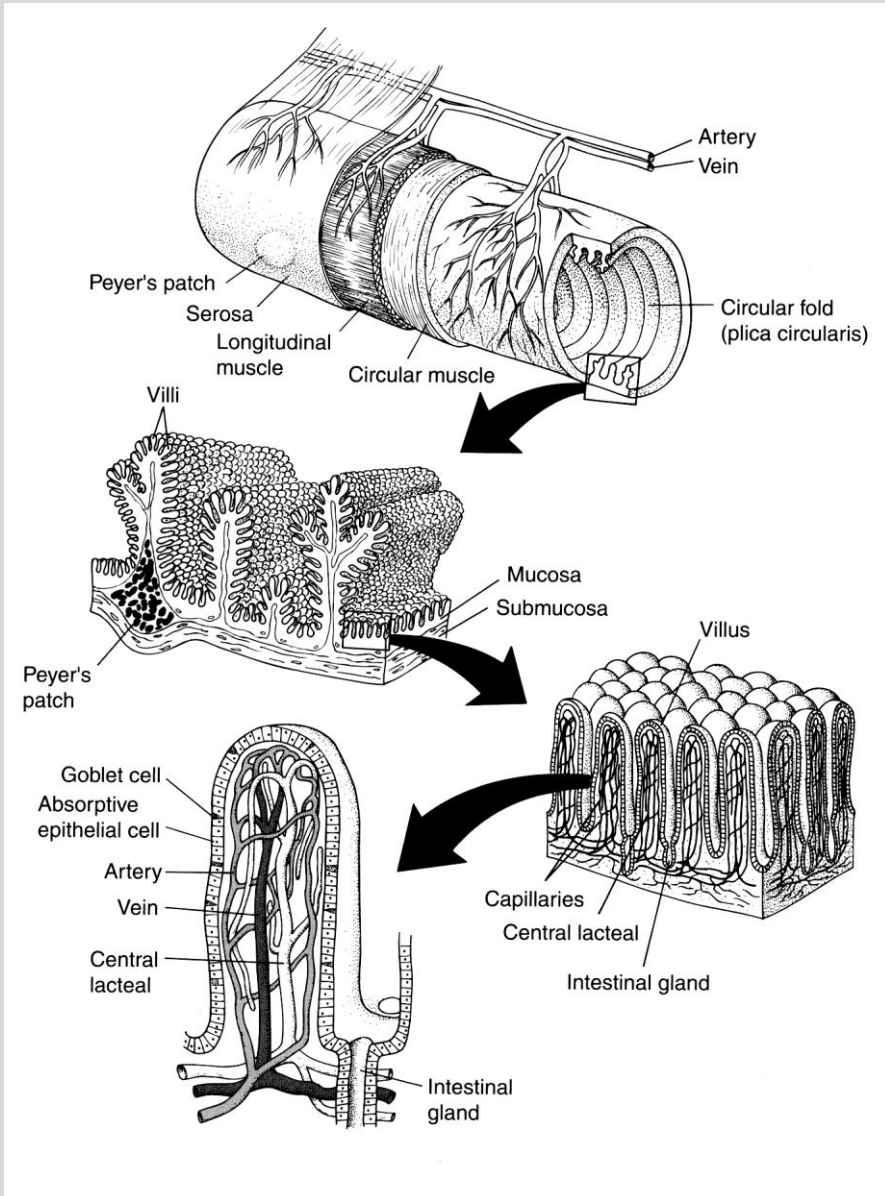
- A enterocyt
- B pohárková buňka
- C chomáčková buňka
- D nediferencovaná (kmenová) buňka
- E M-buňka

- F Panethova buňka
 - G endokrinní buňky
- červeně a modře – krevní cévy
zeleně – mízní cévy

peptidové
hormony

5-hydroxy-
tryptamin

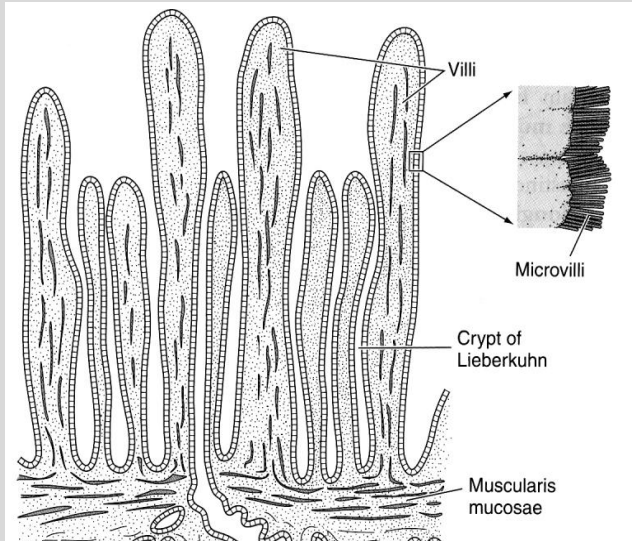
Stavba trávicí trubice



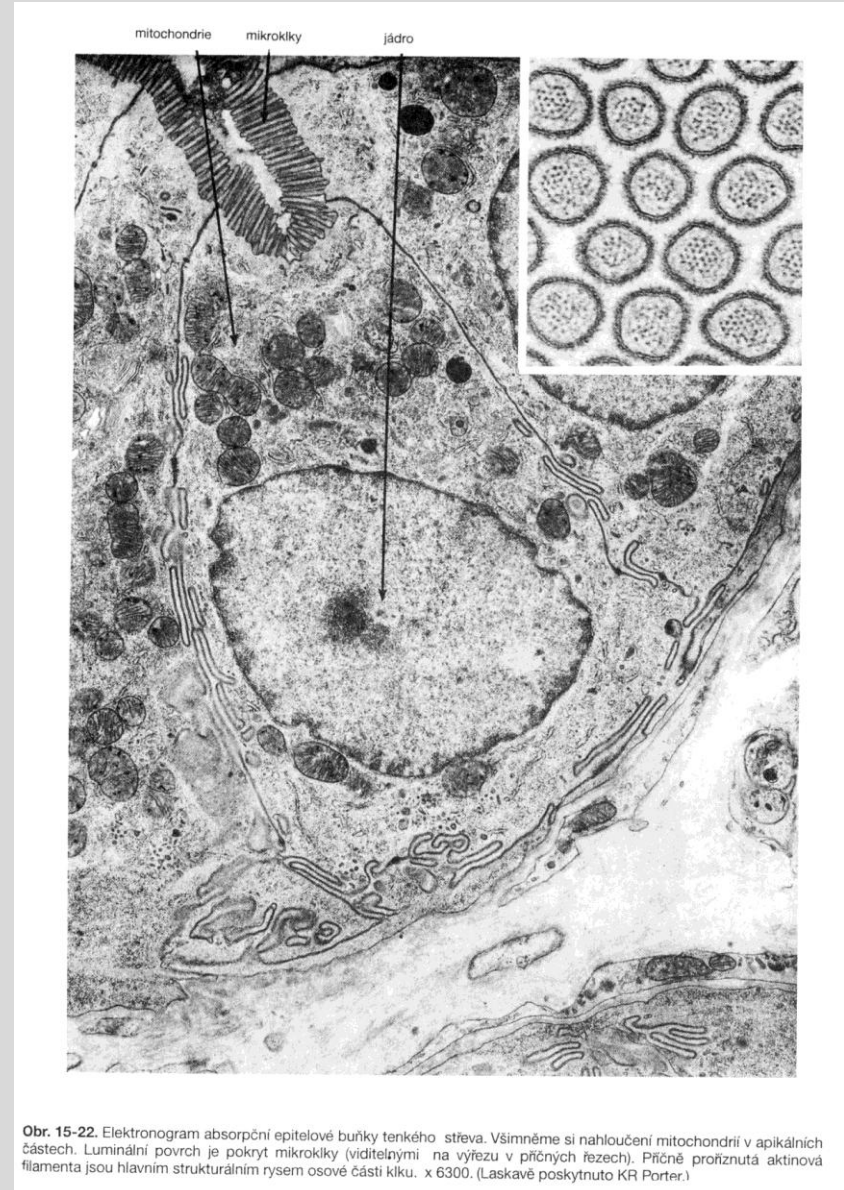
Obr. 15-31. Diagram znázorňující krevní oběh v tenkém střevě; (vlevo) krevní oběh, (uprostřed) lymfatický oběh, (vpravo) nervace.

Klky (villi intestinales)

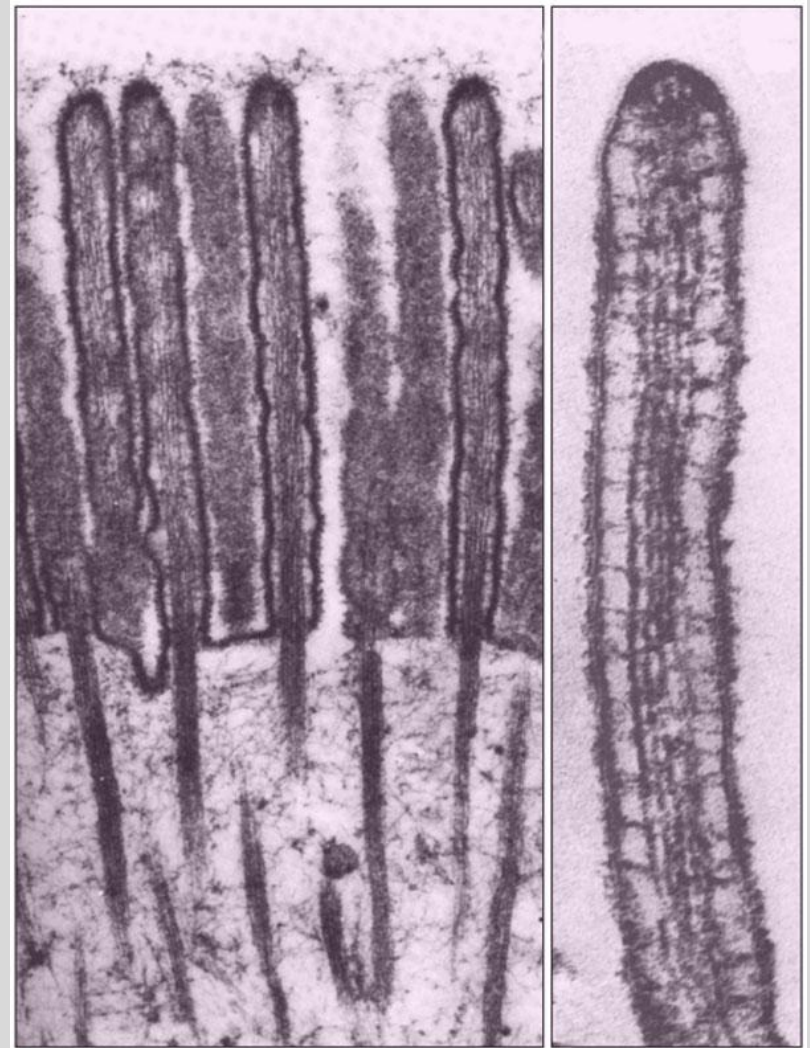
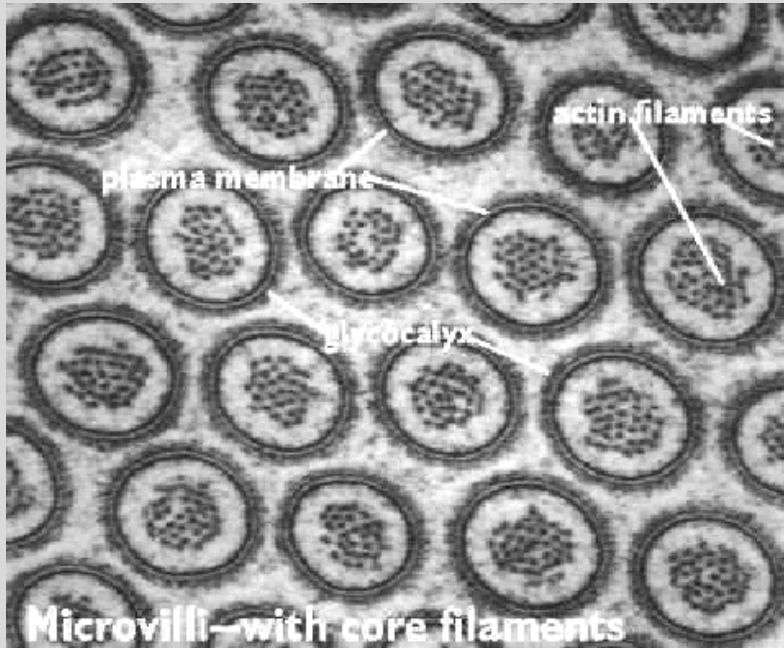
Stavba trávicí trubice



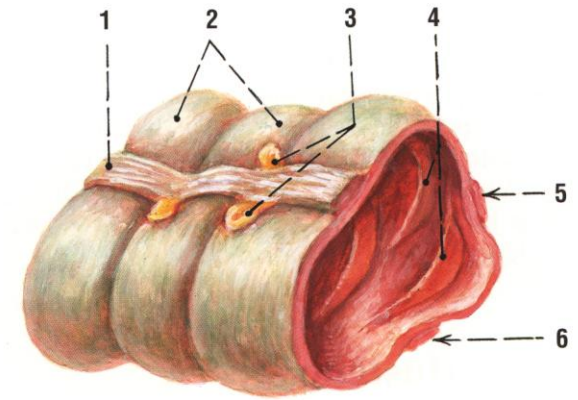
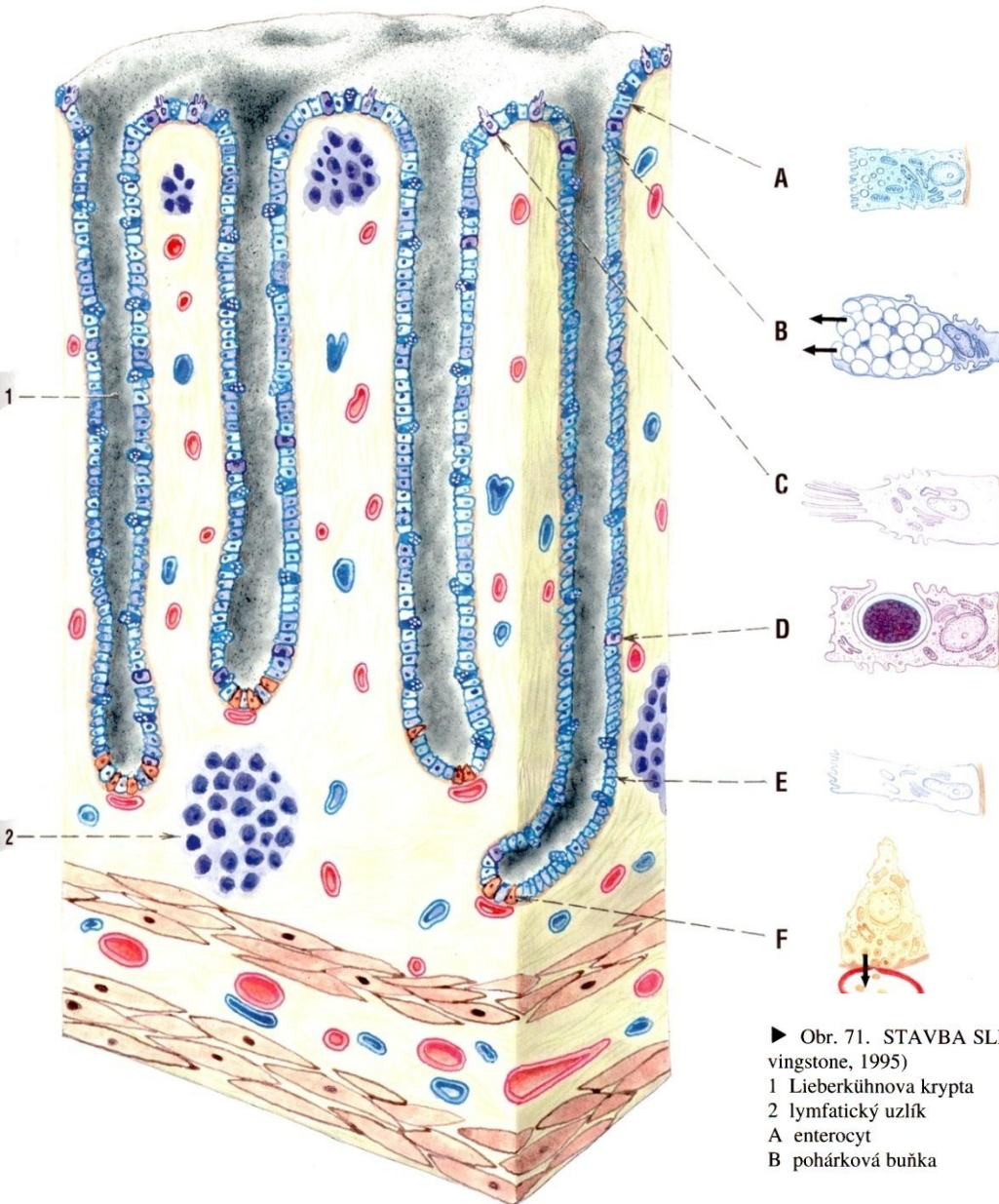
Mikroklky tenkého střeva



Mikroklky střeva



Trusté střevo



Obr. 70. CHARAKTERISTICKÉ ZNAKY TLUSTÉHO STŘEVA

- 1 taenia (taenia omentalis)
- 2 haustra
- 3 appendices epiploicae
- 4 plicae semilunares
- 5 taenia mesocolica
- 6 taenia libera

► Obr. 71. STAVBA SLIZNICE TLUSTÉHO STŘEVA; schematický model (modifikováno podle *Gray's anatomy*, 38. vyd., vington, 1995)

- 1 Lieberkühnova krypta
- 2 lymfatický uzlík
- A enterocyt
- B pohárková buňka

- C chomáčková buňka
- D M-buňka
- E nediferencovaná (kmenová) buňka
- F endokrinní buňka

Členění savčího trávicího traktu

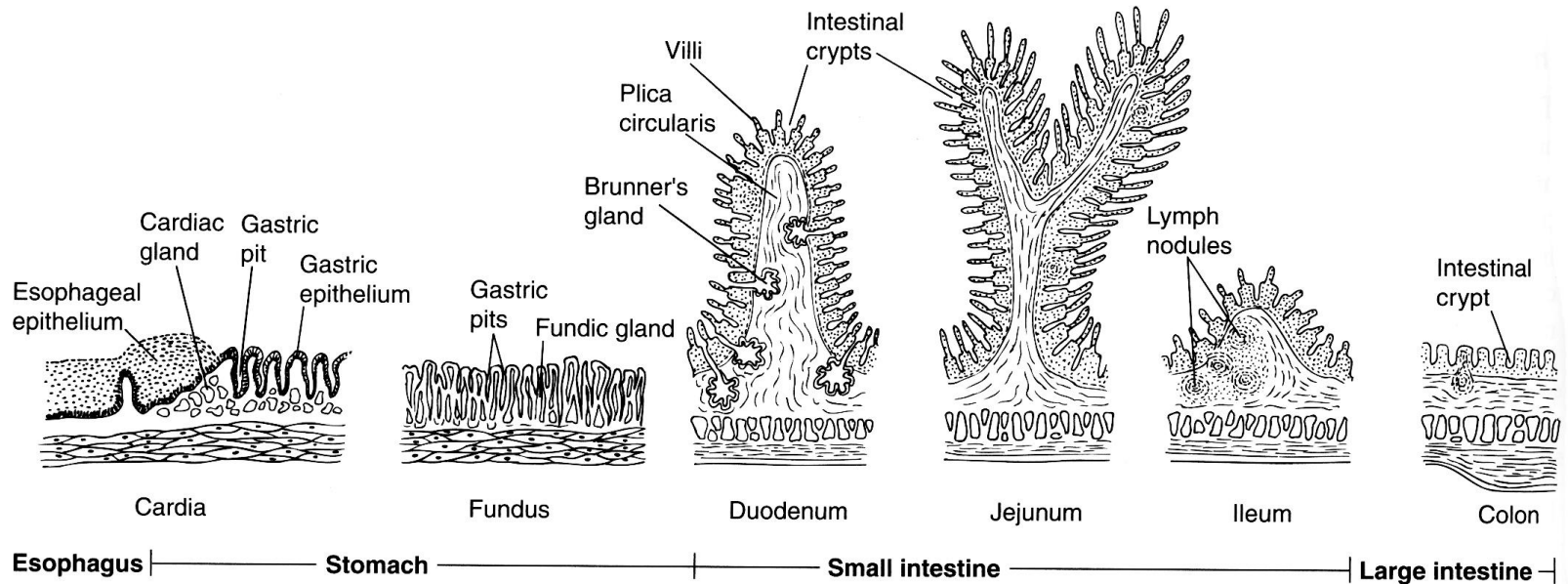


FIGURE 13.26 Comparative histology of the mucosa along the alimentary canal of a mammal. Note that the large intestine, like the small intestine, contains intestinal glands, but villi are absent.

Trávící trakt obratlovců

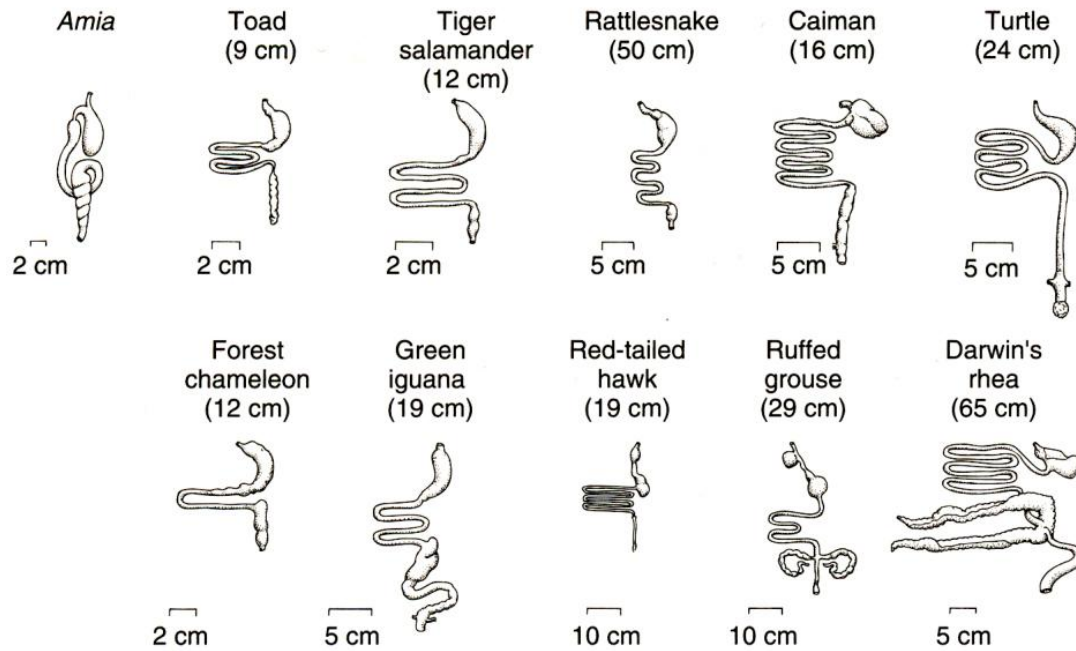


FIGURE 13.27 Variations within the stomach and intestines of lower vertebrates and birds. Amphibians, snakes, caimans, forest chameleons, and red-tailed hawks are carnivores with relatively short, unspecialized intestines. To prolong passage of digesta, various specializations occur, such as the spiral valve of the bowfin, ceca of some herbivores, or the double ceca of the grouse and rhea.

After Hume; Stevens; Degabriele.

Trávící trakt obratlovců

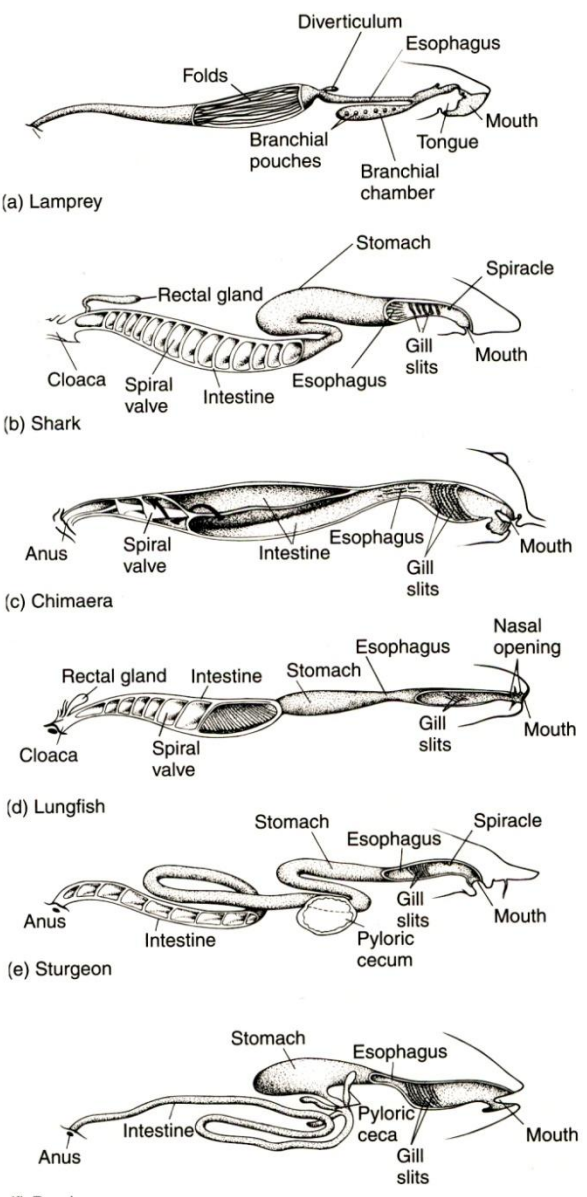


FIGURE 13.29 Digestive tracts of selected fishes.

(a) Lamprey. (b) Shark. (c) Chimaera. (d) Lungfish. (e) Sturgeon. (f) Perch. When a spiral valve is absent, the intestine is often lengthened, as in the perch.

(a) After Youson; (b-f) after Dean.

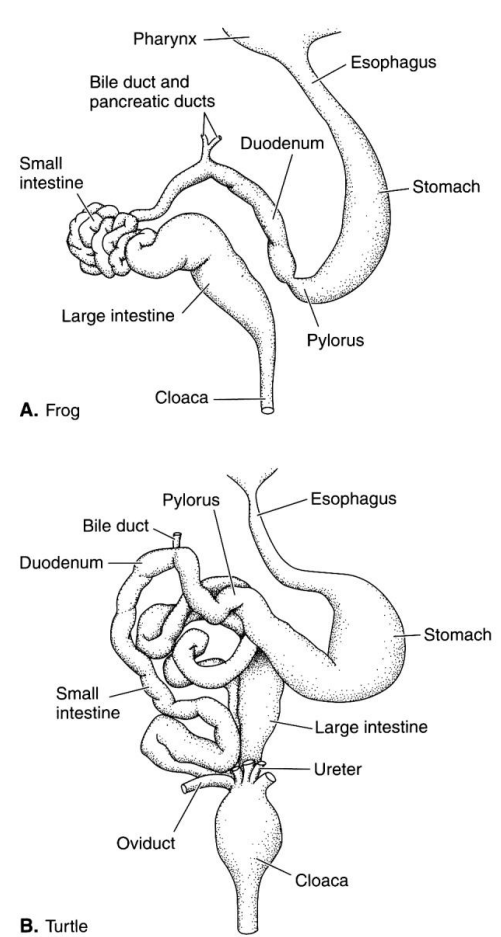


FIGURE 17-3 Ventral views of the digestive tracts of primitive tetrapods. The liver and pancreas have not been included, but the point of entrance of the bile duct is shown. A, A frog, *Rana*. B, A turtle, *Emys*. (A, after Walker; B, after Bolk et al.)

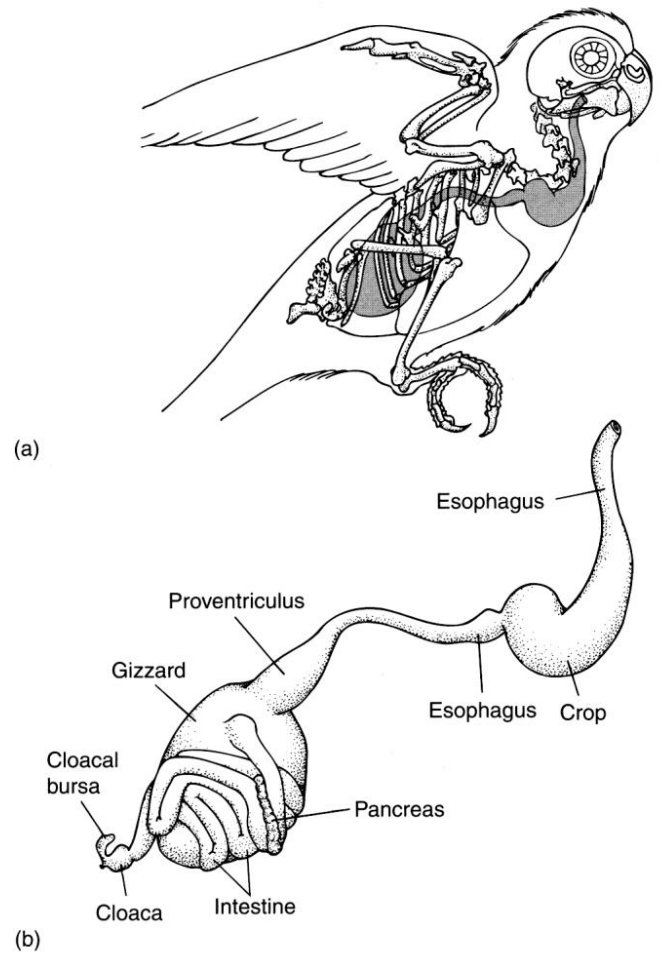


FIGURE 13.33 Alimentary canal of a parakeet. (a) Approximate position of the alimentary canal within the bird. (b) Alimentary canal enlarged.

After Evans.

Délka střeva u savců

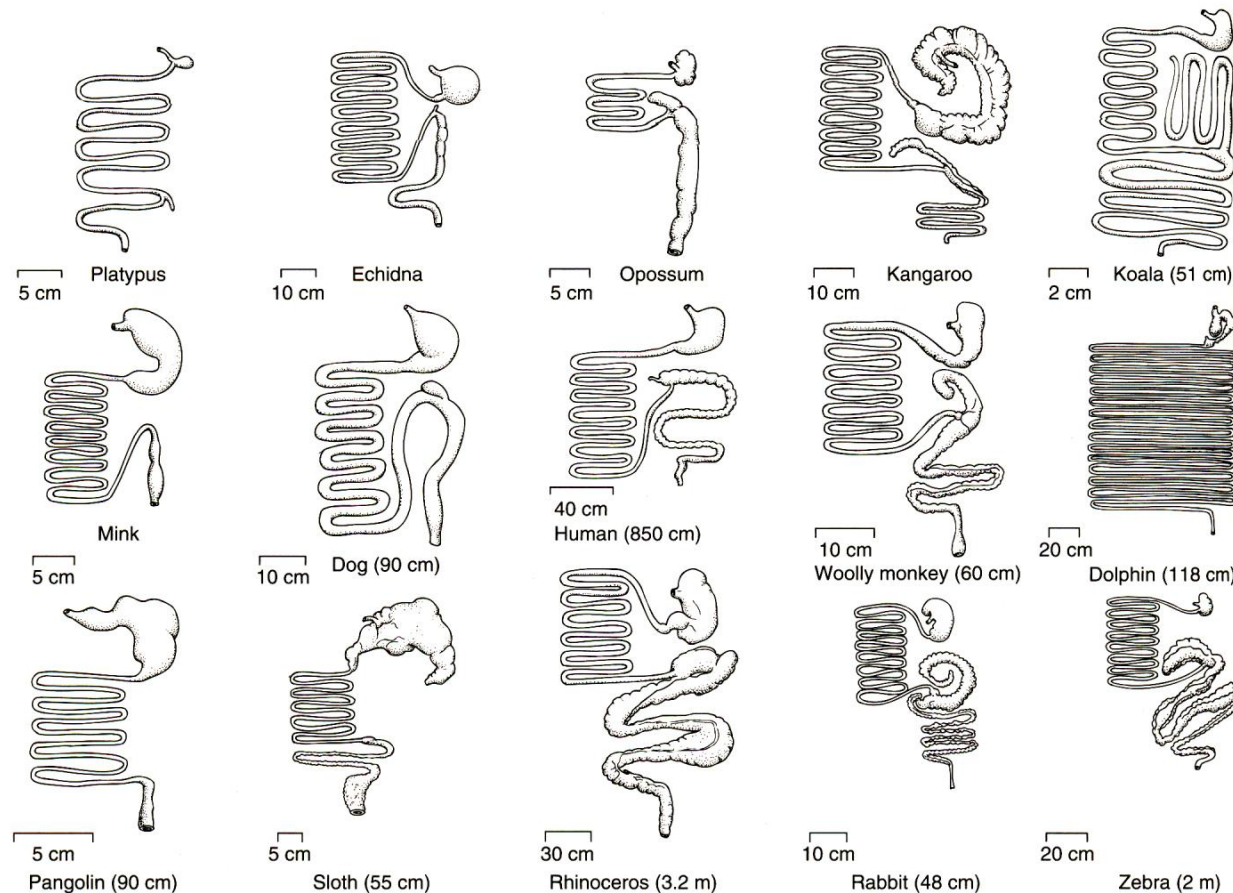


FIGURE 13.28 Variations within the stomach and intestines of mammals. Relatively long small intestines are found in the ant-eating echidna and pangolin, and also in dolphins. Terrestrial mammals that are strict carnivores, such as the mink and dog, have relatively short, unspecialized intestines. Kangaroos, koalas, sloths, rhinoceroses, rabbits, and zebras are herbivores with intestinal specialization that promotes fermentation. Note the relatively simple stomach and intestines of the platypus, whose diet is not well known but is thought to consist of aquatic insects and worms.

After Stevens; Harrop and Hume.

Místo fermentace

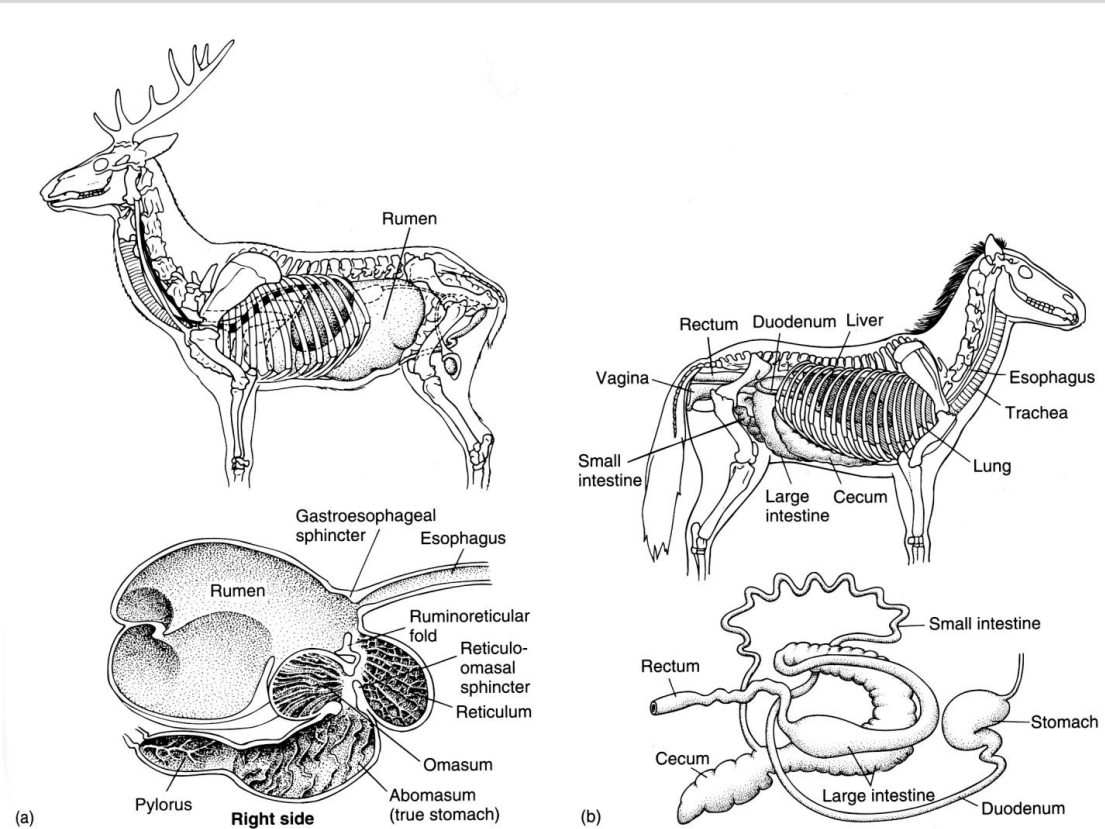
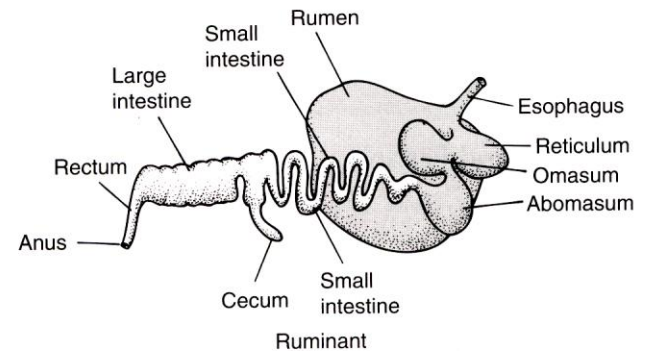
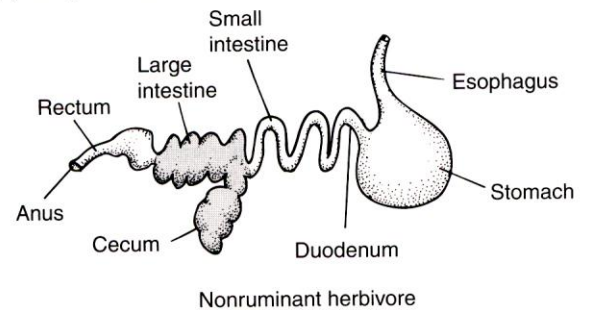


FIGURE 13.34 Alimentary canal of foregut and hindgut fermenters. (a) Ruminants ferment food in their foregut. Note the position of the alimentary canal (top) in this deer. The sagittal section of a sheep's "stomach" (bottom) is illustrated below the deer. Note the series of four chambers. Rumen, reticulum, and omasum are derivatives of the esophagus. The fourth compartment, the abomasum, is the actual or true stomach. (b) Hindgut fermenters. Position of the alimentary canal (top) in a horse. Isolated view (bottom) of the large cecum near the juncture of small and large intestines. There is no four-chambered stomach. In hindgut fermenters, the cecum and/or large intestine are the major sites of fermentation.



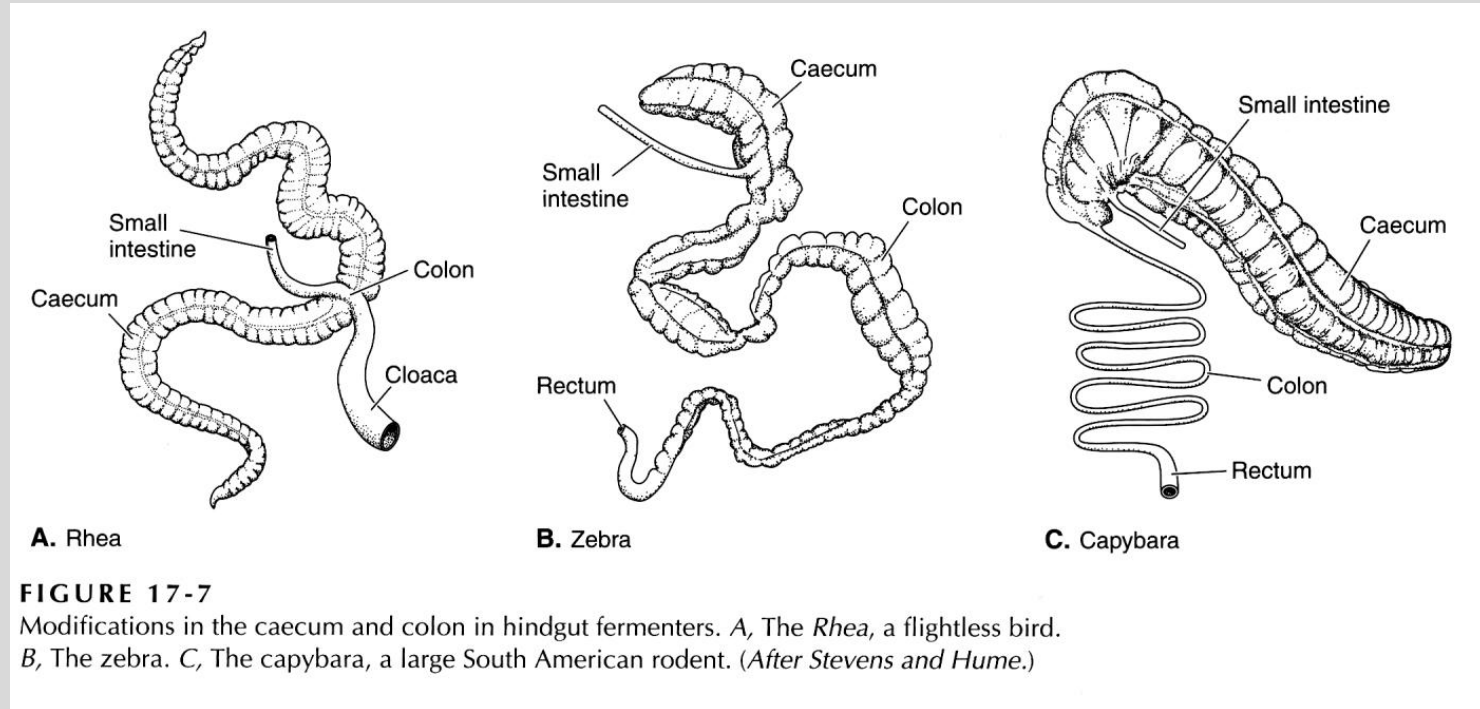
(a) Foregut fermentation



(b) Hindgut fermentation

FIGURE 13.44 Foregut versus hindgut fermentation. (a) Ruminants and other foregut fermenters depend upon microbial activity early in the digestive process as the ruminant "stomachs" chemically attack cellulose in plant cell walls. (b) In hindgut fermenters, fermentation takes place in the long intestines and extended cecum.

Fermentace ve střevě



Tlusté a slepé střevo zvětšeno

Vylučovací soustava

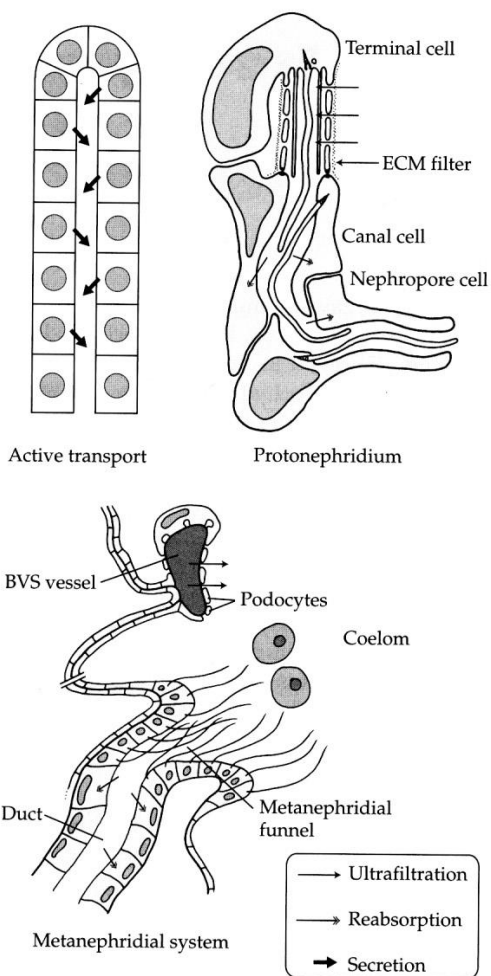


Fig. 9.1. Schematic representation of main principles in excretion. In active transport excreted substances are secreted by cells into a lumen of an epithelially lined tube. In a protonephridium, filtration occurs through the ECM covering slits or pores in the terminal cell (arrows). The filtrate flows 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).

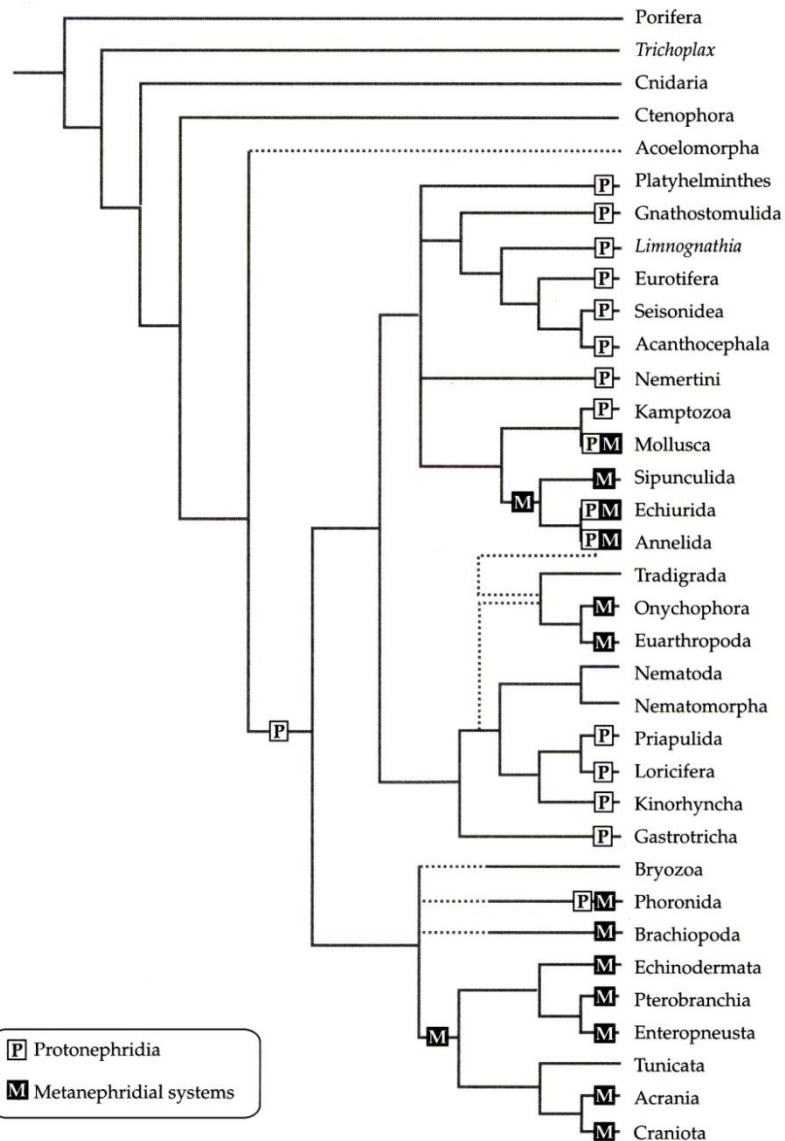


Fig. 9.14. Distribution of protonephridia and metanephridial systems on the phylogenetic tree and reconstruction of the presence of these systems in some ancestors.

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

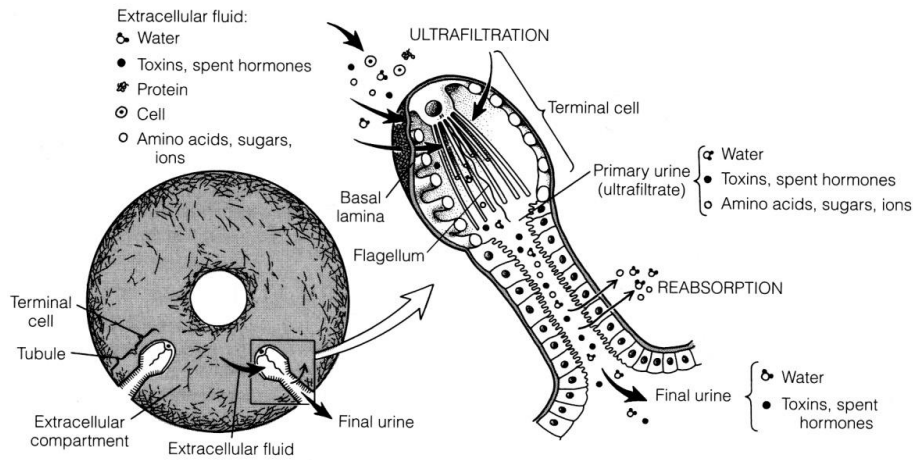


FIGURE 9-19 Bilateral excretion: protonephridia. As in metanephridial systems, protonephridial excretion is a two-step process involving ultrafiltration and modification (reabsorption and secretion) to form final urine. In protonephridia, ultrafiltration occurs across the wall of a terminal cell, which 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.

Protonefridie



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

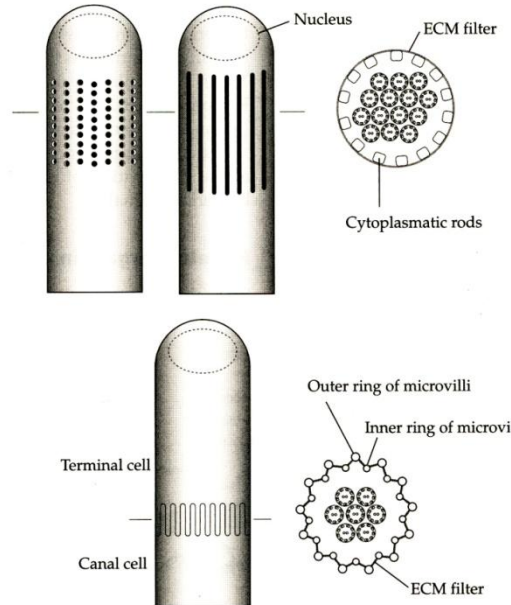


Fig. 9.2. Schematic representation of different designs in terminal cells. On top are cells with pores or slits; cross section at indicated level shows the filter composed of ECM covering the pores or slits. Below is a weir, where the filtration area is composed of microvilli from the terminal and the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

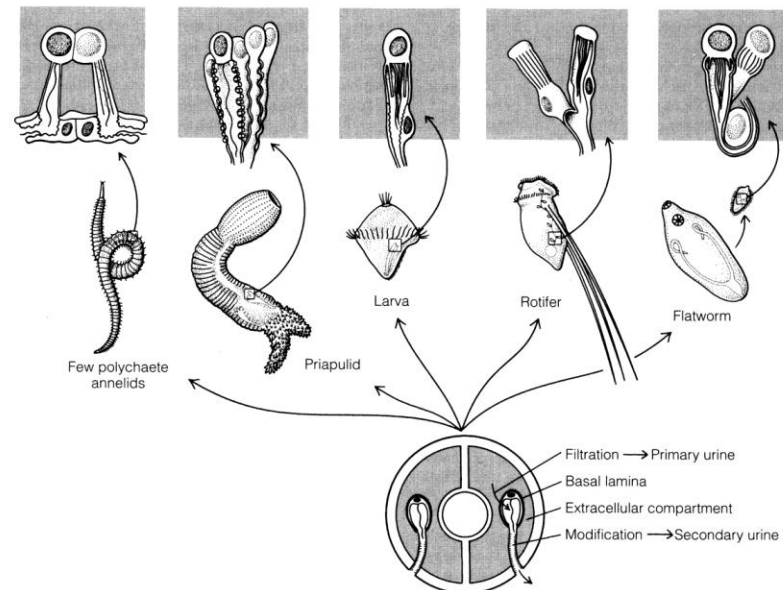
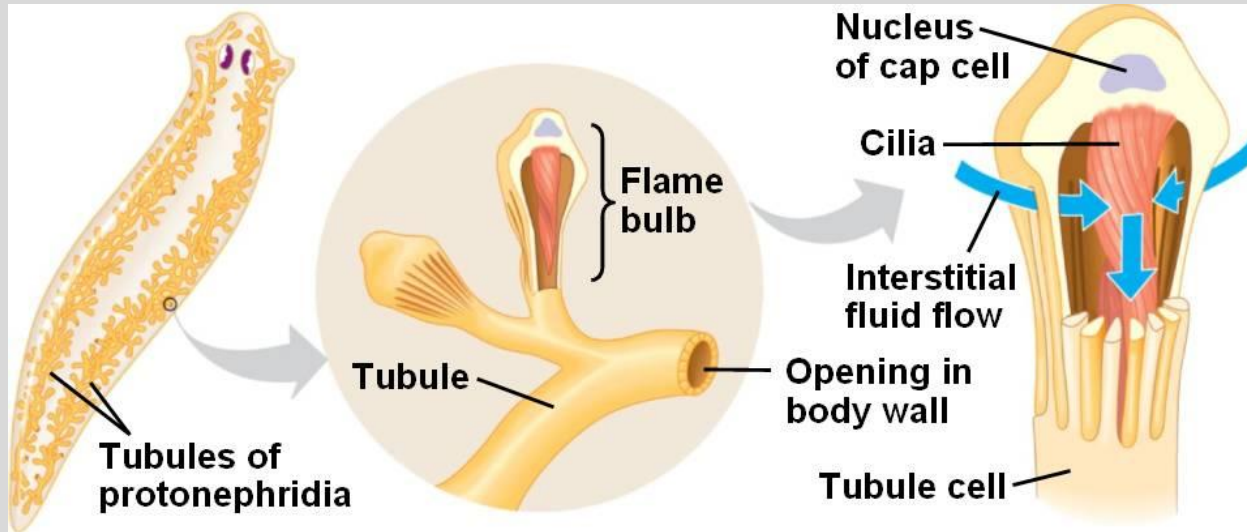
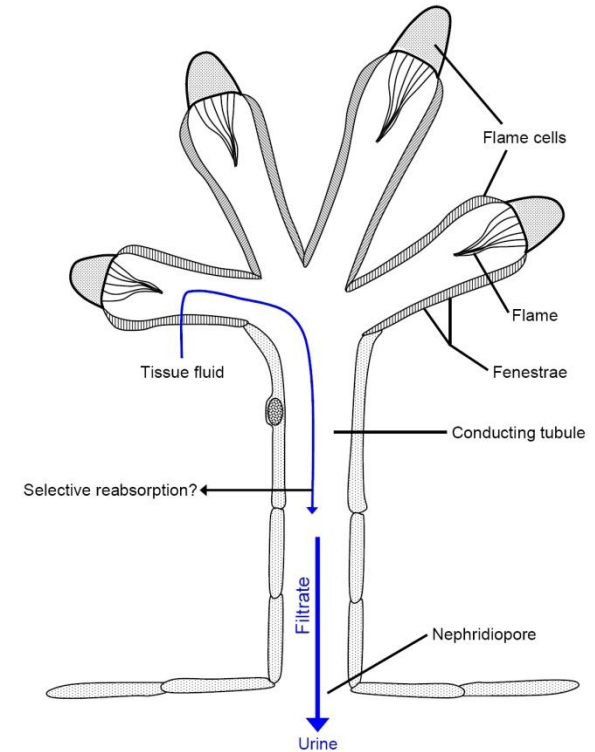
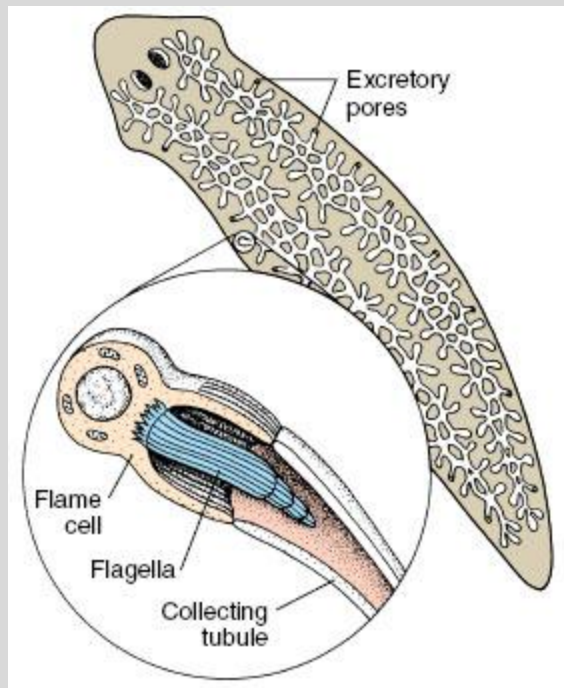


FIGURE 9-20 Bilateral excretion: body design and the occurrence of protonephridia. Bilaterians that lack a hemal system, a coelomic system, or both have protonephridia instead of a metanephridial system. Typically these are small animals that rely on simple diffusion for internal transport. Protonephridia 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



The Protonephridium



Metanefridie

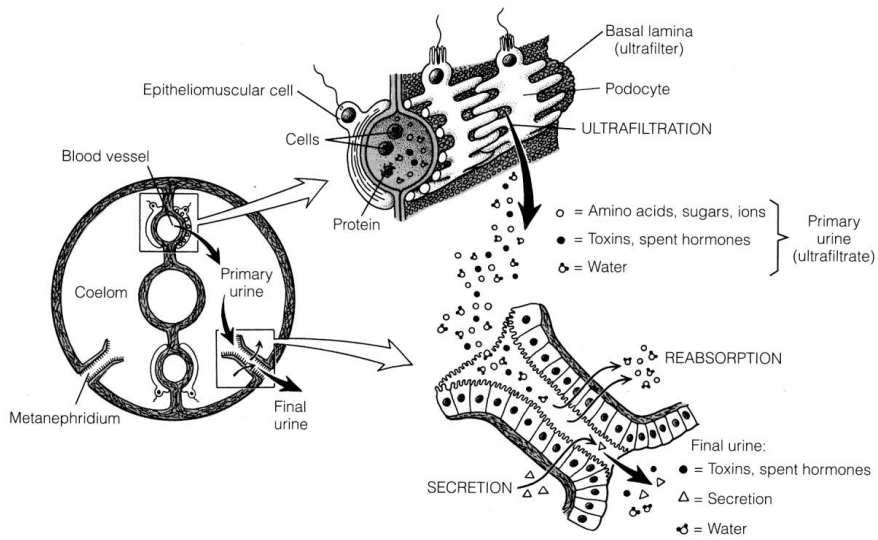


FIGURE 9-17 Bilateral excretion: metanephridial system. A metanephridial excretory system consists of an ultrafiltration site on a blood vessel (indicated by podocytes), a coelom, and a tubule (metanephridium) that leads to the exterior. Muscular contraction of the blood vessel pressurizes the blood, 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 céloomu.

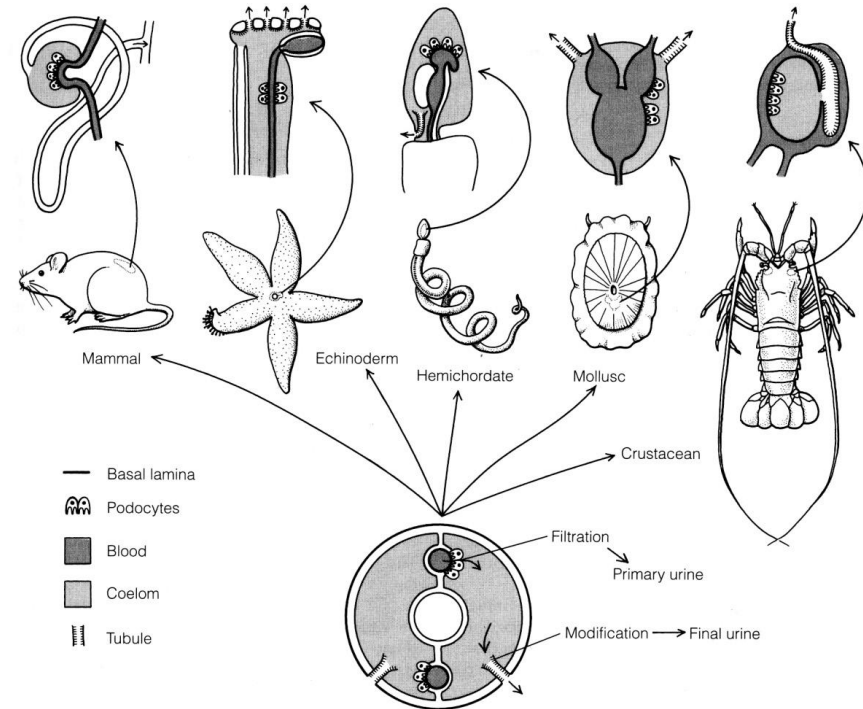
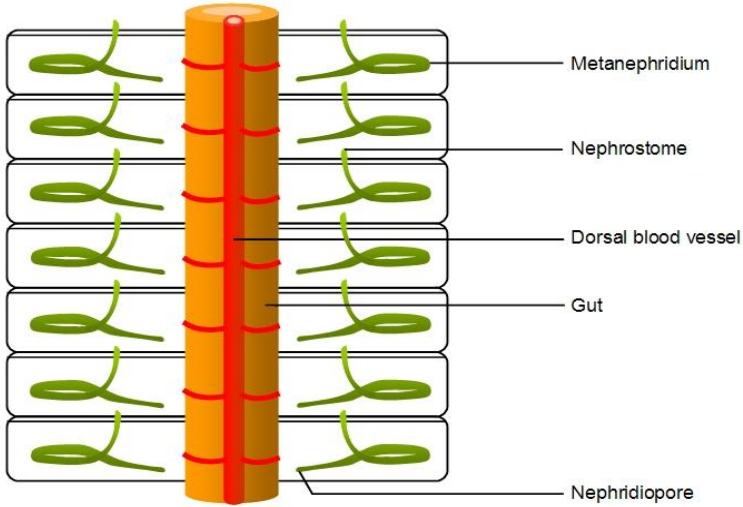
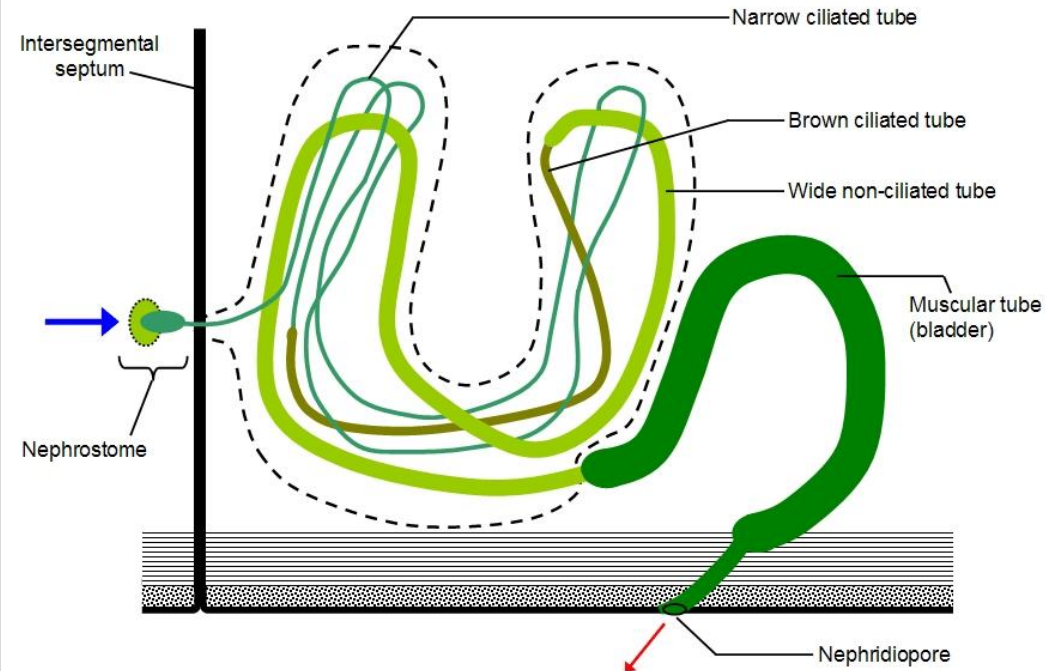
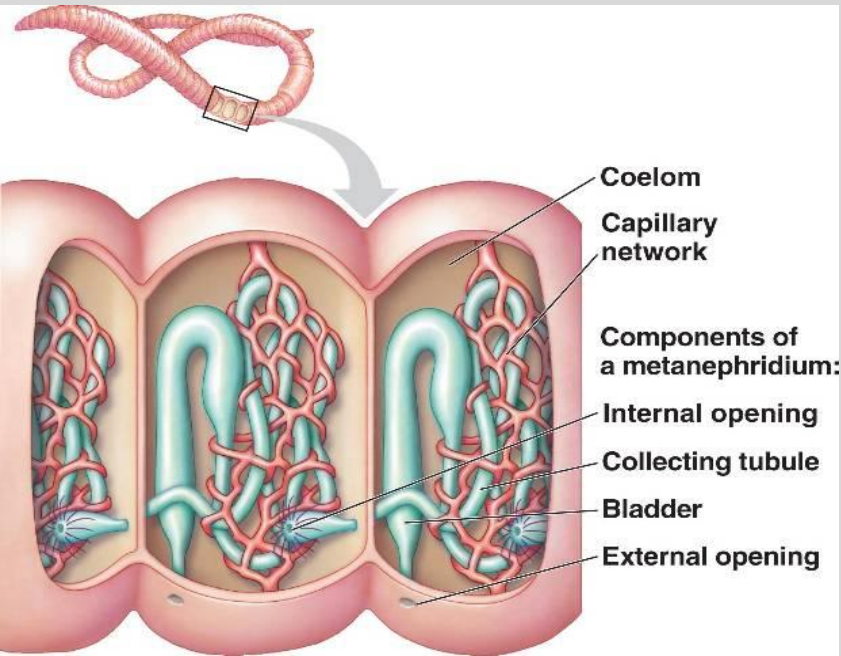


FIGURE 9-18 Bilateral excretion: body design and the occurrence of metanephridial systems. Metanephridial systems usually occur in large bilaterians with both coelomic and hemal compartments. (From Ruppert, E. E., and Smith, P. R. 1988. *The functional organization of filtration nephridia*. *Biol. Rev.* 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.

Mnohoštětinatci (Polychaeta) – aneb vše je možné

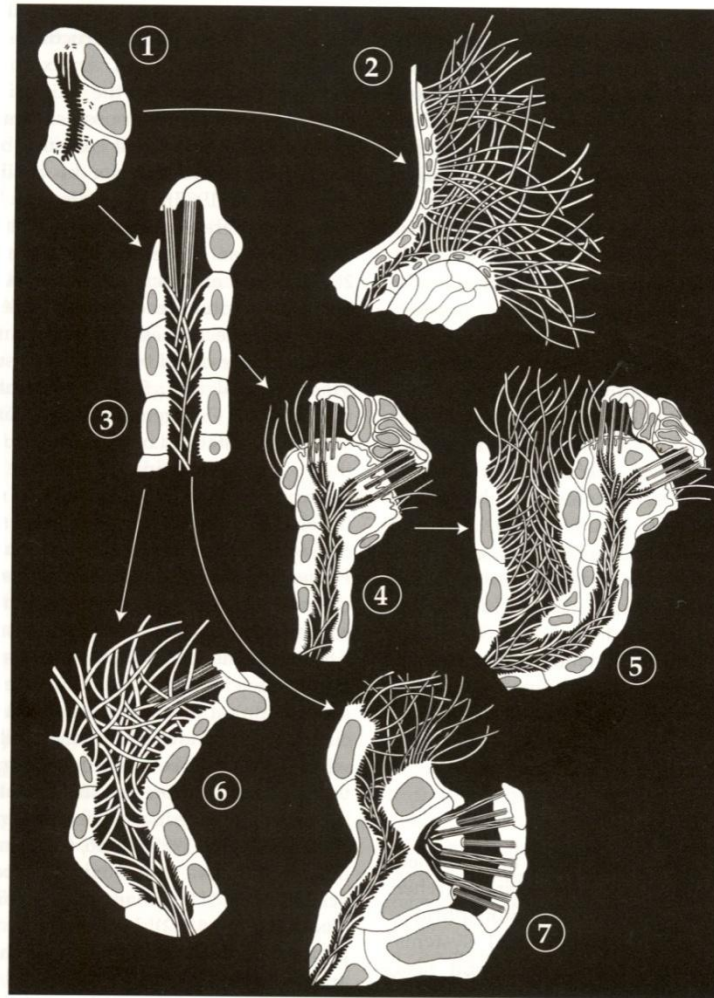


Fig. 9.7. Correspondence of protonephridial and metanephridial systems in polychaetes. In all cases, development starts with an anlage composed of few cells (1). During further development, this either directly opens to the coelom with a metanephridial funnel (2) or terminal cells develop in the proximal 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).

Malpighiho trubice hmyzu

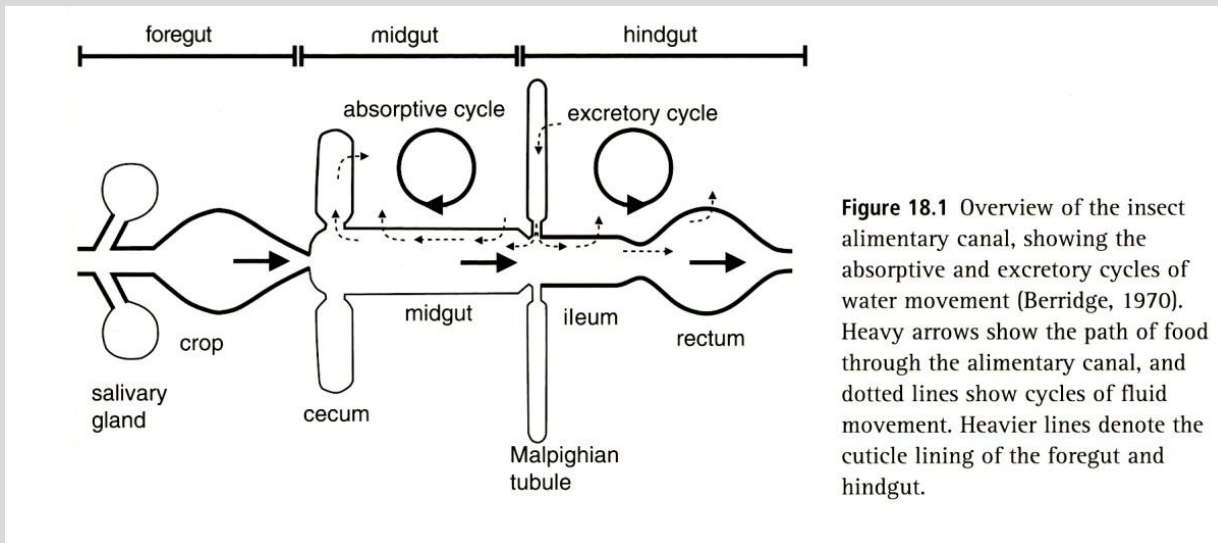
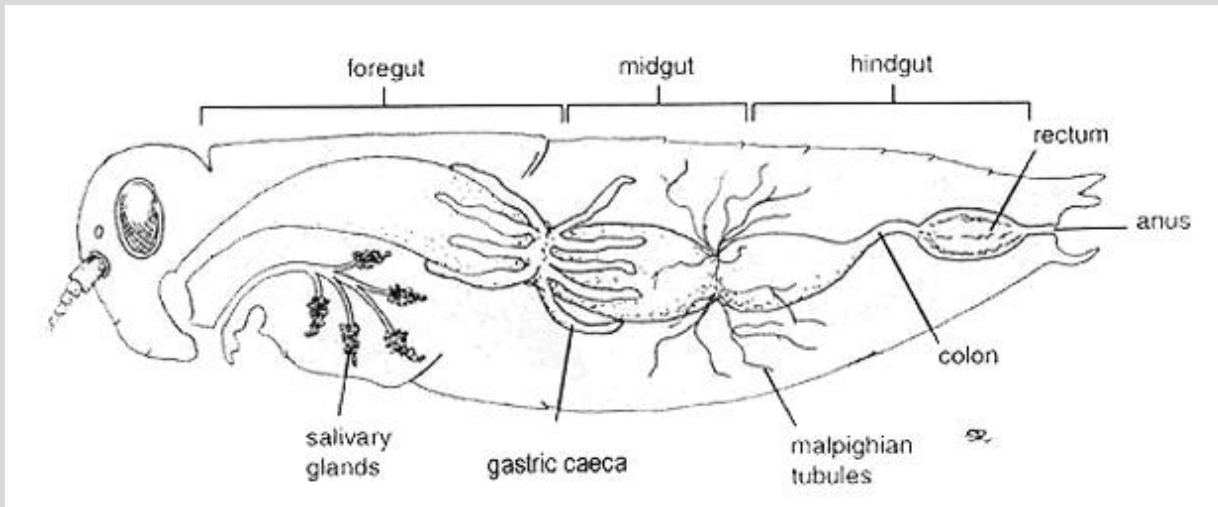


Figure 18.1 Overview of the insect alimentary canal, showing the absorptive and excretory cycles of water movement (Berridge, 1970). Heavy arrows show the path of food through the alimentary canal, and dotted lines show cycles of fluid movement. Heavier lines denote the cuticle lining of the foregut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

Malpighiho trubice hmyzu

Fig. 12.13 Malpighian tubules (M) and rectal gland (RG) of insects. \rightarrow = food; \rightarrow = water and some ions (note that the spatial organization of Malpighian tubules and rectal gland is such that water and ions can be reabsorbed); \dots = uric acid (after Potts & Parry, 1964). The ultrastructure of the Malpighian tubule is also shown (after Oschman & Berridge, 1971). Notice that it is rich in mitochondria, suggesting that it is involved in active transport.

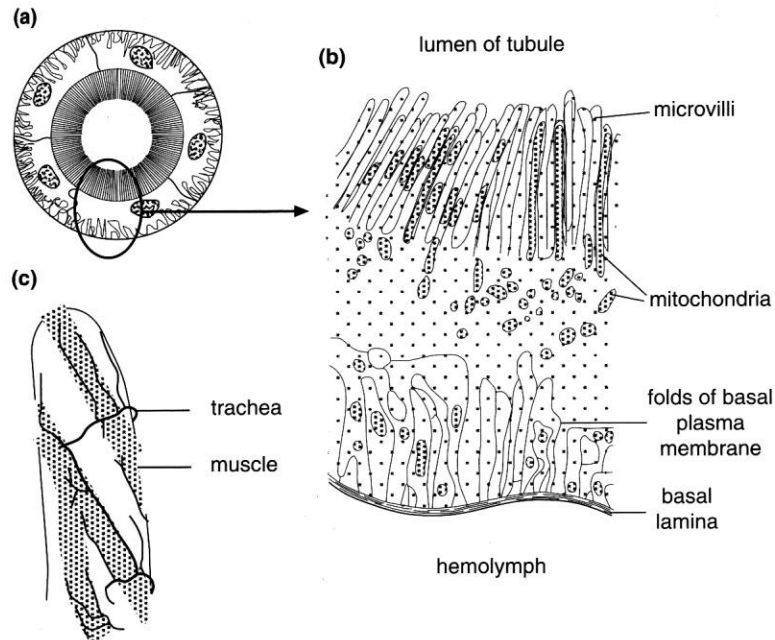
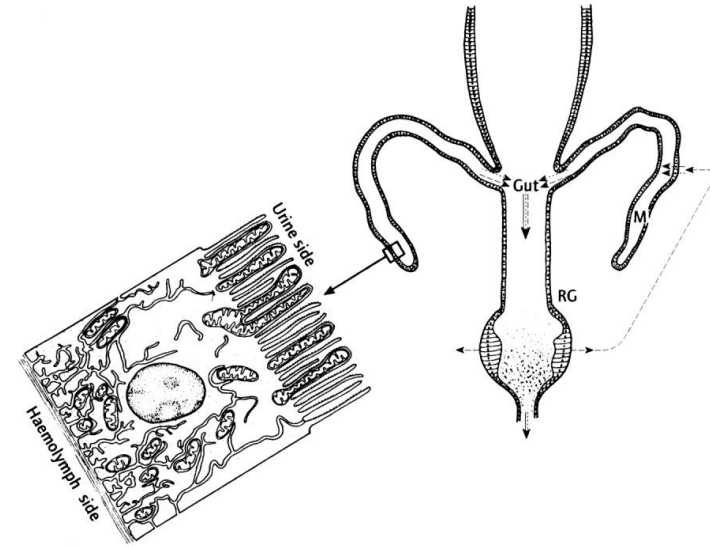
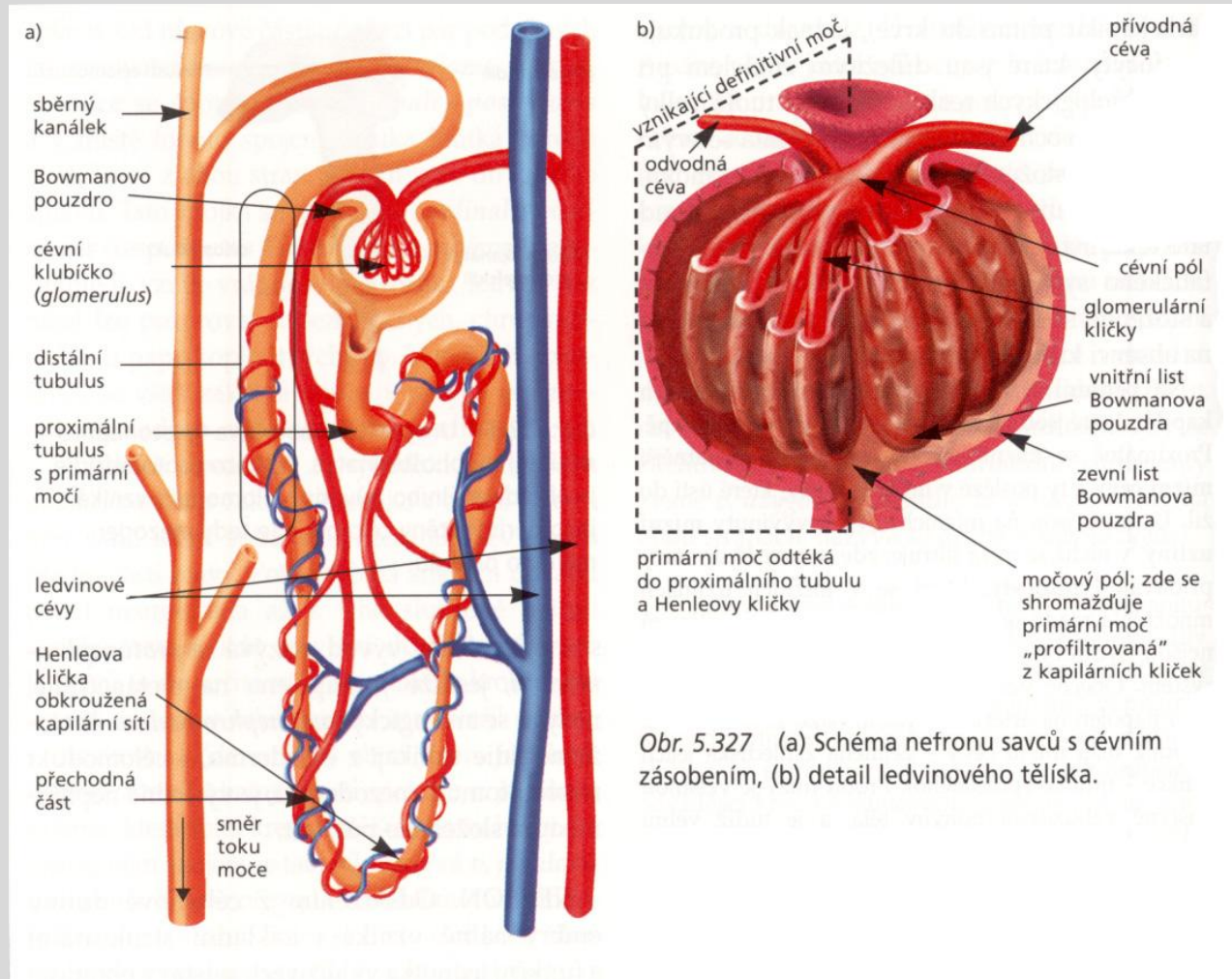


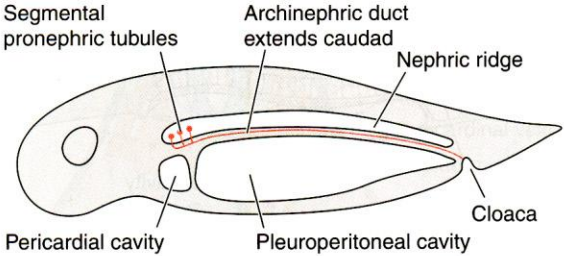
Figure 18.2 Structure of a typical Malpighian tubule. (a) Cross-section of a tubule. (b) Detail of part of one cell. (c) End of a Malpighian tubule of *Apis* showing the spiral muscle strands and the tracheal supply (after Wigglesworth, 1965).

Nefron obratlovců = zdokonalená metanefridie

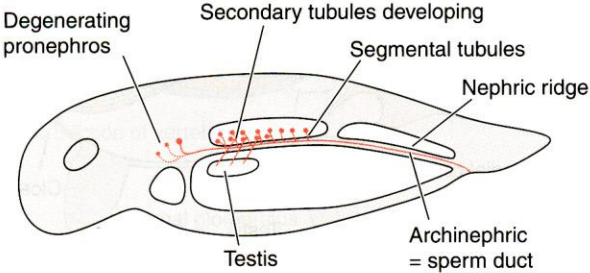


Obr. 5.327 (a) Schéma nefronu savců s cévním zásobením, (b) detail ledvinového tělíska.

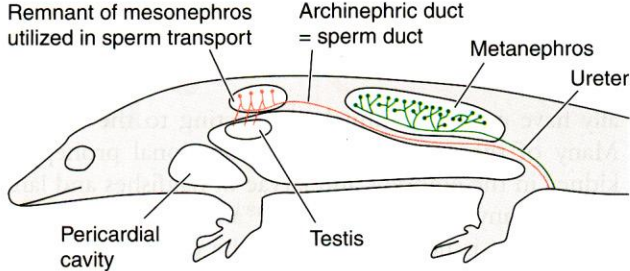
Evoluce ledvin



A. Pronephros in early embryo



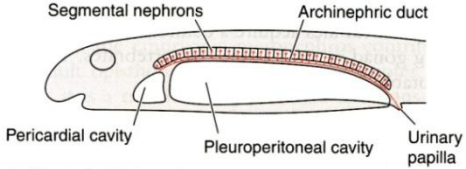
B. Mesonephros in intermediate embryo



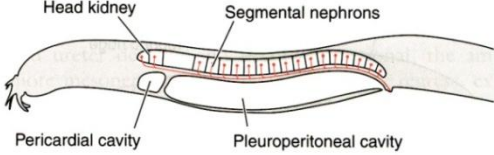
C. Metanephros in late embryo and adult

FIGURE 20-6

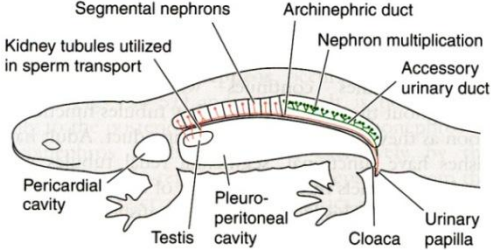
A–C, Lateral views of the sequence of kidneys that occurs during the embryonic development of an amniote.



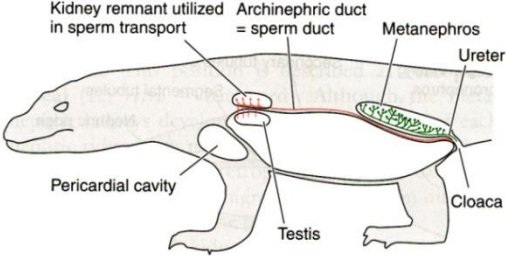
A. Theoretical holonephros



B. Primitive opisthonephros



C. Advanced opisthonephros



D. Metanephros

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.

