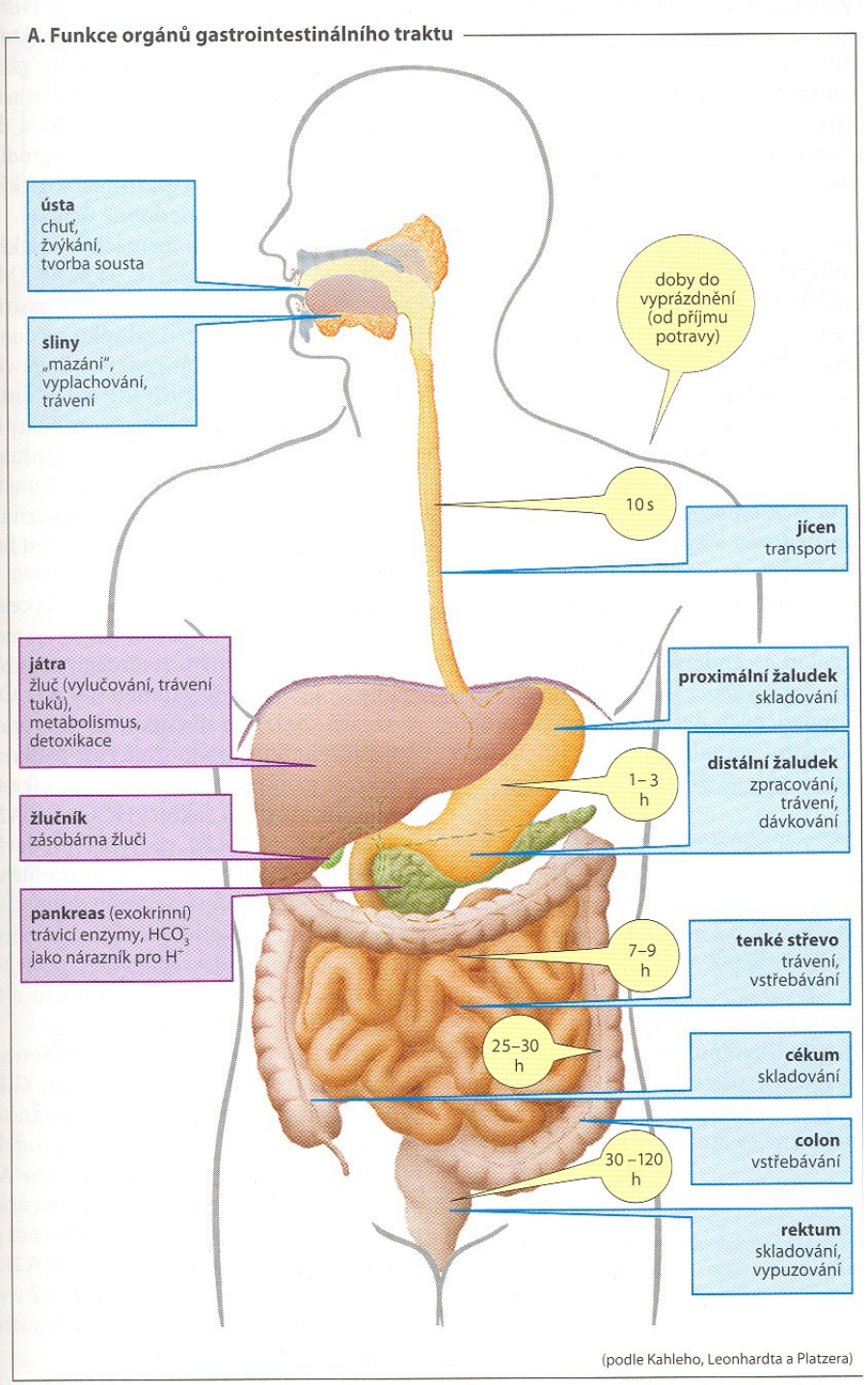
Fyziologie živočichů a člověka

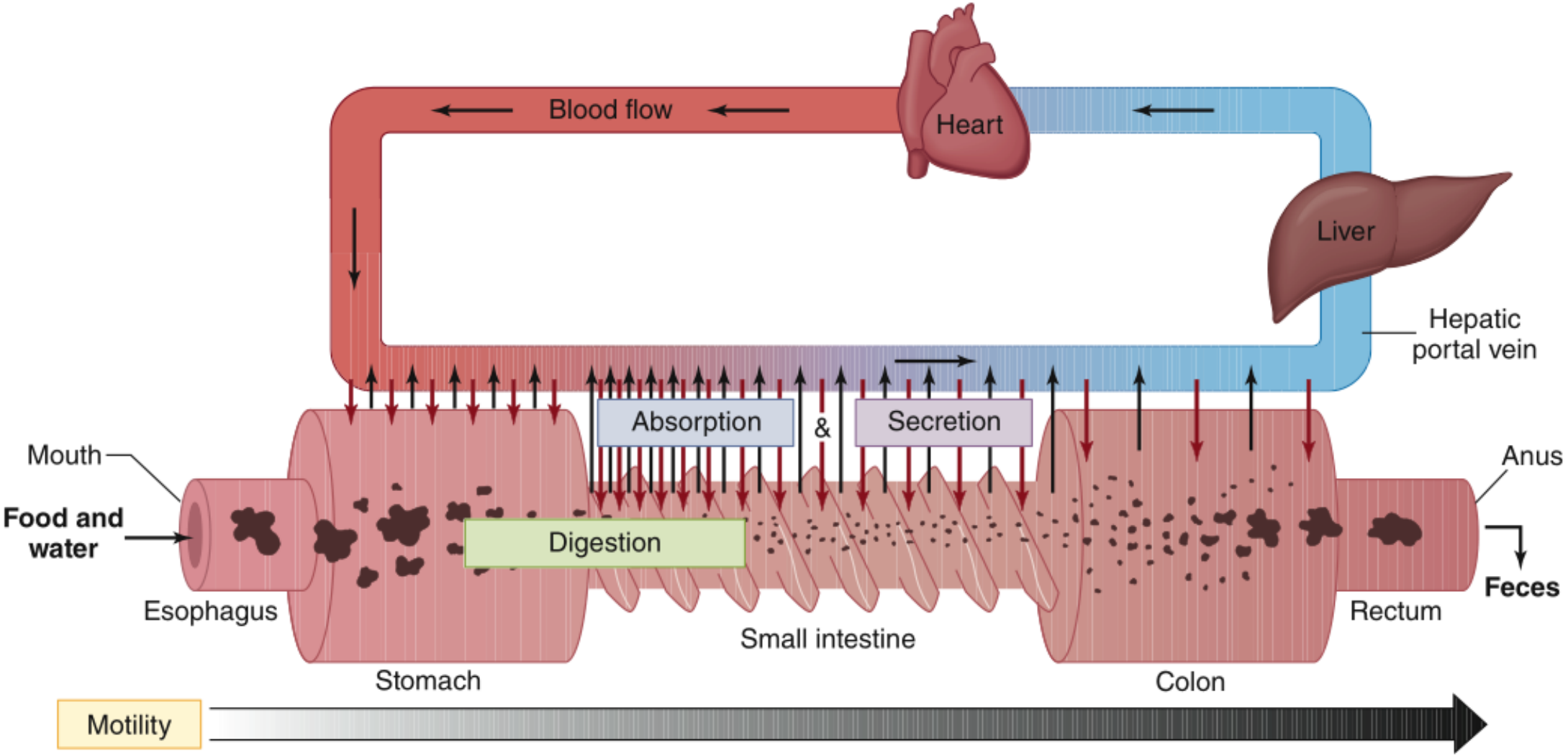
Fyziologie trávicí soustavy (GIS)

RNDr. Ing. Edvard Ehler, Ph.D.

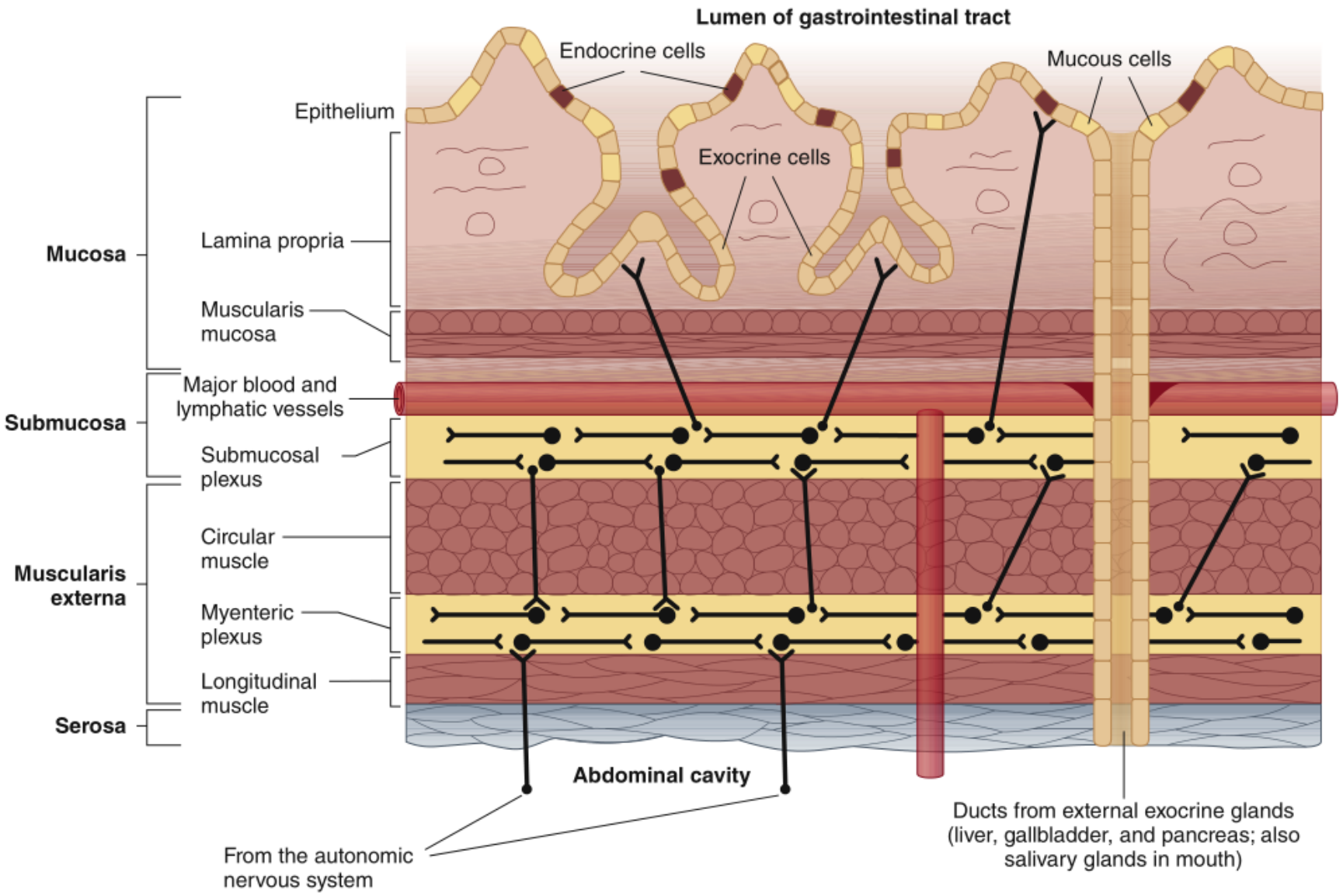
Soustava trávicí



GIS – obecná struktura a funkce

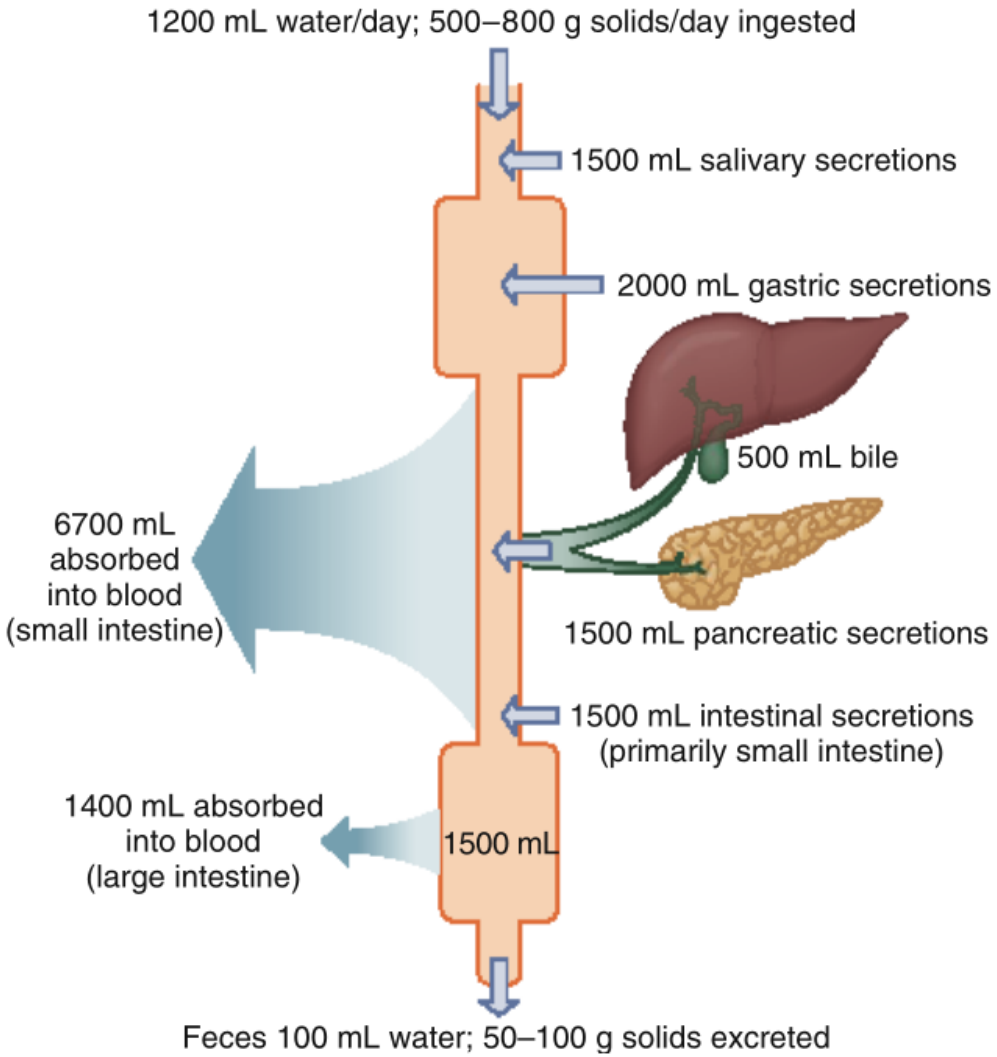


Funkce trávicí soustavy a obecná stavba trávicí trubice



1) Trávení – mechanické a chemické zpracování přijímané potravy
2) Vstřebávání (resorbce) – jednoduché látky jsou aktivně převáděné z lumen trávicí trubice do vnitřního prostředí organismu
3) Odstraňování nestravitelných odpadových látek z organismu

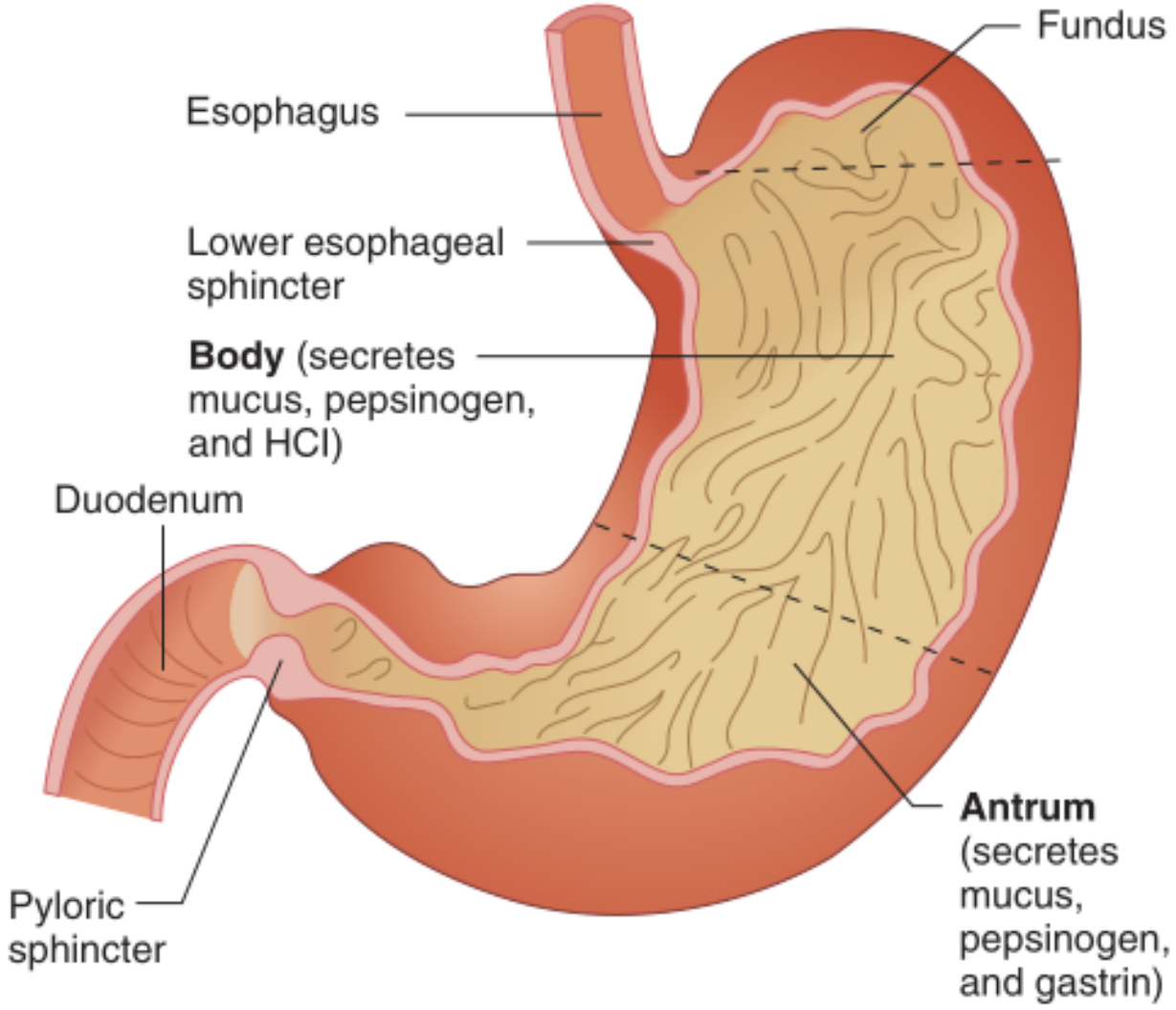
Voda v GIS

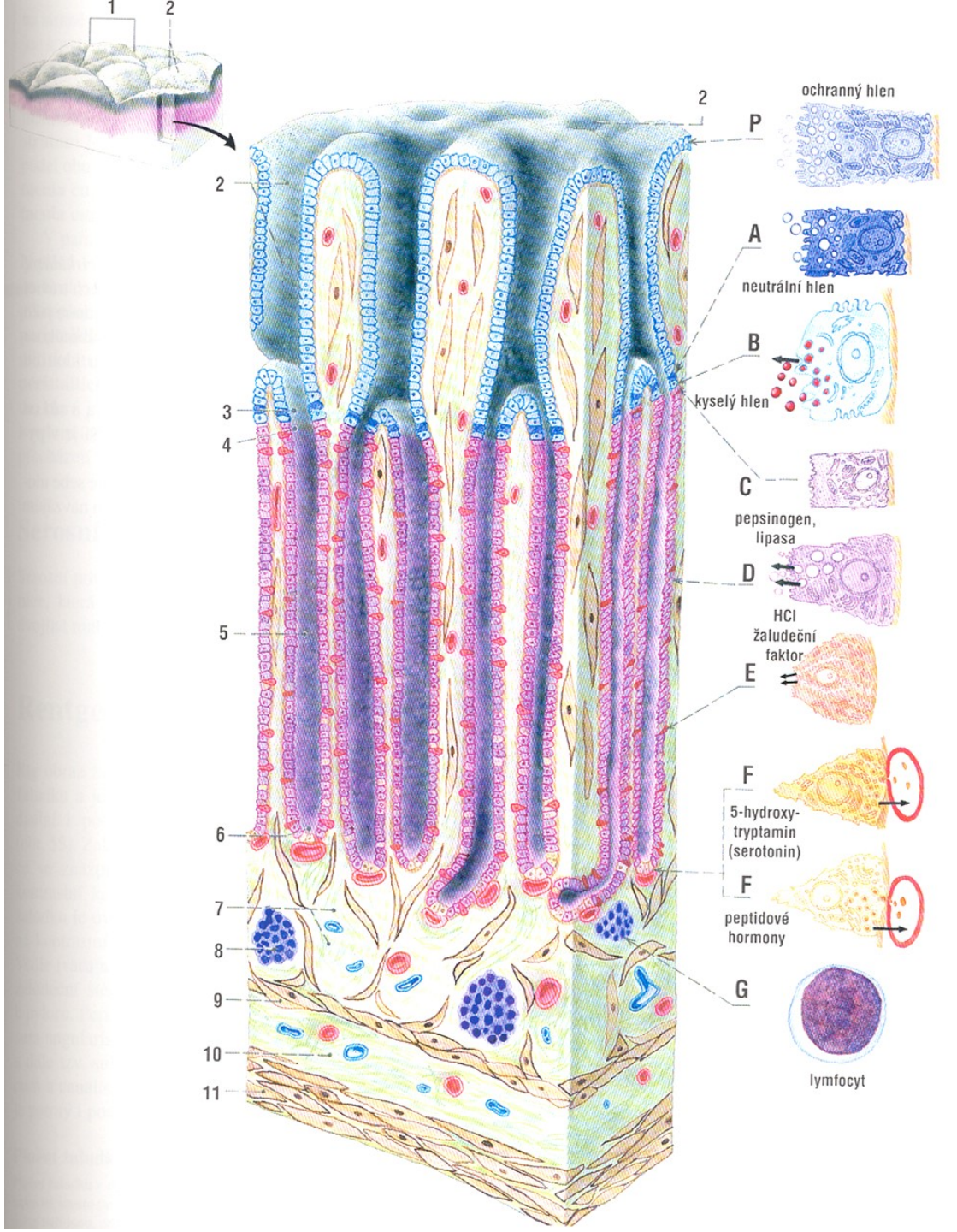


- H_20:
- Přijato v potravě: 1-2 l
- Sekrece v GIS: ca. 7 l
- Vyloučeno stolicí: 100-200 ml

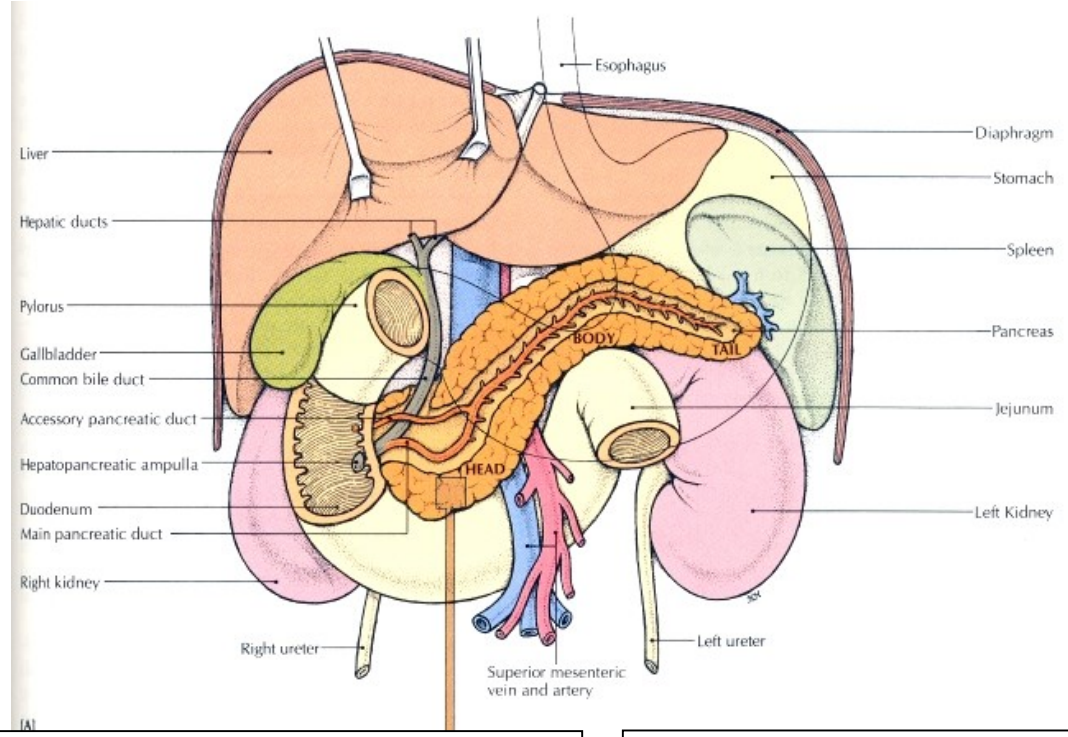
- Většina H_20 absorbována v GIS, kolem 8 litrů

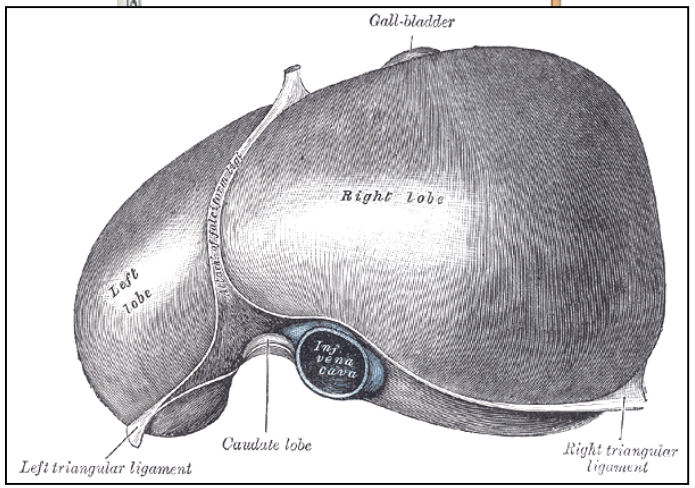
Žaludek – funkce a stavba, tubulární žlázy

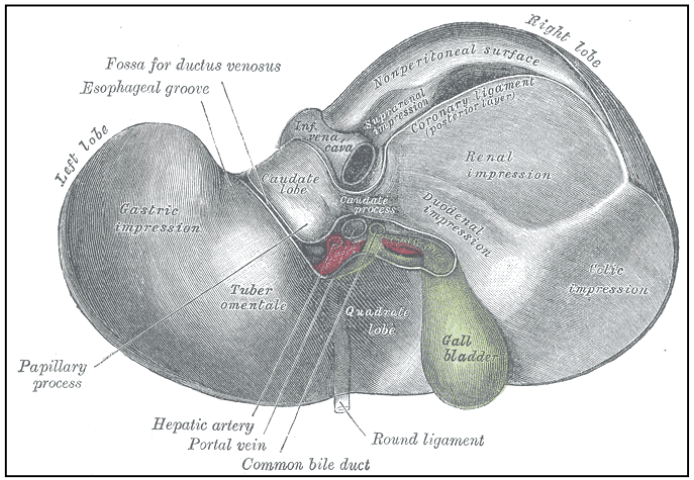


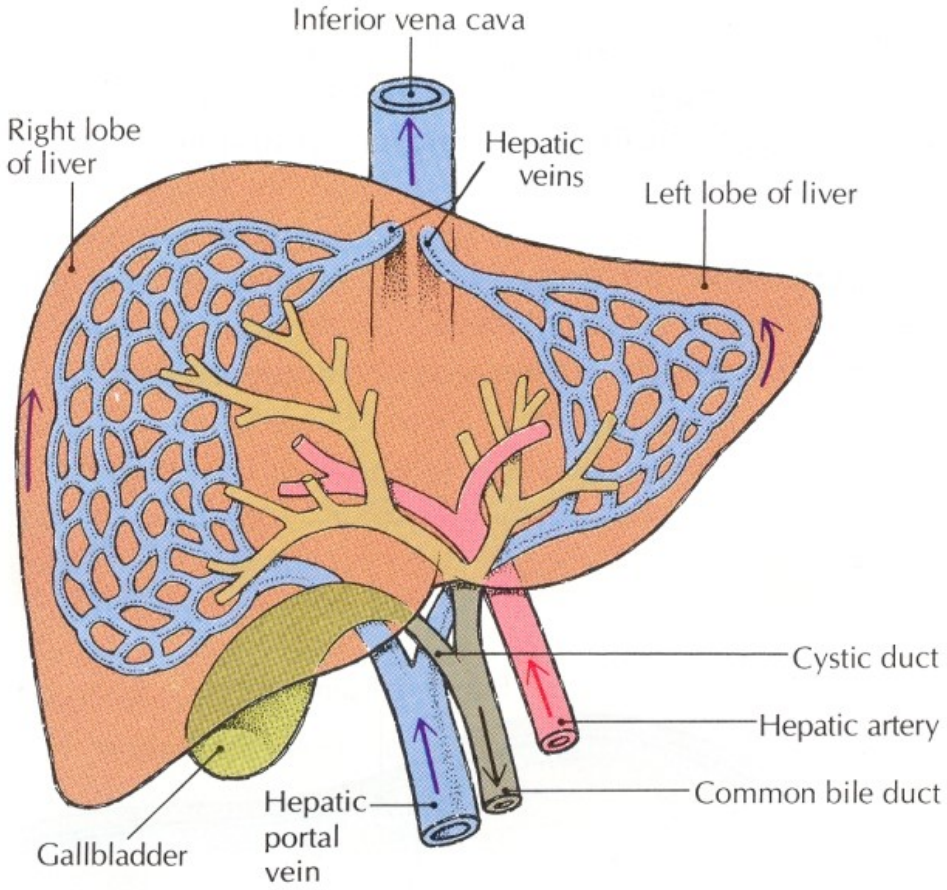


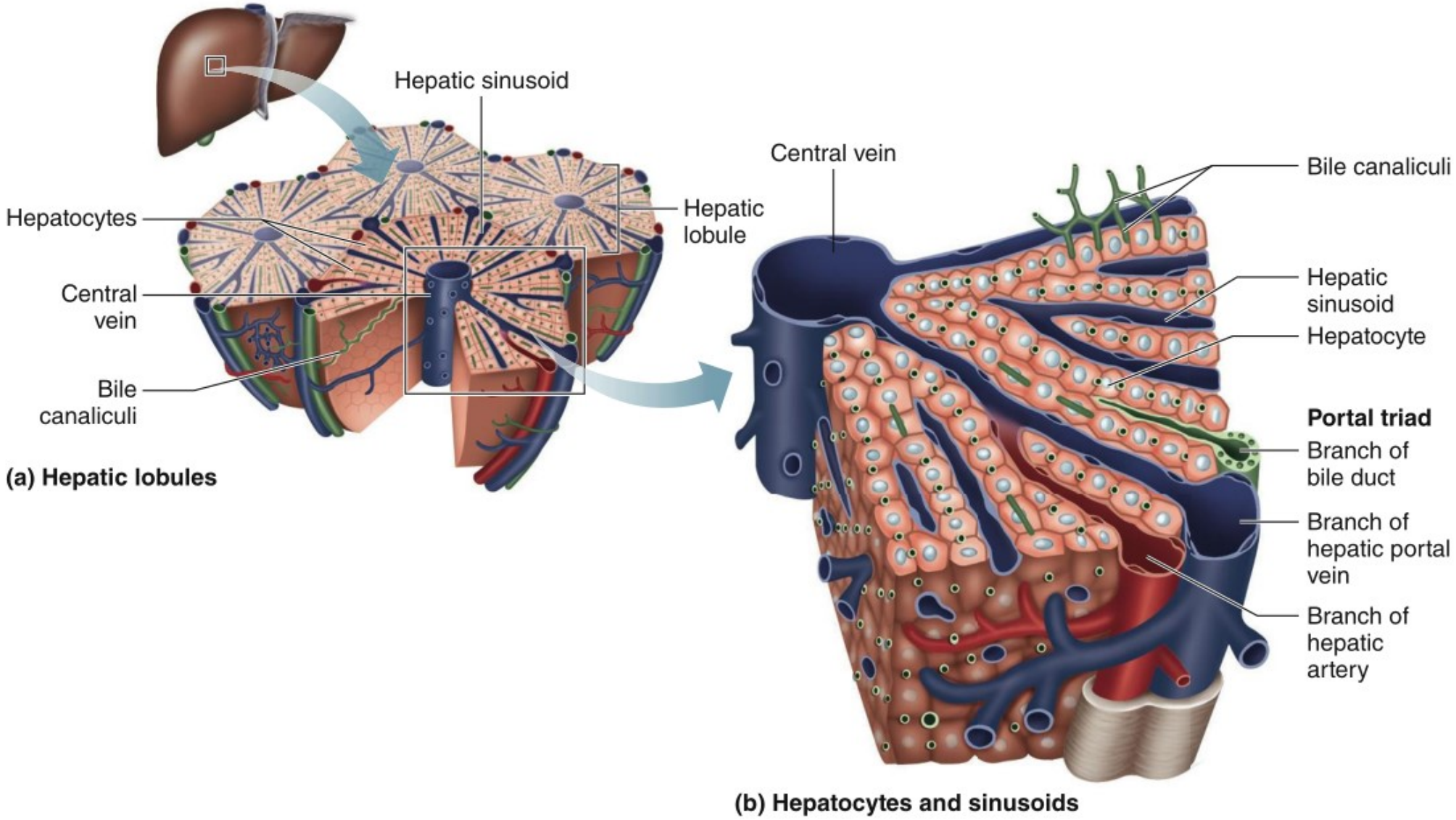
Játra - *hepar*


Esophagus
Liver
Diaphragm
Stomach
Hepatic ducts
Spleen
Pylorus
Pancreas
BODY
TAIL
Gallbladder
Common bile duct
Jejunum
Accessory pancreatic duct
Hepatopancreatic ampulla
HEAD
Duodenum
Left Kidney
Main pancreatic duct
Right kidney
Right ureter
Left ureter
Superior mesenteric vein and artery
(A)


Gall-bladder
Right lobe
Left lobe
Inf. vena cava
Caudate lobe
Left triangular ligament
Right triangular ligament

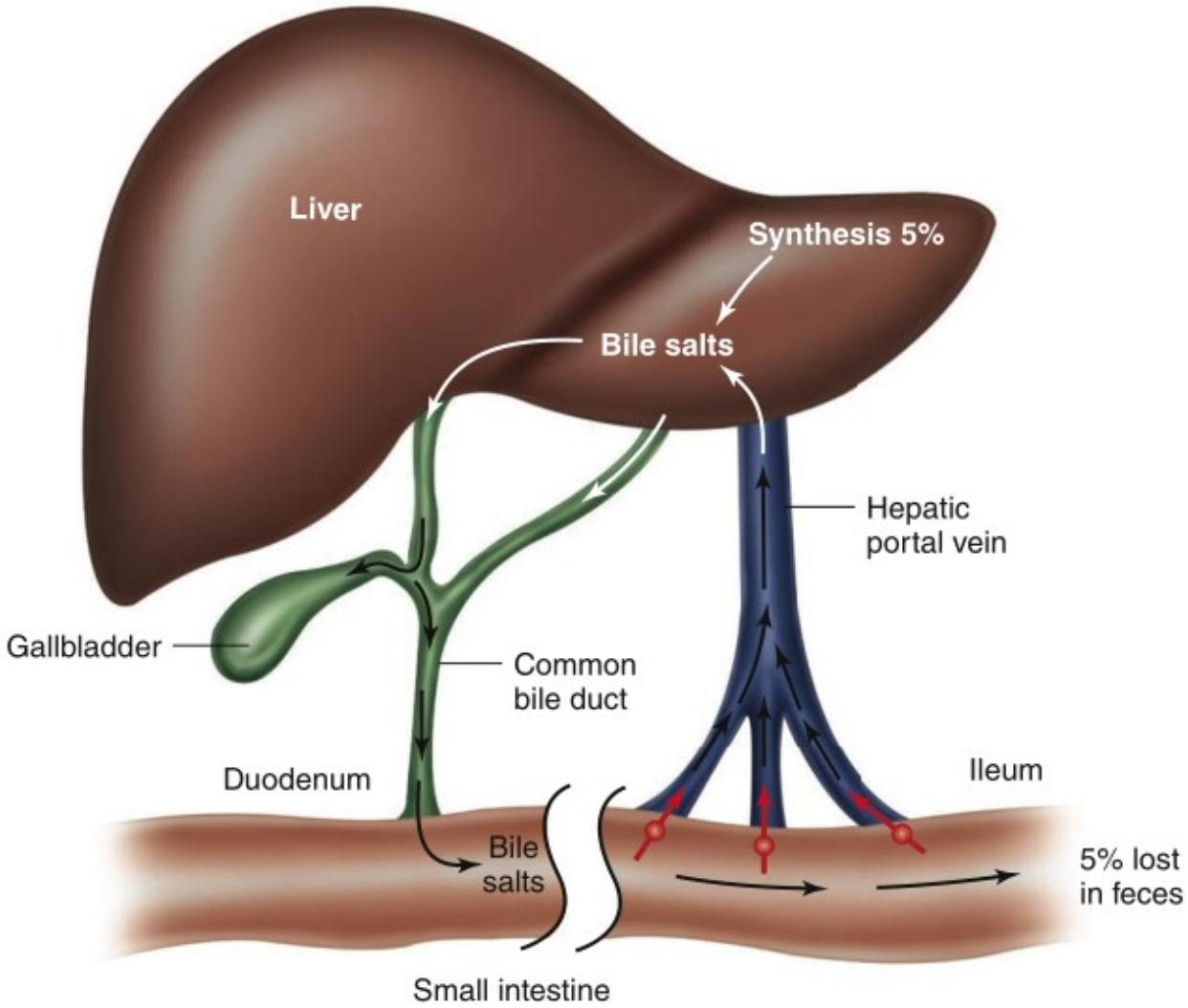

Fossa for ductus venosus
Esophageal groove
Nonperitoneal surface
Right lobe
Left lobe
Inf. vena cava
Renal impression
Caudate lobe
Caudate process
Gastric impression
Duodenal impression
Colic impression
Tuber omentale
Quadrate lobe
Gall bladder
Papillary process
Hepatic artery
Portal vein
Common bile duct
Round ligament


Inferior vena cava
Right lobe of liver
Hepatic veins
Left lobe of liver
Cystic duct
Hepatic artery
Common bile duct
Hepatic portal vein
Gallbladder

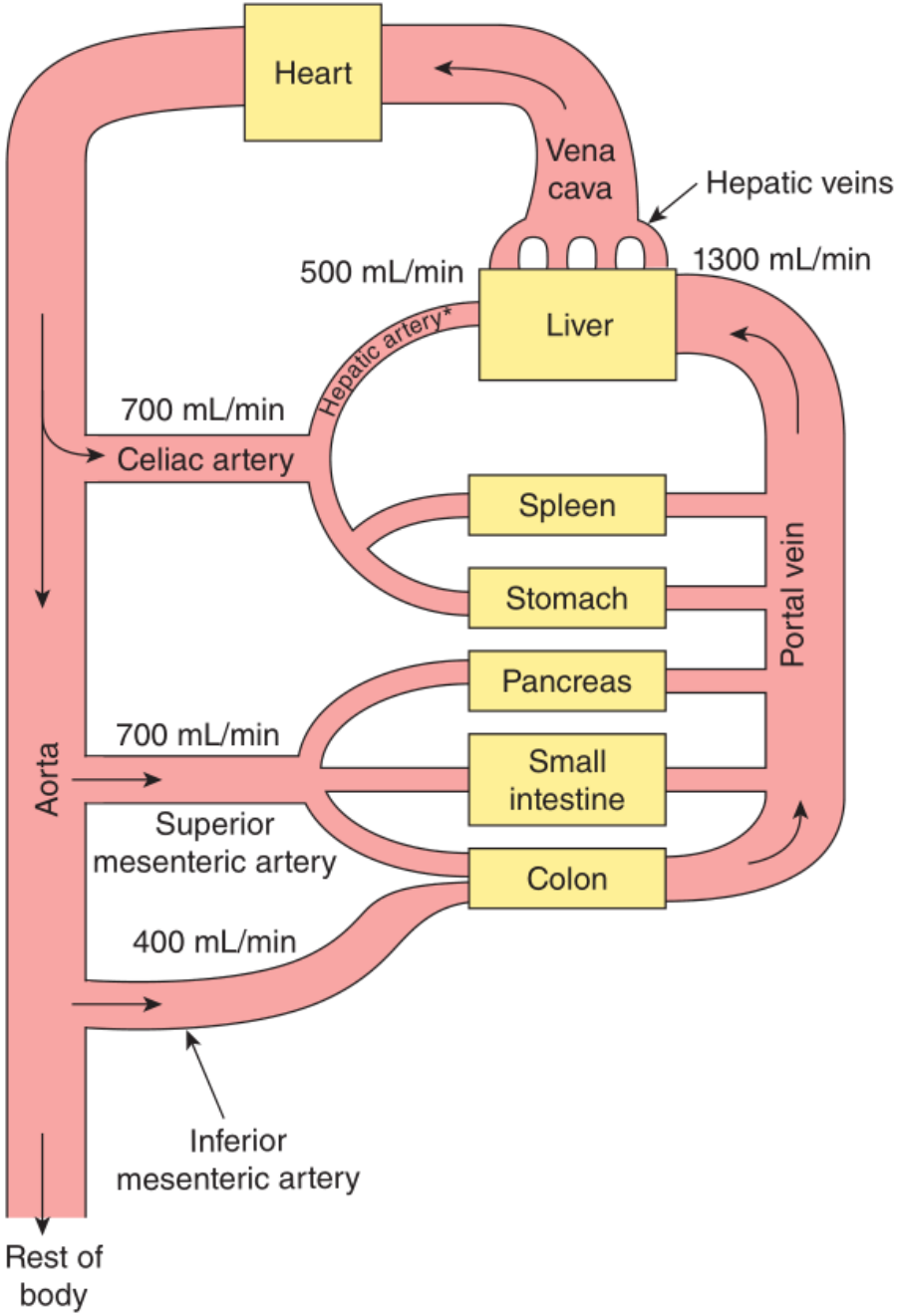


AP|R **Figure 15.31** Microscopic appearance of the liver. (a) Hepatic lobules are the functional units of the liver. (b) A small section of the liver showing the location of bile canaliculi and ducts with respect to blood and liver cells (hepatocytes). The hepatic portal veins communicate with the hepatic sinusoids and bring absorbed substances to the liver from the small intestines. Hepatocytes take up and process nutrients and other factors from the hepatic sinusoids. Bile (green) is formed by uptake by hepatocytes of bile salts and secretion into bile canaliculi. Finally, central veins, located at the center of each lobule, drain blood from the lobules into the systemic venous circulation.

Koloběh žlučových solí (a cholesterolu)



Vrátnicová žíla a funkční (portální) oběh jater



*Branches of the hepatic artery also supply the stomach, pancreas and small intestine.

Sbírá krev z nepárových orgánů břišní dutiny – funkční zásobení jater

<u>systém:</u>

kapilární síť

céva

kapilární síť

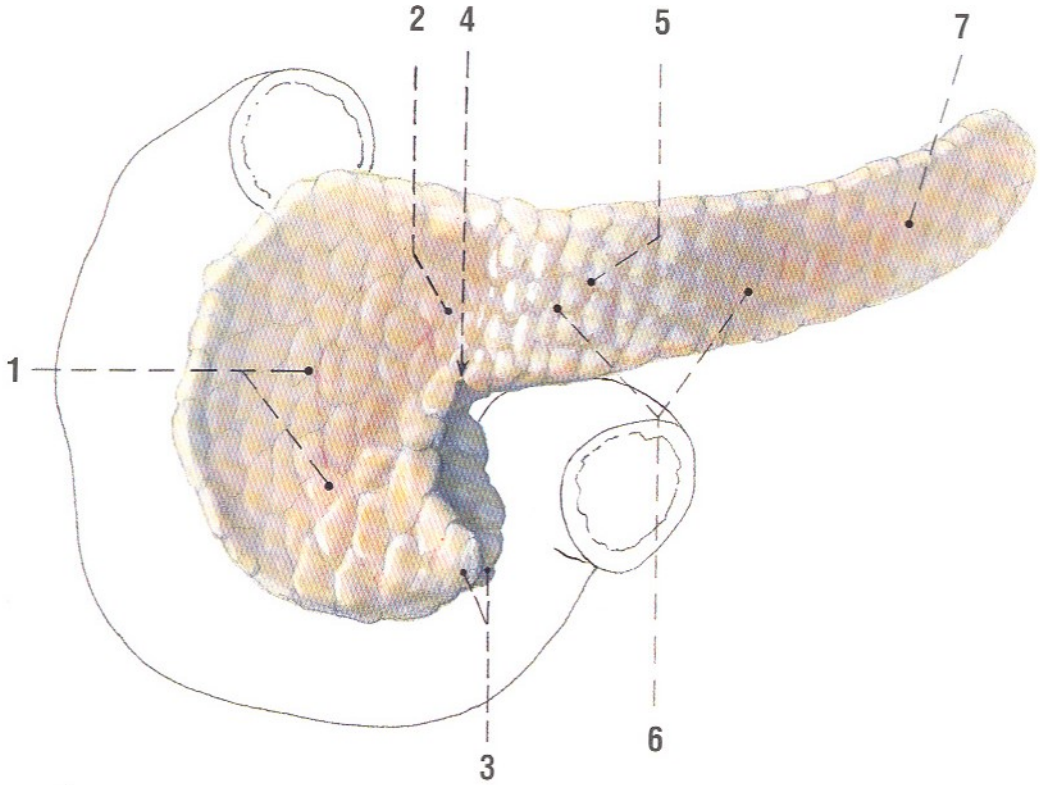
Slinivka břišní – pankreas

Exokrinní funkce:

produkce HCO_3 a enzymů štěpících cukry (α-amyláza), tuky (pankreatická lipáza) a bílkoviny (trypsin, chymotrypsin, proelastáza, karboxypeptidáza)

Endokrinní funkce:

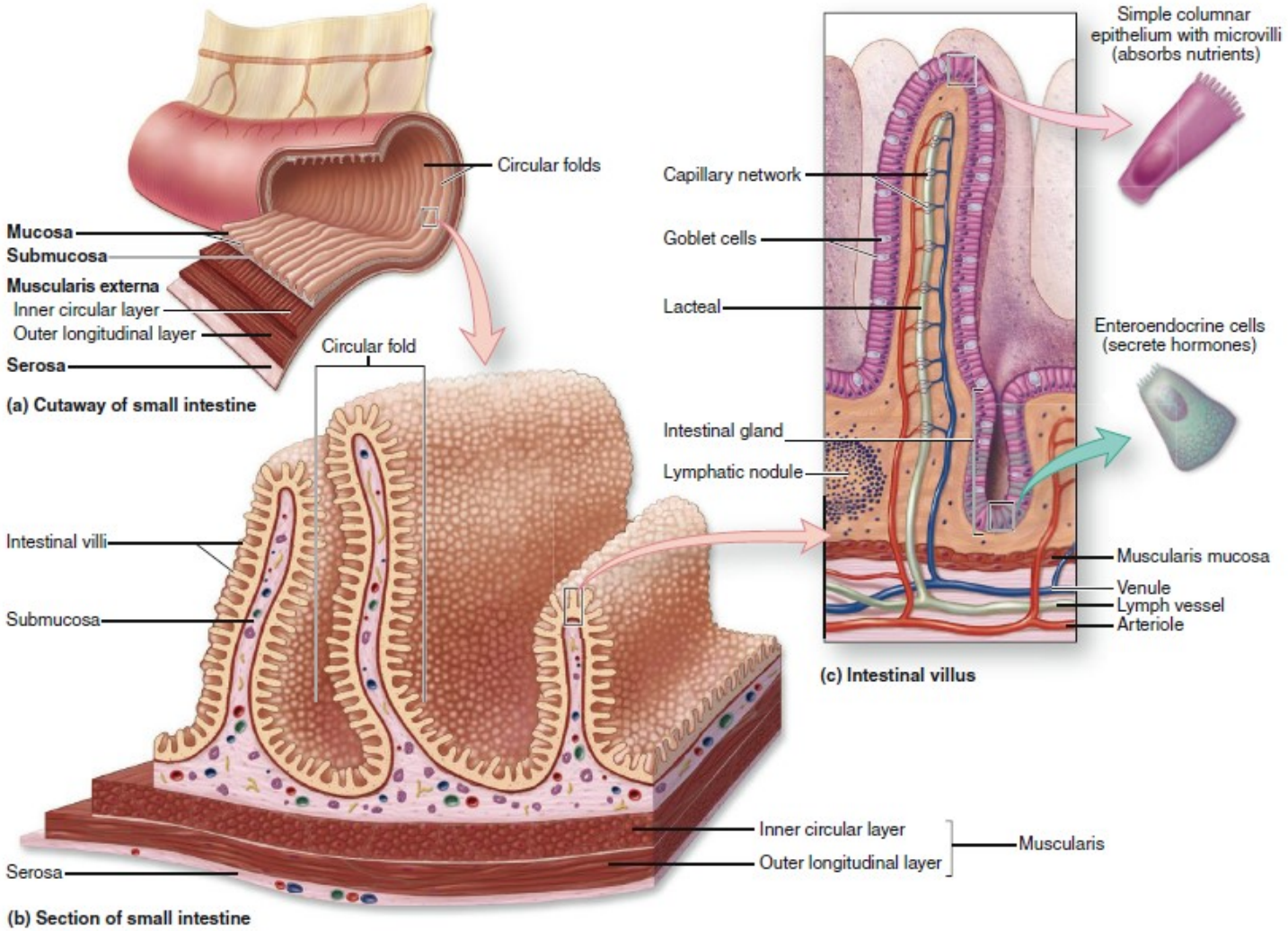
Langerhansovy ostrůvky produkující inzulin a glukagon, asi 1,5% hmotnosti slinivky

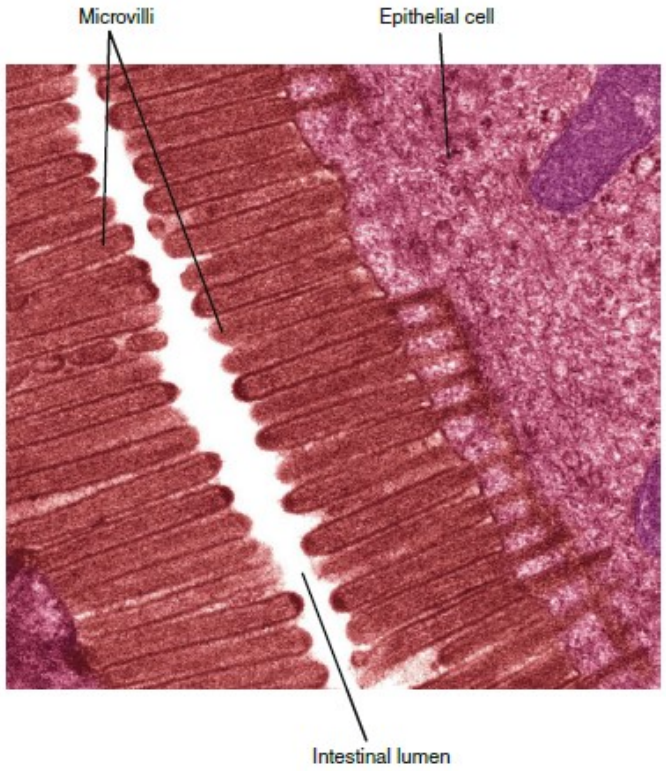


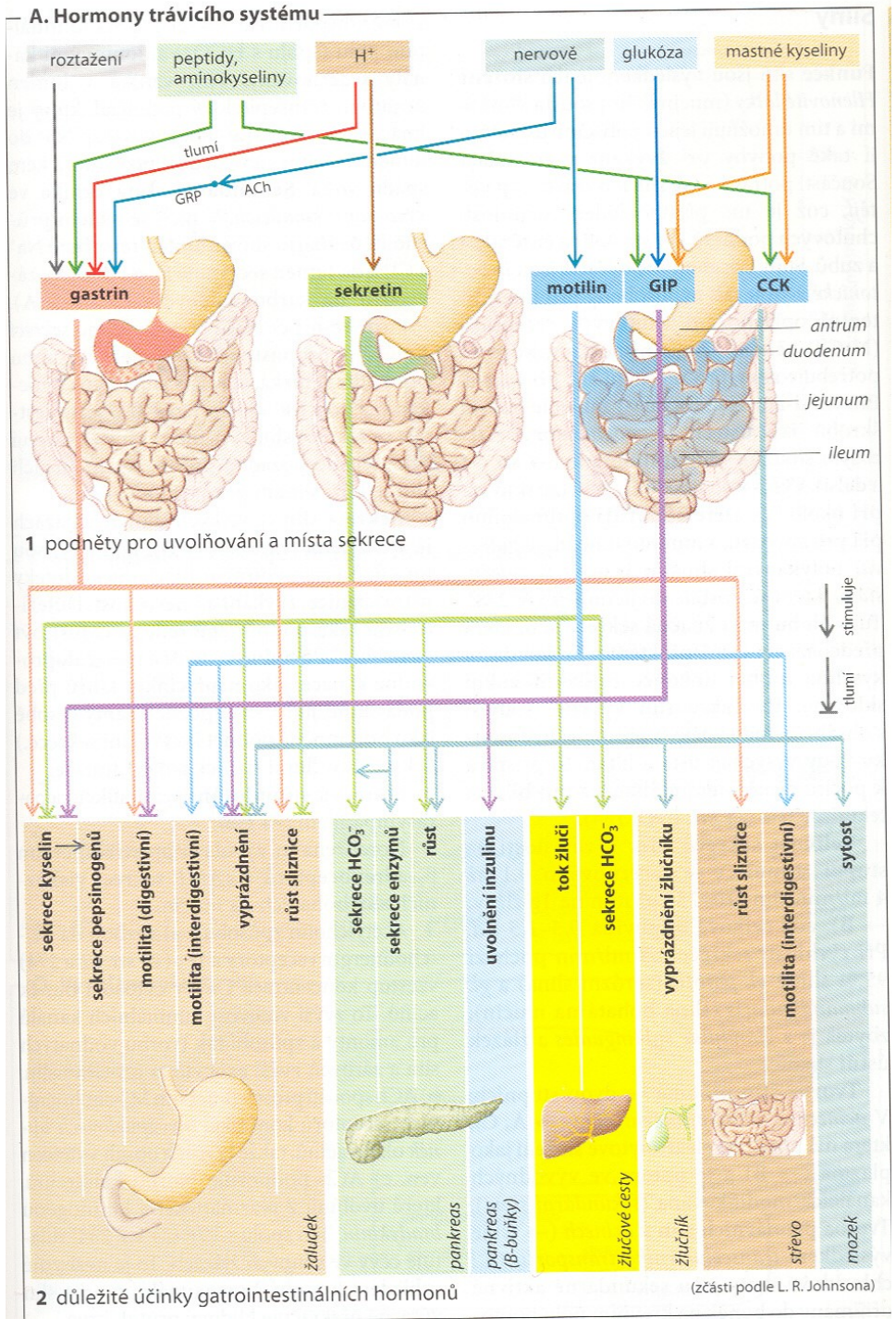
Obr. 89. PANCREAS; naznačen průběh duodena; pohled zpředu

1 caput pancreatis
2 collum pancreatis
3 proc. uncinatus
4 incisura pancreatis
5 tuber omentale
6 corpus pancreatis
7 cauda pancreatis

Střevo - výstelka







Kontrola funkcí trávicí soustavy

- Nervově (vegetativní nerv. systém) a hormonálně

Gastrin – tvořen v žaludku, zvyšuje produkci HCl

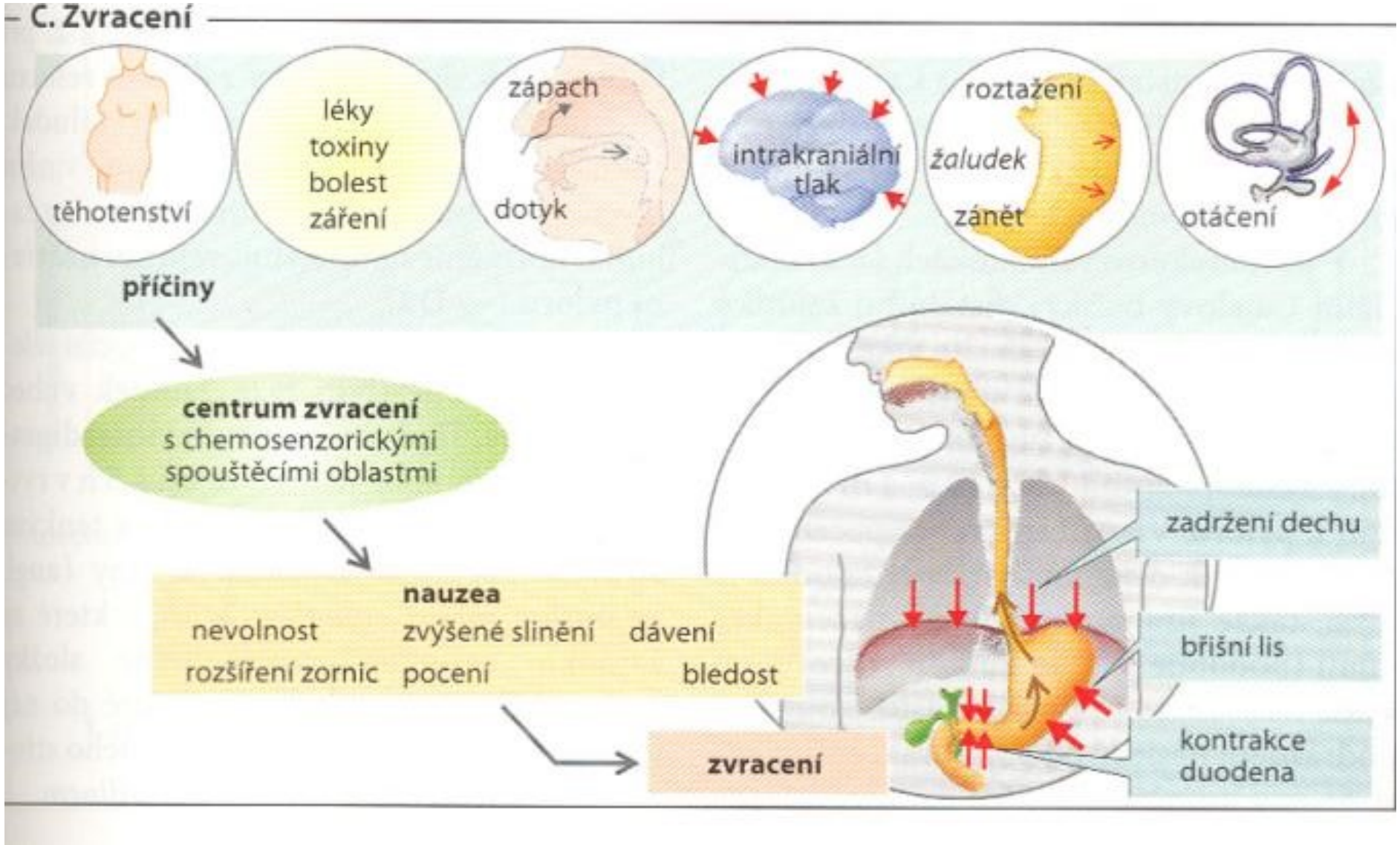
Sekretin – v duodenu, stimulem je kyselý chymus. Tlumí produkci HCl, a zvyšuje funkci pankreasu

Cholecystokinin – v celém int. tenue, stimul jsou mastné kyseliny a aminokyseliny, podporuje sekreci žluči a pankreat. šťáv

GIP (glucose-dependent insulinotropic peptide) – duodenum a jejunum, bílkoviny, cukry, tuky, stimuluje uvolňování inzulinu, tlumí sekreci HCl

Motilin – v tenkém střevě, uvolňován neuronálně, řídí motilitu střeva

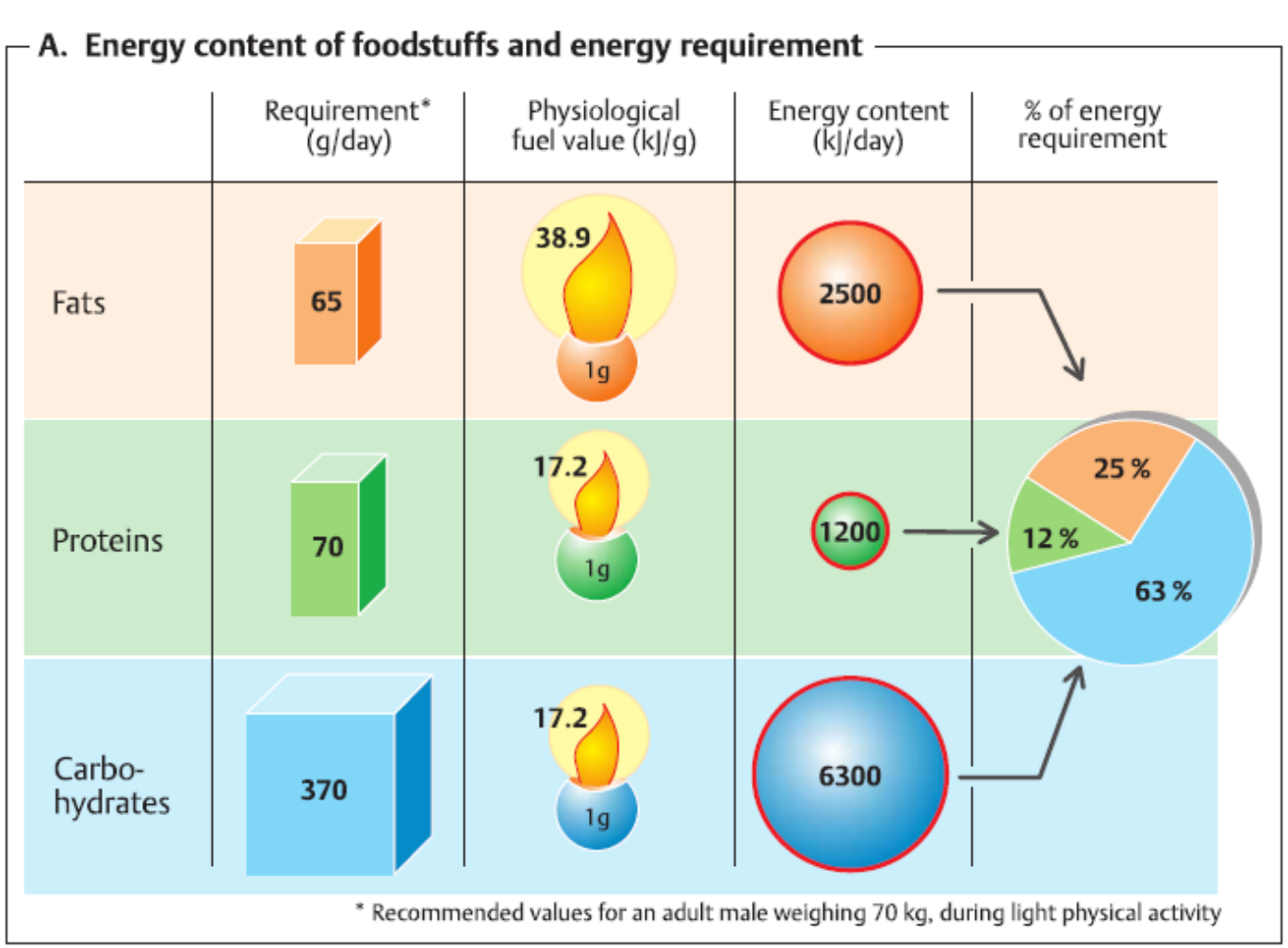
Zvracení – důležitý život zachraňující reflex

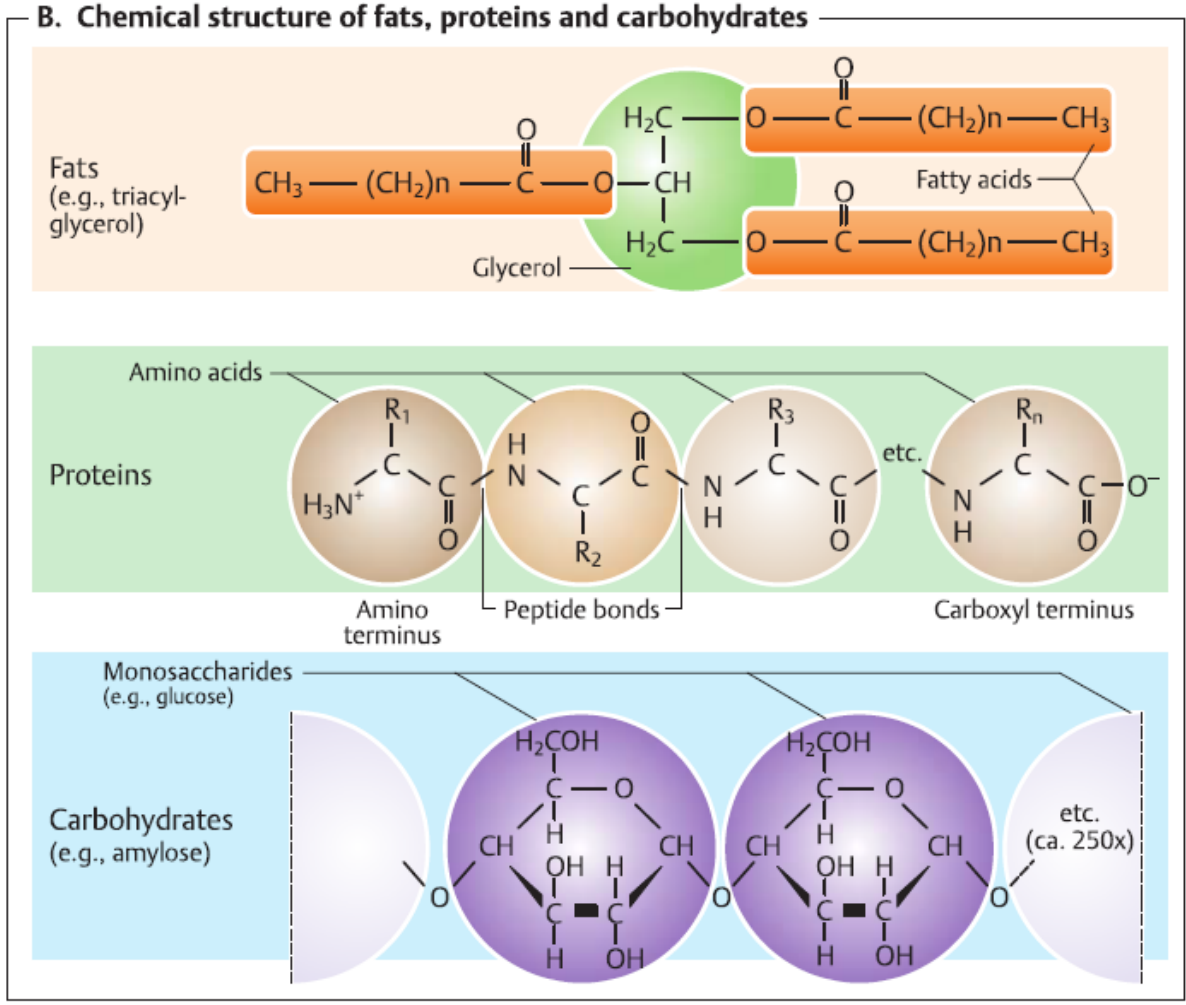


Fyziologie výživy člověka

- Výživa jako zdroj energie
- Výživa jako zdroj živin a dalších biologicky důležitých látek

Energie a látky v potravě





Energetické hospodaření organismu

- **Příjem kalorií v potravě** = ztráta tepla + vykonaná práce ± střádaná energie

nebo lépe

- **Příjem kalorií v potravě** = bazální metabolismus + specificko-dynamický efekt potravin + výdej energie na práci ± střádaná energie

Energetické hospodaření organismu

- Potřeba energie = bazální metabolismus x faktor aktivity + dietou indikovaná termogeneze (počítá se cca 6 %, většinou se zanedbává)
- = bazální metabolismus x faktor aktivity x faktor onemocnění x faktor tělesné teploty

Faktor aktivity

•Klid, spánek = 1,1

•Klid na lůžku, sedící = 1,2

•Chodící pacient = 1,3

•Lehká práce = 1,5

•Středně těžká = 1,6

•Těžká fyzická p. = 1,7+

Faktor onemocnění

•Malnutrice = 0,8

•Umělá ventilace = 0,9

•Kóma = 1

•Selektivní operace, trauma = 1–1,2

•Peritonitis = 1,2–1,5

•Mnohočetné zlomeniny = 1,2–1,35

•Těžká poranění hlavy = 1,3–1,5

•Sepse, trauma CNS = 1,5

•Polytrauma = 1,5–2

•Popáleniny (20–40%) = 1,5–1,85

Faktor TT – 1 + 0,13 na každý zvýšený stupeň nad 37

Kolik energie potřebuje člověk?

- Bazální metabolismus 70kcal/hodinu
- Navýšení o (kcal/h): 40 při psaní/práci na počítači, 40 šití, 70 mytí nádobí, 100 úklid, praní prádla 170, práce krejčího 80, truhláře 150, stavebního dělníka 200, kováře 300, dřevorubce/horníka 400.

Denní kalorická potřeba pro děti a adolescenty							
věk	*1-3*	*4-6*	*7-9*	*10-12*		*13-15*	*16-19*
kcal	1300	1700	2100	2500	♂	3100	3600
					♀	2600	2400

Cukry

- Cca 4 kcal/g
- Jednoduché cukry by měli krýt do 15 % energetické potřeby (nyní >20 %), polysacharidy 40 % (nyní <20 %)
- Různě dlouhé řetězce hexoz a pentoz – různá stravitelnost – jednoduché cukry = lehce stravitelné; polysacharidy = těžce nebo vůbec nestravitelné)
- Monosacharidy - ↑ přívod energie, vyčerpání inzulinového aparátu, vznik závislosti
- Polysacharidy – ideální zdroj energie (škrob), důležitá funkce nestravitelné vlákniny na sliznici střeva

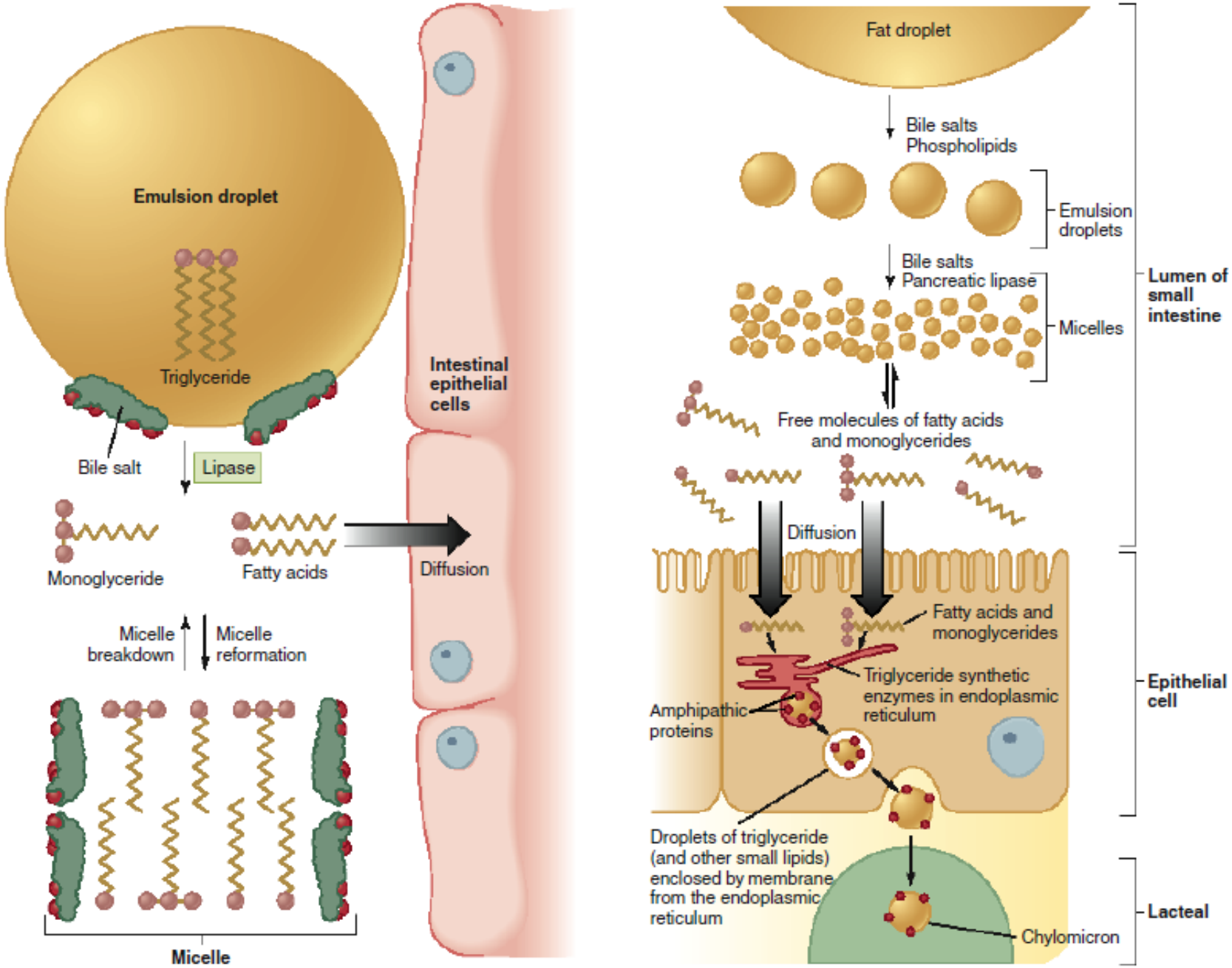
Glykemický index

- Rychlost využití glukózy z potravy v těle
- Závisí na složení cukrů v potravě (mono, di, poly-sacharidy), množství vlákniny, typ přípravy, doba varu (rozštěpení složitějších cukrů, GI ↑)
- Čistá glukóza GI=100
- Jídla s nízkým GI (<55) (zelenina, černý chléb)
- Jídla se středním GI (<70) (sladké ovoce, bílé pečivo)
- Jídla s vysokým GI (>70) (med, sladkosti, pivo, vařené brambory)

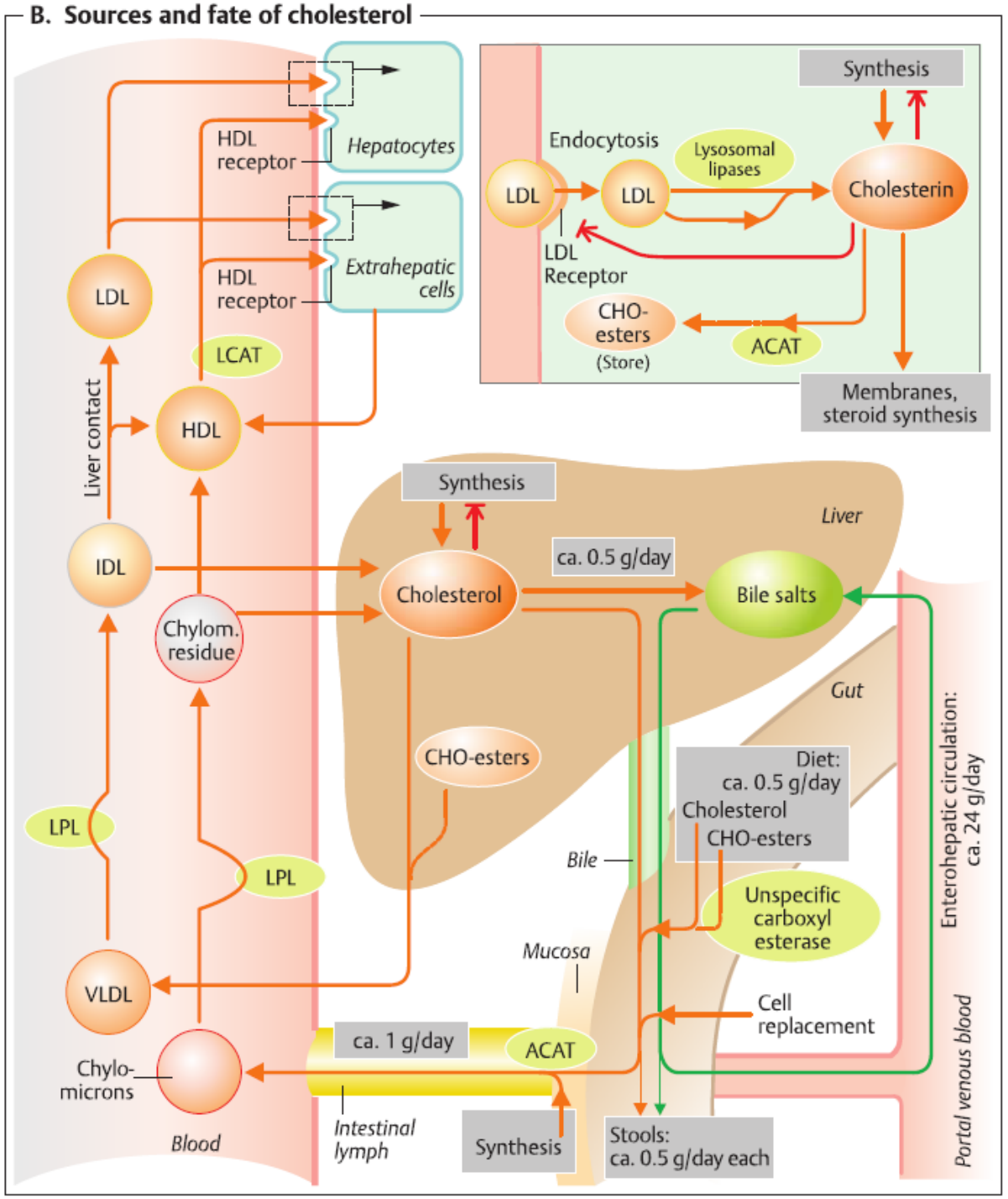
Tuky

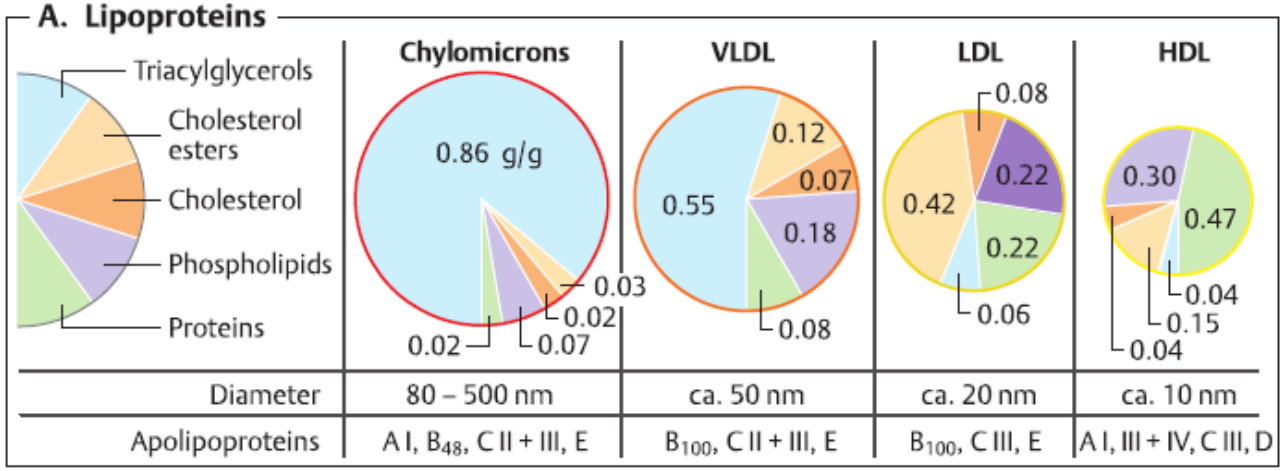
- Cca 9 kcal/g
- Měly by hradit do 30 % energetické potřeby (1:1:1 nasycené, mono-,poly-nenasycené)
- Energeticky bohaté, stavební látky buněčné stěny, základ pro steroidní hormony
- Trávení lipidů – důležitá žluč a lipázy slinivky/tenkého střeva
- Transport krví ve vazbě na proteiny – lipoproteiny (VLDL, LDL, HDL, chylomikrony)

Tuky


Emulsion droplet
Triglyceride
Bile salt
Lipase
Monoglyceride
Fatty acids
Micelle breakdown
Micelle reformation
Micelle
Intestinal epithelial cells
Diffusion
Fat droplet
Bile salts
Phospholipids
Emulsion droplets
Bile salts
Pancreatic lipase
Micelles
Lumen of small intestine
Free molecules of fatty acids and monoglycerides
Diffusion
Fatty acids and monoglycerides
Triglyceride synthetic enzymes in endoplasmic reticulum
Amphipathic proteins
Epithelial cell
Droplets of triglyceride (and other small lipids) enclosed by membrane from the endoplasmic reticulum
Chylomicron
Lacteal

Metabolismus tuků/ cholesterolu





Proteiny

- Cca 1 kcal/g
- Měly by hradit kolem *15 % energetické hodnoty*
- Potřeba aminokyselin pro stavbu vlastních bílkovin (9-10 esenciálních)
- Málo energeticky bohaté, nevýhodná glukoneogeneze
- Důležitá bohatost směsi z hlediska zastoupení AMK, zde kvalita >> kvantita
- Rostlinná potrava neobsahuje kompletní výčet AMK, nutno kombinovat a doplňovat (mléčné výrobky, živočišné bílkoviny, soja)

Proteiny - funkce

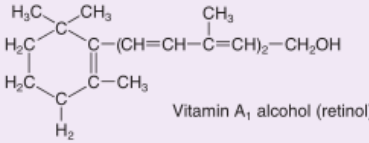
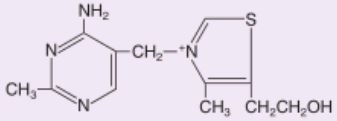
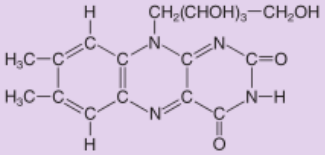
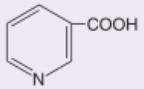
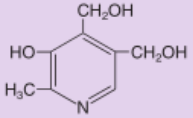
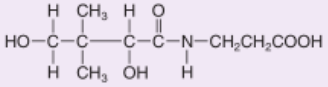
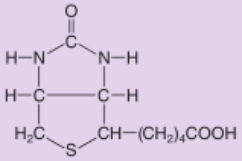
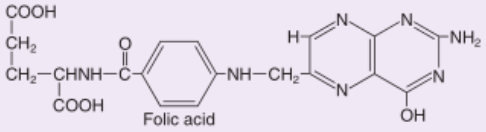
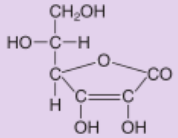
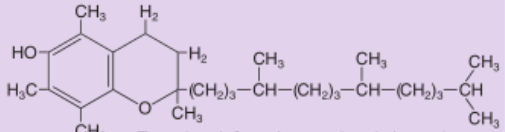
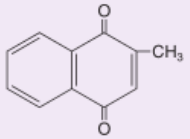
TABLE 2.6 Major Categories and Functions of Proteins

Category	Functions	Examples
Proteins that regulate gene expression	Make RNA from DNA; synthesize polypeptides from RNA	Transcription factors activate genes; RNA polymerase transcribes genes; ribosomal proteins are required for translation of mRNA into protein.
Transporter proteins	Mediate the movement of solutes such as ions and organic molecules across plasma membranes	Ion channels in plasma membranes allow movement across the membrane of ions such as Na^+ and K^+.
Enzymes	Accelerate the rate of specific chemical reactions, such as those required for cellular metabolism	Pancreatic lipase, amylase, and proteases released into the small intestine break down macromolecules into smaller molecules that can be absorbed by the intestinal cells; protein kinases modify other proteins by the addition of phosphate groups, which changes the function of the protein.
Cell signaling proteins	Enable cells to communicate with each other, themselves, and with the external environment	Plasma membrane receptors bind to hormones or neurotransmitters in extracellular fluid.
Motor proteins	Initiate movement	Myosin, found in muscle cells, provides the contractile force that shortens a muscle.
Structural proteins	Support, connect, and strengthen cells, tissues, and organs	Collagen and elastin provide support for ligaments, tendons, and certain large blood vessels; actin makes up much of the cytoskeleton of cells.
Defense proteins	Protect against infection and disease due to pathogens	Cytokines and antibodies attack foreign cells and proteins, such as those from bacteria and viruses.

Doporučné denní dávky bílkovin

Věk, pohlaví	g proteinů na kg váhy	g na hlavu	% z celkových kalorií
1-3	2,4	29	9,0
4-6	2,0	36	8,5
7-9	1,8	42	8,0
Ženy			
13-15	1,0	48	7,5
16-19	0,8	44	7,25
20+	0,75	41	7,0
Gravidita		+ 8	
Kojení		+ 20	
Muži			
13-15	1,3	58	7,5
16-19	1,0	65	7,25
20+	0,85	55	7,0

TABLE 26–4 Vitamins essential or probably essential to human nutrition.[a]

Vitamin	Action	Deficiency Symptoms	Sources	Chemistry
A (A_1, A_2)	Constituents of visual pigments (see Chapter 12: Vision); necessary for fetal development and for cell development throughout life	Night blindness, dryskin	Yellow vegetables and fruit	 Vitamin A_1 alcohol (retinol)
B complex				
Thiamin (vitamin B_1)	Cofactor in decarboxylations	Beriberi, neuritis	Liver, unrefined cereal grains	
Riboflavin (vitamin B_2)	Constituent of flavoproteins	Glossitis, cheilosis	Liver, milk	
Niacin	Constituent of NAD^+ and $NADP^+$	Pellagra	Yeast, lean meat, liver	 Can be synthesized in body from tryptophan
Pyridoxine (vitamin B_6)	Forms prosthetic group of certain decarboxylases and transaminases. Converted in body into pyridoxal phosphate and pyridoxamine phosphate	Convulsions, hyperirritability	Yeast, wheat, corn, liver	
Pantothenic acid	Constituent of CoA	Dermatitis, enteritis, alopecia, adrenal insufficiency	Eggs, liver, yeast	
Biotin	Catalyzes CO_2 "fixation" (in fatty acid synthesis, etc)	Dermatitis, enteritis	Egg yolk, liver, tomatoes	
Folates (folic acid) and related compounds	Coenzymes for "1-carbon" transfer; involved in methylating reactions	Sprue, anemia. Neural tube defects in children born to folate-deficient women	Leafy green vegetables	 Folic acid
Cyanocobalamin (vitamin B_{12})	Coenzyme in amino acid metabolism. Stimulates erythropoiesis	Pernicious anemia (see Chapter 25: Overview of Gastrointestinal Function & Regulation)	Liver, meat, eggs, milk	Complex of four substituted pyrrole rings around a cobalt atom (see Chapter 25: Overview of Gastrointestinal Function & Regulation)
C	Maintains prosthetic metal ions in their reduced form; scavenges free radicals	Scurvy	Citrus fruits, leafy green vegetables	 Ascorbic acid (synthesized in most mammals except guinea pigs and primates, including humans)
D group	Increase intestinal absorption of calcium and phosphate (see Chapter 21: Hormonal Control of Calcium & Phosphate Metabolism & the Physiology of Bone)	Rickets	Fish liver	Family of sterols (see Chapter 21: Hormonal Control of Calcium & Phosphate Metabolism & the Physiology of Bone)
E group	Antioxidants; cofactors in electron transport in cytochrome chain?	Ataxia and other symptoms and signs of spinocerebellar dysfunction	Milk, eggs, meat, leafy vegetables	 α-Tocopherol; β- and γ-tocopherol also active
K group	Catalyze γ carboxylation of glutamic acid residues on various proteins concerned with blood clotting	Hemorrhagic phenomena	Leafy green vegetables	 Vitamin K_3; a large number of similar compounds have biological activity

[a]Choline is synthesized in the body in small amounts, but it has recently been added to the list of essential nutrients.

Bazální metabolismus - výpočet

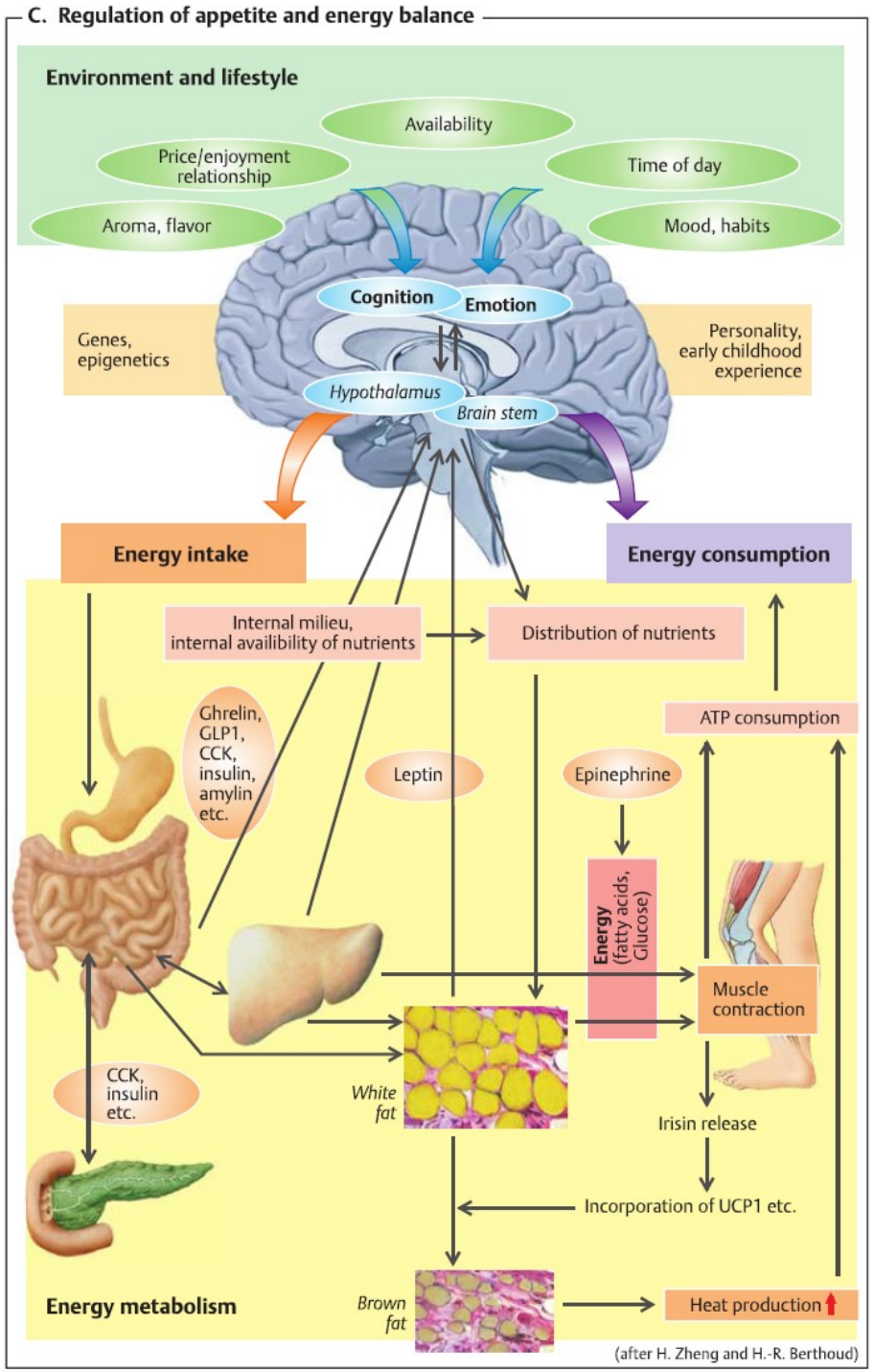
♀

- 655 + 9,6 x hmotnost (kg) + 1,8 x výška (cm) – 4,8 x věk (roky) [kcal]

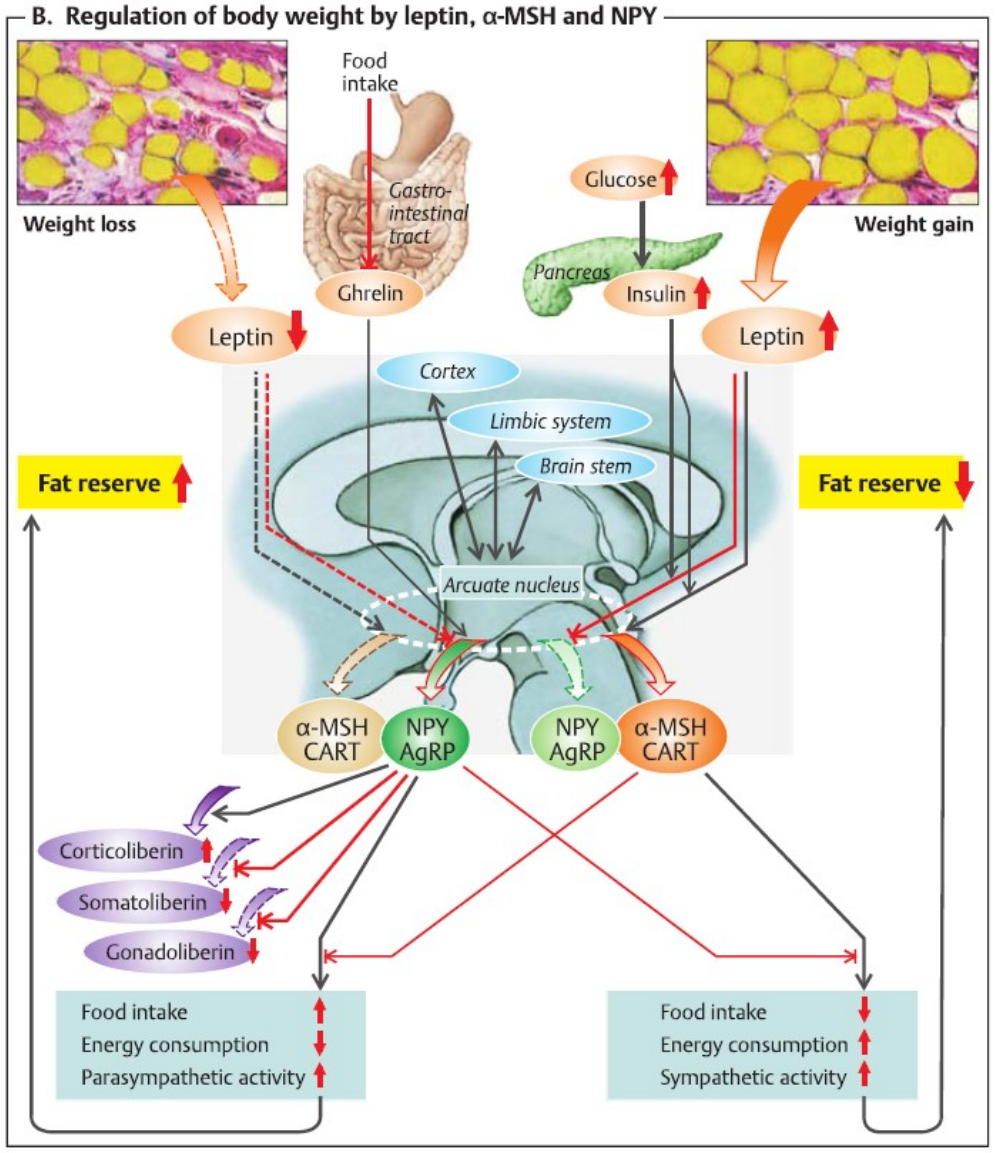
♂

- 66,5 + 13,8 x hmotnost (kg) + 5 x výška (cm) – 6,8 x věk (roky) [kcal]

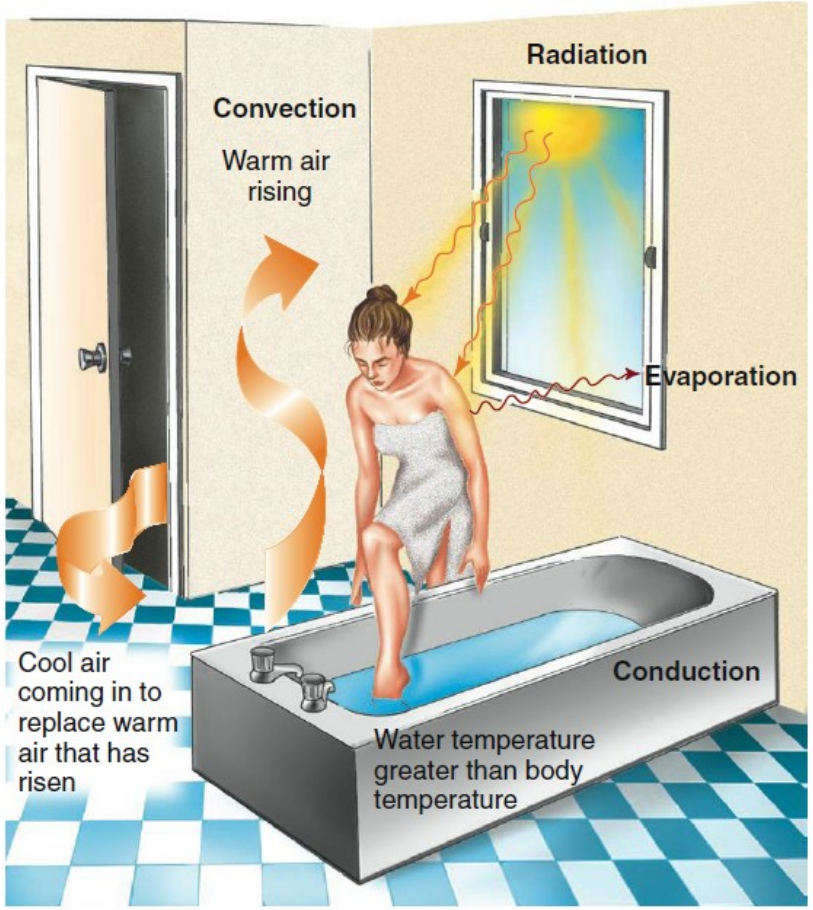
Regulace příjmu potravy

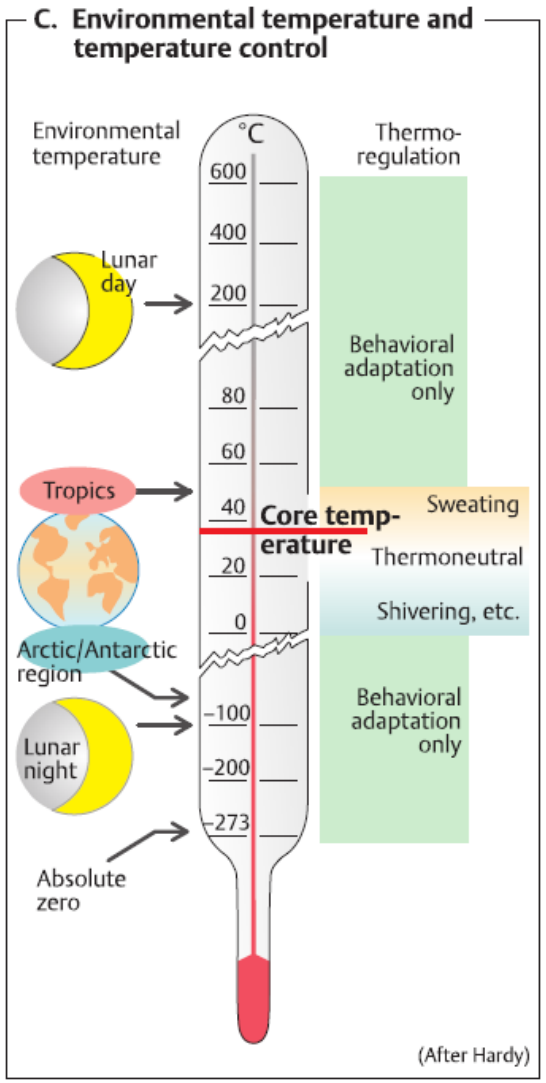


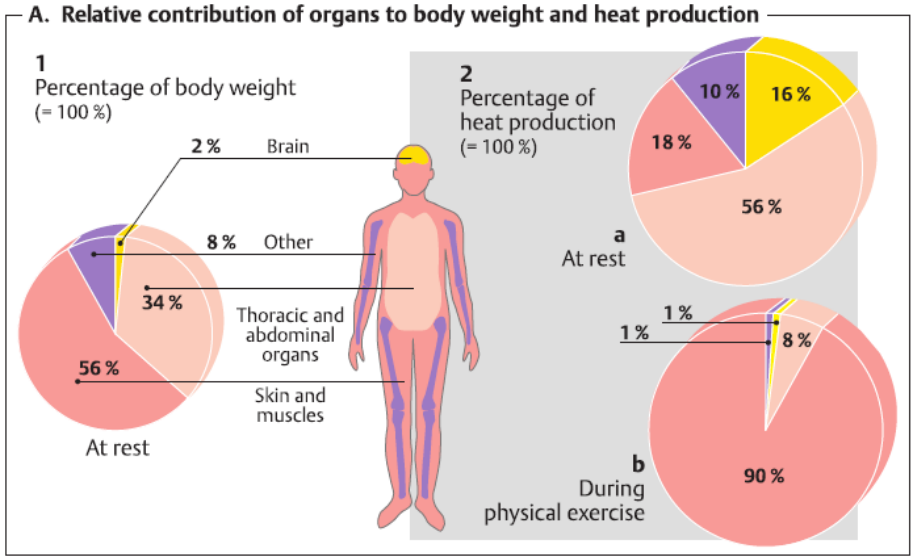
- Leptin – tuková tkáň
- Neuropeptid Y (NPY) – neurotransmiter, podporuje hlad a apetit -> příjem potravy
- A-melanocyty stimulující hormon (MSH) – hlavně hypotalamus, neurotransmiter

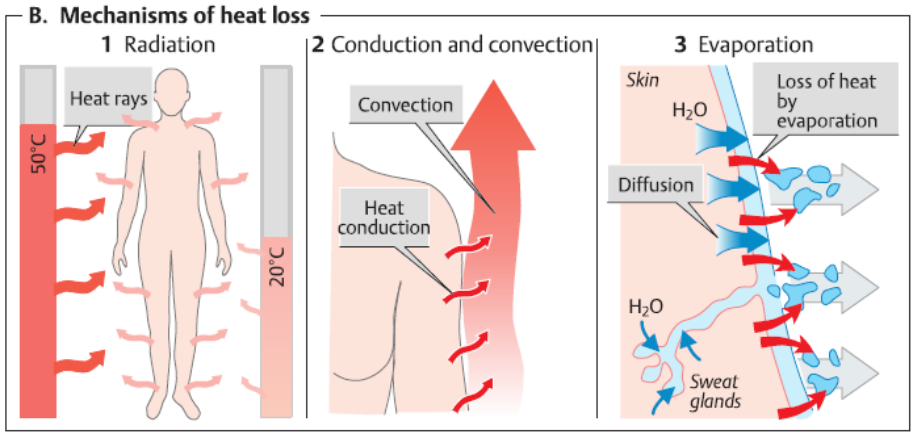


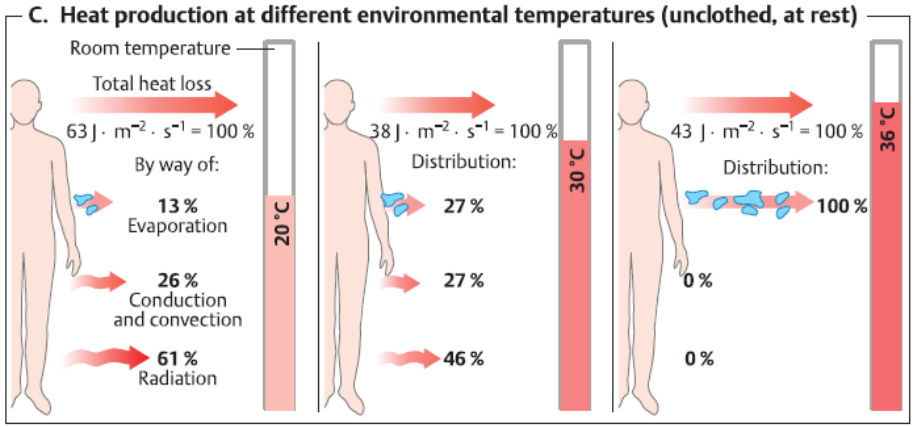
Teplota těla – principy



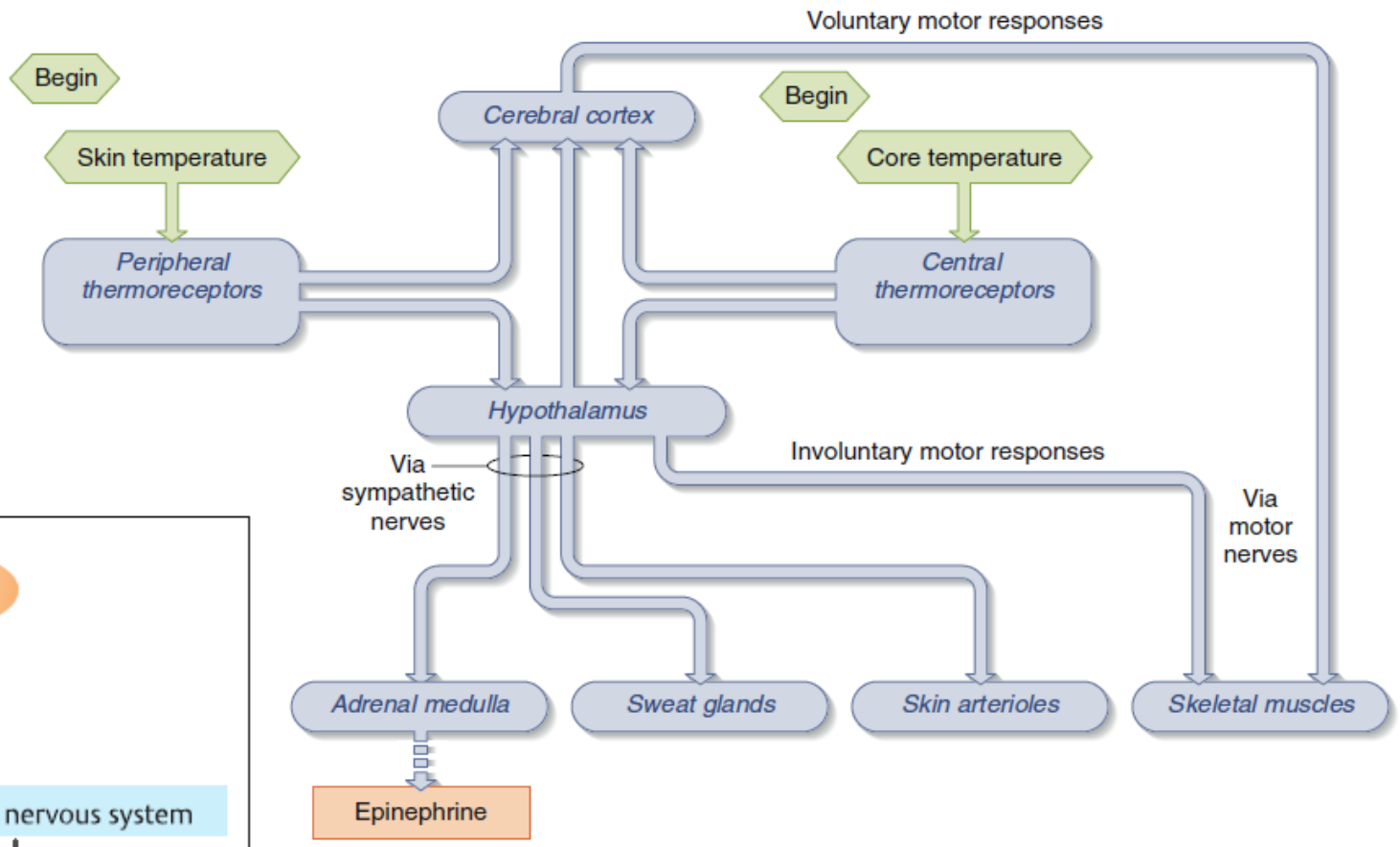


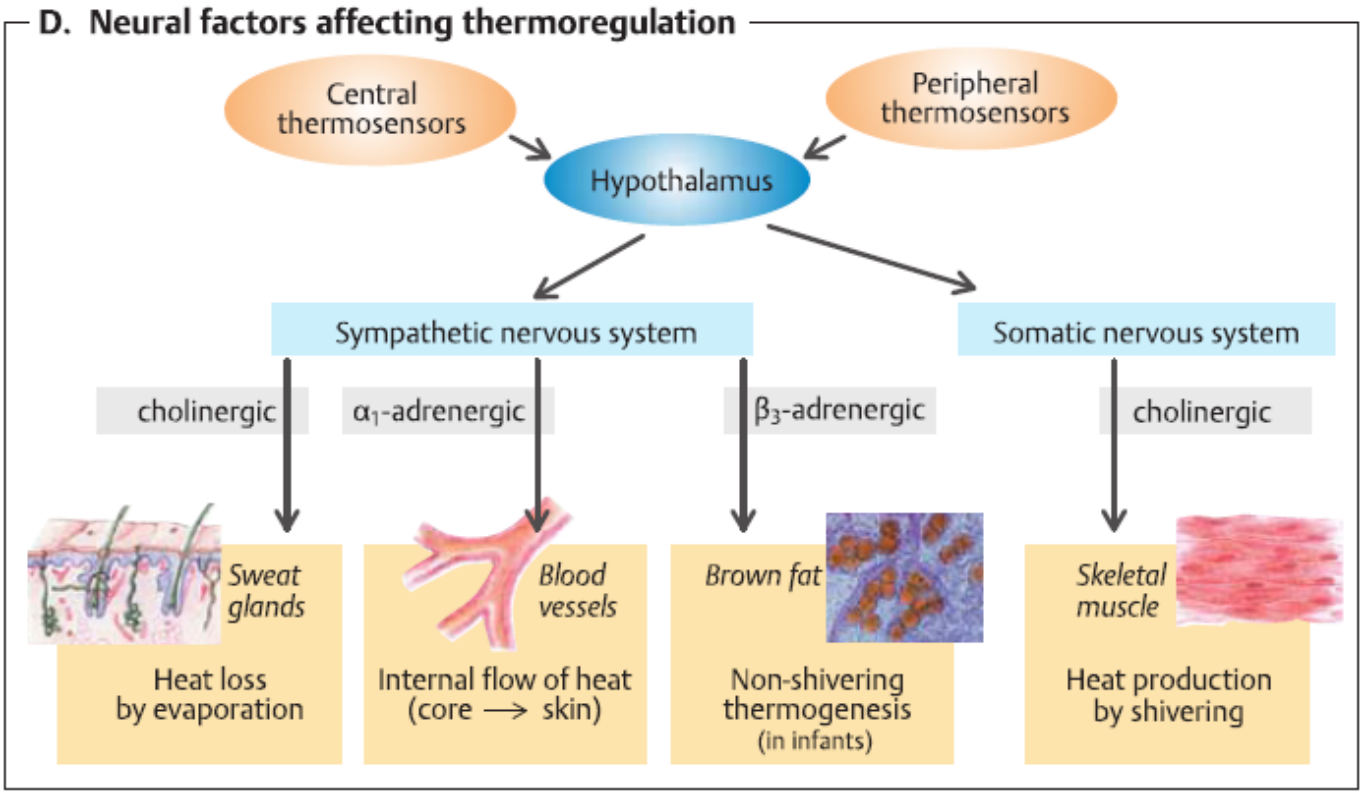




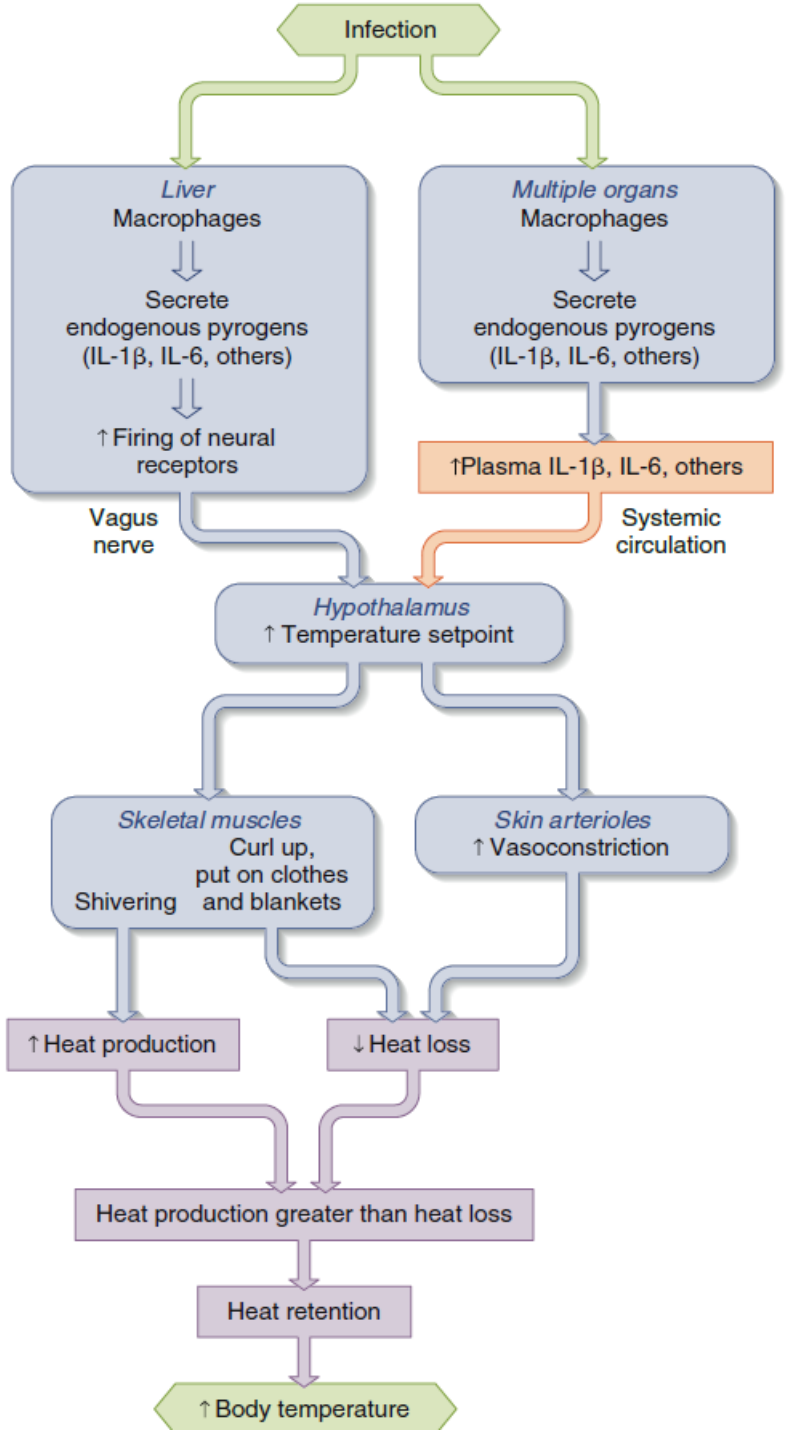


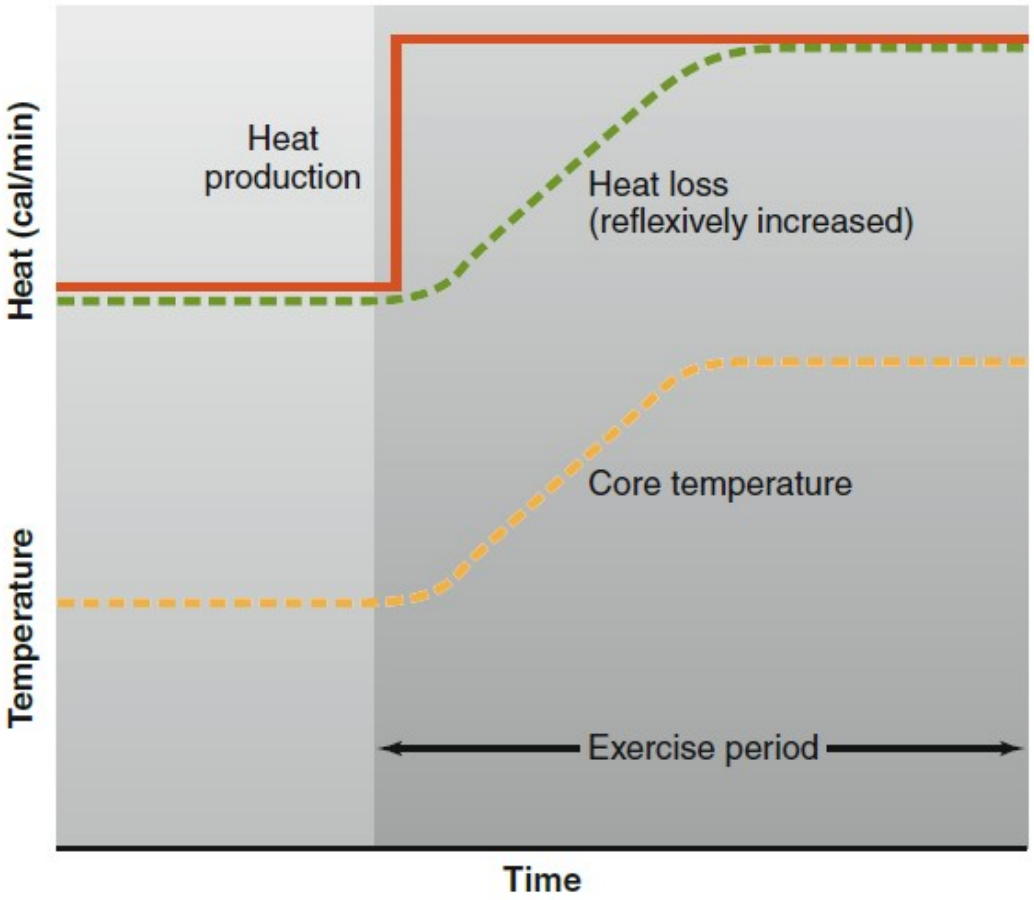
Termoregulace





Horečka a zvýšená produkce tepla





Složení těla – prvky, látky

TABLE 3.8 Essential Nutrients

Water		
Mineral Elements		
7 major mineral elements (see Table 2.1)		
13 trace elements (see Table 2.1)		
Essential Amino Acids		
Histidine		
Isoleucine		
Leucine		
Lysine		
Methionine		
Phenylalanine		
Threonine		
Tryptophan		
Valine		
Essential Fatty Acids	*Other Essential Nutrients*	
Linoleic acid	Inositol	
Linolenic acid	Choline	
	Carnitine	
Vitamins		
Water-soluble vitamins		
B_1: thiamine		Vitamin B complex
B_2: riboflavin		Vitamin B complex
B_6: pyridoxine		Vitamin B complex
B_{12}: cobalamine		Vitamin B complex
Niacin		Vitamin B complex
Pantothenic acid		Vitamin B complex
Folic acid		Vitamin B complex
Biotin		Vitamin B complex
Lipoic acid		
Vitamin C		
Fat-soluble vitamins		
Vitamin A		
Vitamin D		
Vitamin E		
Vitamin K		

TABLE 2.1 Essential Chemical Elements in the Body (Neo-Latin Terms in Italics)

Element	Symbol
Major Elements: 99.3% of Total Atoms in the Body	
Hydrogen	H (63%)
Oxygen	O (26%)
Carbon	C (9%)
Nitrogen	N (1%)
Mineral Elements: 0.7% of Total Atoms in the Body	
Calcium	Ca
Phosphorus	P
Potassium	K (*kalium*)
Sulfur	S
Sodium	Na (*natrium*)
Chlorine	Cl
Magnesium	Mg
Trace Elements: Less than 0.01% of Total Atoms in the Body	
Iron	Fe (*ferrum*)
Iodine	I
Copper	Cu (*cuprum*)
Zinc	Zn
Manganese	Mn
Cobalt	Co
Chromium	Cr
Selenium	Se
Molybdenum	Mo
Fluorine	F
Tin	Sn (*stannum*)
Silicon	Si
Vanadium	V