

Petrozavodsk State University
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Department of Life Safety and Health Saving Technologies

The role of the liver and pancreas in digestion

Features of the development of the liver and pancreas

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Physiology of the pancreas

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- During the day, the pancreas secretes 1.5-2 liters of juice

2

- The juice is a product of the activity of exocrine pancreocytes

3

- pH of the juice = 7.8 – 8.4 (alkaline medium)

4

- The juice contains active amylase, lipase, nuclease, and inactive proteases (proteases are activated by other enzymes)

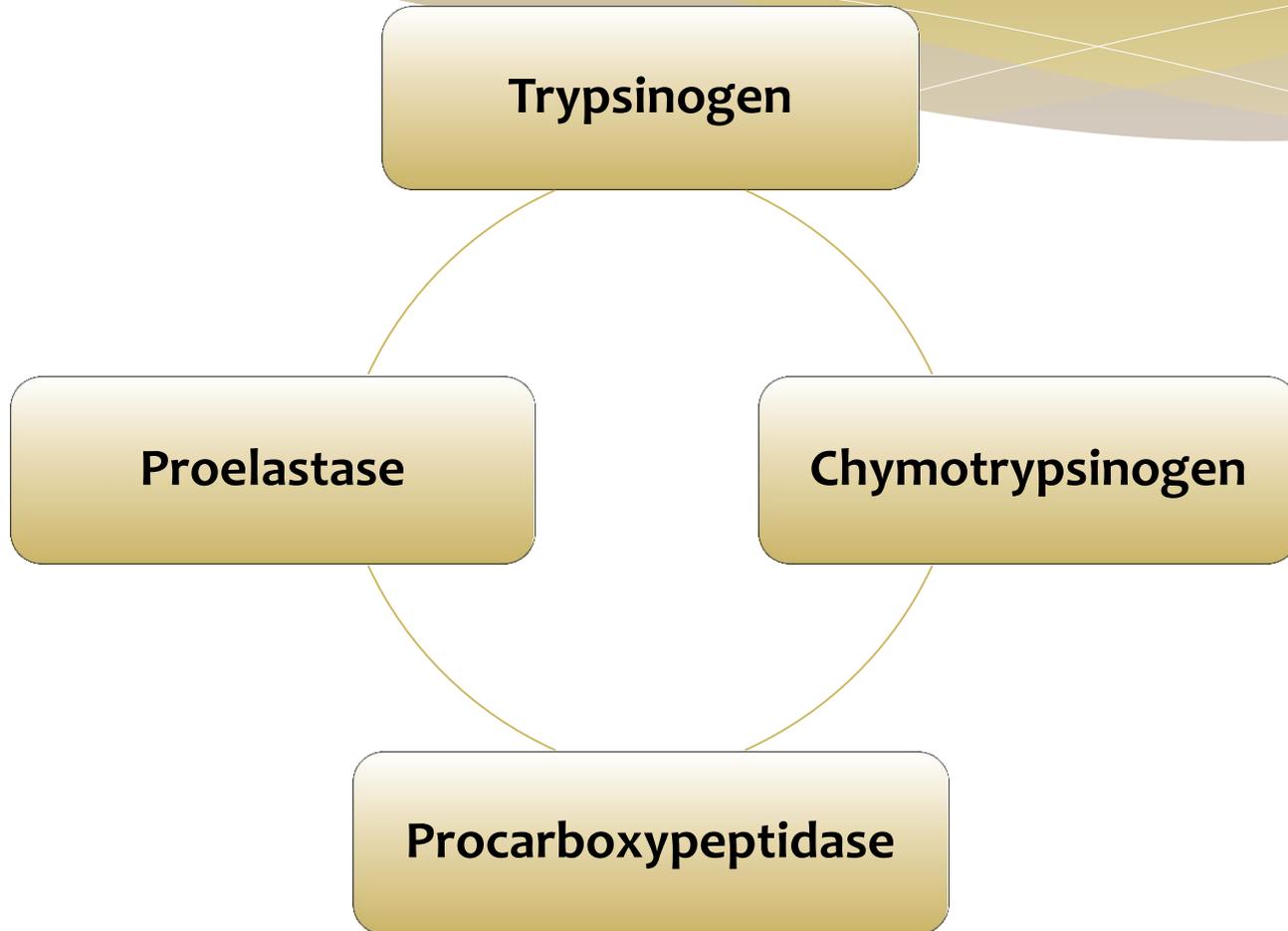
5

- The higher the acidity of the food lump that has entered the duodenum, the higher the alkalinity of the pancreatic juice and the more it is released

Pancreatic proteases

- ❑ **Trypsinogen** (under the influence of enterokinase of the duodenum, it turns into trypsin)
- ❑ **Chymotrypsinogen** (under the influence of trypsin, it turns into chymotrypsin)
- ❑ **Proelastase** (under the influence of trypsin, it turns into elastase)
- ❑ **Procarboxypeptidase** (under the influence of trypsin, it turns into carboxypeptidase)

Pancreatic proteases



Neural regulation of pancreatic secretion

The pancreas secretes juice according to a conditionally reflex (the sight, smell of food) and unconditionally reflex principle (the intake of food into the oral cavity, esophagus, stomach)

The parasympathetic division (vagus nerve) increases the secretion of juice

The sympathetic division inhibits the secretory activity of the gland

Humoral regulation of pancreatic secretion

Substances that stimulate the production of pancreatic juice:

- Secretin
- Cholecystokinin-pancreosimin
- Gastrin
- Serotonin
- Insulin
- Bombesin
- Substance P

Substances that inhibit the production of pancreatic juice:

- Glucagon
- Calcitonin
- Vasoactive intestinal peptide

Bile

- ❑ During the day, a person forms 500-1500 ml of bile
- ❑ Bile is synthesized by liver hepatocytes
- ❑ Hepatic bile is the bile found in the bile ducts of the liver
- ❑ Cystic bile is the bile stored in the gallbladder
- ❑ Liver bile is golden yellow in color, but after storing it in the gallbladder, water is absorbed from its composition and the bile becomes darker in color
- ❑ The chemical composition of bile includes water, bile acid salts, fatty acids, lipids, pigments, cholesterol, inorganic salts
- ❑ Bile pH 7.3-8

Human bile acids (cholic acids)

Primary and secondary bile acids

- ❑ Bile acids are hydroxy acids from the class of steroids.
- ❑ **Primary bile acids** (primarily secreted by the liver):
cholic acid and cheno-deoxy-cholic acid
- ❑ **Secondary bile acids** (formed from primary bile acids in the large intestine under the action of intestinal microflora): deoxy-cholic acid, lithocholic, allocholic and urso-deoxy-cholic acids

Primary and secondary bile acids

Primary bile acids

- Cholic acid
- Cheno-deoxy-cholic acid

Secondary bile acids

- Deoxy-cholic acid
- Litocholic acid
- Allocholic acid
- Urso-deoxy-cholic acid

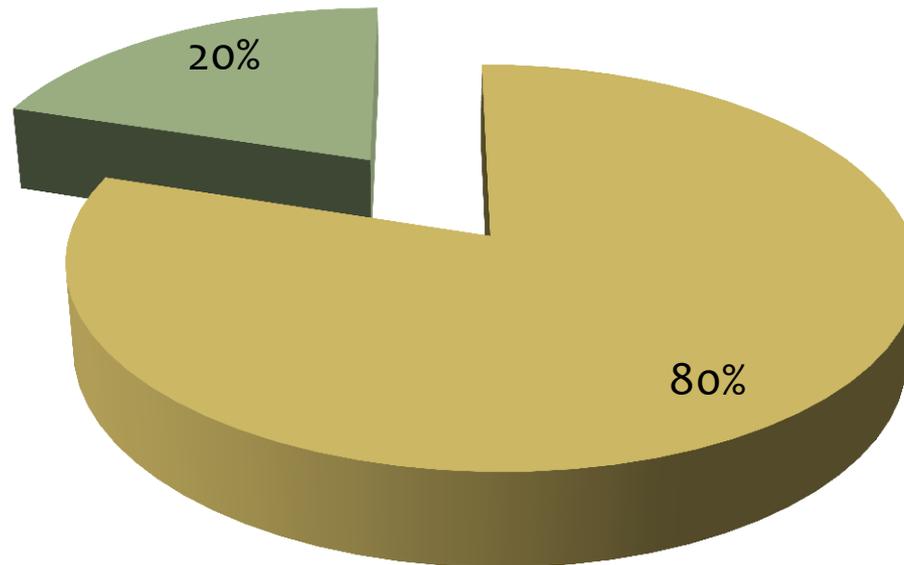
Human bile acids (cholic acids) Glycocholic and taurocholic acids

- ❑ Bile acids in the body are contained in the form of compounds with **amino acids** with **glycine** and **taurine**
- ❑ The associated acids are called **glycocholic acids** and **taurocholic acids**, respectively
- ❑ The ratio between these acids in the body is as follows: 80 % glycocholic acids and 20 % taurocholic acids
- ❑ Glyco-cholic acids are more involved in the breakdown of carbohydrate foods, and tauro-cholic acids are more involved in the breakdown of protein foods

Ratio between acids

acids

■ glycocholic acids ■ taurocholic acids



Bile pigments

Bile pigments give it color

Bile pigments are products of the breakdown of hemoglobin

Bilirubin - red-yellow pigment (the main pigment)

Biliverdin - green pigment (contained in trace amounts)

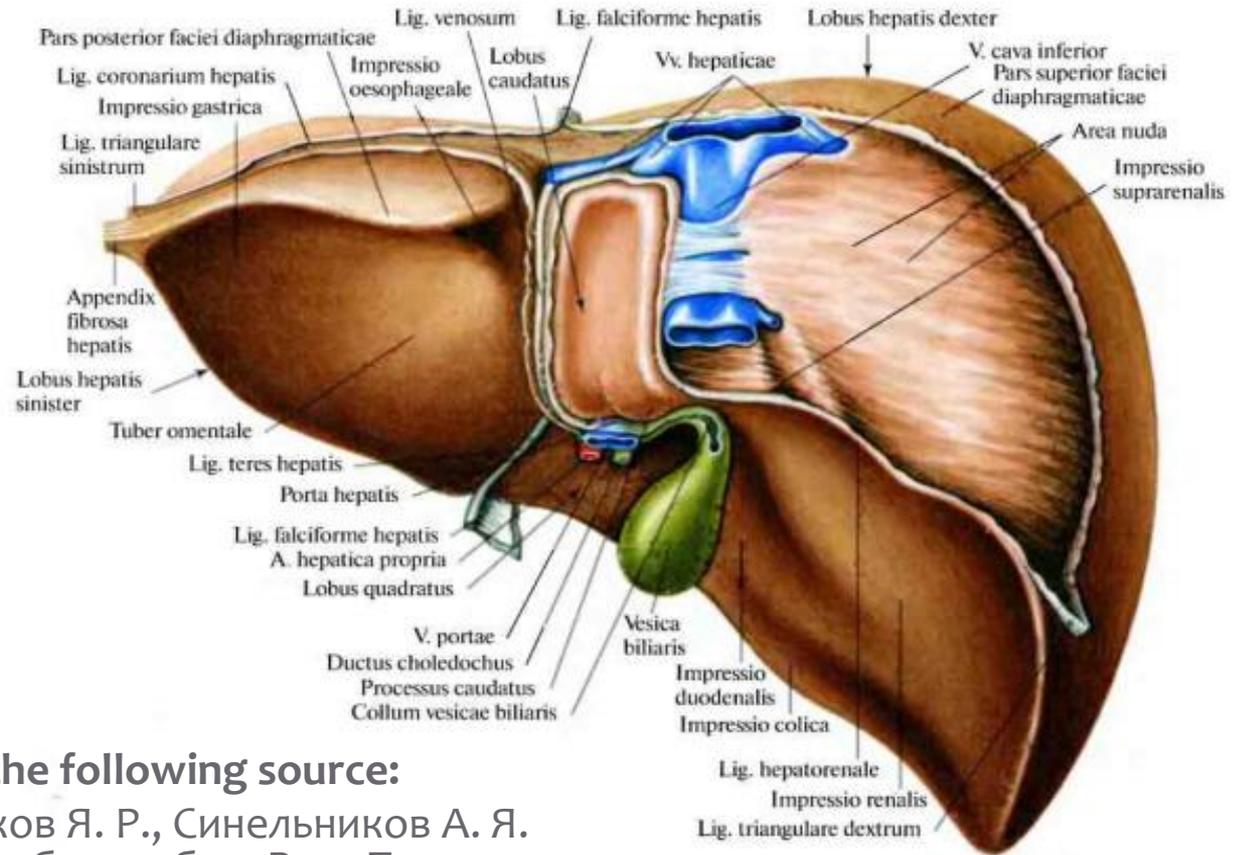
Regulation of bile excretion from the gallbladder

- ❑ **Humoral regulation** (hormones that promote the evacuation of bile from the bladder-cholecystokini-pancreosimin, gastrin, secretin, bombesin; hormones that inhibit the excretion of bile-glucagon, calcitonin, VIP)
- ❑ **Nervous regulation** (conditioned-reflex and unconditionally-reflex regulation; parasympathetic division - increases the excretion of bile, and sympathetic - slows down the excretion of bile)
- ❑ The **chemical composition of food** contributes to the formation and excretion of bile. Fatty and protein foods actively stimulate the secretion of bile.

Functions of bile

- ❑ Bile – the main product of the liver
- ❑ Bile emulsifies fats, increasing the surface on which they are hydrolyzed by lipase
- ❑ Bile dissolves the products of fat hydrolysis, which contributes to their absorption
- ❑ Bile increases the activity of pancreatic and intestinal enzymes (especially lipase)
- ❑ Bile stimulates the motor activity of the intestine
- ❑ Bile is able to neutralize gastric acids and pepsin that have entered the duodenum from the stomach
- ❑ Bile has a bacteriostatic property
- ❑ Bile promotes the absorption of fat-soluble vitamins, cholesterol, amino acids and calcium salts in the intestine

Liver Gallbladder



* This picture is taken from the following source:

Синельников Р. Д., Синельников Я. Р., Синельников А. Я.
 Атлас анатомии человека : Учеб. пособие: В 4т. Т.2.-7-е
 изд., перераб.- М.: РИА «Новая волна» : Издатель
 Умеренков, 2009. – 248 с. : ил. ISBN 978-5-7864-0200-2
 (Новая волна) ISBN 978-5-94368-051-9 (Изд. Умеренков)

Sinelnikov R. D. Sinelnikov, Y. R., A. Y. Sinelnikov Atlas of
 human anatomy : Textbook. allowance: 4T. vol. 2 7th ed. Rev.
 - Moscow: RIA "New wave" : the Publisher Umerenkov, 2009.
 – 248 p.: Il. ISBN 978-5-7864-0200-2 (New wave) ISBN 978-5-
 94368-051-9 (Ed. Umerenkov)

Age-related features of the development of the pancreas

- ❑ In newborns, the pancreas is very small in size. Its length ranges from 3 to 6 cm; weight-2.5-3 g; the gland is located slightly higher than in adults, but it is weakly fixed to the posterior abdominal wall and is relatively mobile.
- ❑ By the age of 3, its mass reaches 20 grams, by the age of 10-12 — 30 g. The type characteristic of adults, the gland takes to the age of 5-6 years.

Age-related features of the development of the liver

- ❑ The weight of the liver in newborns and children of the first year of life is $\frac{1}{8}$ of the body weight, in an adult- $\frac{1}{36}$ - $\frac{1}{50}$.
- ❑ In children, the liver is very mobile and easily changes position. Bile is released by the liver from the first day of life. With age, bile production increases. The content of bile acids in the bile is very high in the first days after birth, in preschool and primary school age it decreases, in adults it rises sharply again. During the development of the child, the ability of the gallbladder to concentrate bile increases. In children, morphologically, the liver cells are not yet fully mature, and therefore its function is imperfect. In diseases, its cells easily die, which leads to a violation of metabolic processes, the barrier function of the liver. This greatly complicates the course of intestinal diseases in children.

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Questions:

1

- What enzymes does pancreatic juice contain?

2

- What role does the nervous system play in regulating the functions of the pancreas?

3

- What role does the humoral system play in the regulation of pancreatic functions?

4

- What function does bile perform in digestion?

5

- What is the chemical composition of bile?

6

- What age-related features of the growth and development of the pancreas and liver do you know?

Recommended literature

Recommended main literature:

- * Nozdrachev A.D. et al. The beginning of physiology: textbook for universities [gryph of the Ministry of education of the Russian Federation] / ed. A.D. Nozdrachev. - 3rd ed. - St. Petersburg.; m.; Krasnodar: LAN, 2004. - 1088 p.: Il.

Recommended additional literature:

- * Kositsky, G. I. human Physiology: Textbook for universities / G. I. Kositsky et al. - Moscow: Alliance, 2015. - 544 p.
- * Pokrovsky V. M., Korotko G. F. human Physiology. Moscow. – «Medicine». -2003. - 656 p.
- * Sinelnikov R. D. Sinelnikov, Y. R., A. Y. Sinelnikov Atlas of human anatomy : Textbook. allowance: 4T. vol. 2 7th ed. Rev. - Moscow: RIA "New wave" : the Publisher Umerenkov, 2009. – 248 p.: Il. ISBN 978-5-7864-0200-2 (New wave) ISBN 978-5-94368-051-9 (Ed. Umerenkov)

Рекомендуемая литература

Рекомендуемая основная литература:

- * Ноздрачев А. Д. и др. Начала физиологии: учебник для вузов [гриф Минобразования рф] / ред. А. Д. Ноздрачев. – 3-е изд. – СПб.; м.; Краснодар : лань, 2004. – 1088 с. : ил.

Рекомендуемая дополнительная литература:

- * Косицкий, Г. И. Физиология человека: Учебник для вузов / Г.И. Косицкий и др. - М.: Альянс, 2015. - 544 с.
- * Покровский В. М., Коротько Г. Ф. Физиология человека. Москва. – «Медицина». -2003. – 656 с.
- * Синельников Р. Д., Синельников Я. Р., Синельников А. Я. Атлас анатомии человека : Учеб. пособие: В 4т. Т.2.-7-е изд., перераб.- М.: РИА «Новая волна» : Издатель Умеренков, 2009. – 248 с. : ил. ISBN 978-5-7864-0200-2 (Новая волна) ISBN 978-5-94368-051-9 (Изд. Умеренков)