of sodium currently increases the gradient for the diffusion of potassium from cells into the lumen. The substances being absorbed in the large intestine include also the chains of fatty acids which are produced during fermentation. Neither saccharides, nor amino acids are absorbed in the large intestine.

Under physiological circumstances, the gastric contents, owing to the presence of HCl, is almost sterile. The bacterial reproduction in the duodenum is inhibited by bile and antibodies. Duodenum contains only a minimal amount of aerobic, and no anaerobic microbes. Anaerobic microbes harbour the more remote part of the ileum – the ileocoecal area. The intestinal flora mostly includes Escherichia coli, Clostridium Welchi and streptococci. Bacteria significantly participate in the metabolism of bile acids, namely in the reabsorption of bile components, elimination of toxic metabolites from bile and the breakdown of fibrous material. The intestinal bacterial flora participates in the metabolism of oestrogens, androgens, lipids, various nitrogen substances and drugs.

7.10 Malabsorption

The main function of the gastrointestinal tract is to digest and absorb the nutrients serving as the source of energy. In addition to the latter, an organism needs small amounts of other significant substances for the optimal procurement of specific functions.

In a precise pathophysiological sense, the term **malabsorption** refers to a defective absorption of nutrients by the intestinal mucosa, whereas an impaired hydrolysis of nutrients is referred to as **maldigestion**. However, as the processes of digestion and absorption are very closely associated, all aspects of impaired digestion and absorption are in clinical practice commonly referred to as malabsorption syndrome.

7.10.1 Inadequate digestion (maldigestion)

The malabsorption syndrome often develops in consequence of defective digestion. The accepted food must be initially processed down to basic components. These acitivites enable further steps to be carried out with subsequent resorption. The process takes place within the lumen, on the mucosal surface (contact digestion). A significant role in the process of digestion is carried out by the pancreas. It produces lipase, colipase and proteases, especially trypsin. Therefore malabsorption is the cardinal symptom of chronic pancreatitis. In order to procure the optimal digestion of fat, the chyme must contain a sufficient amount of bile acids which are necessary for normal lipolysis and formation of micelles. A decreased production of bile salts can develop in consequence of its decreased synthesis in the liver, however more often it is caused by cholestasis in coincidence with hepatic cirrhosis. A further cause resides in an increased deconjugation of bile acids caused by bacterial overgrowth.

Bile acids deficiency may be caused also by diseases of the ileum or ileal bypass by leading to insufficient recirculation of bile acids. The liver in these cases is not able to synthesize bile acids de novo in a sufficient amount. This condition results in **malabsorption of fat** and deficiency of fat-soluble vitamins. These global disturbances can be simultaneously present in specific defects of digestion. Thus, e.g. lactase deficiency on the surface of enterocytes deteriorates the absorption of saccharides. This condition can result in intolerance to milk and clinical symptoms as flatulence, intestinal distension and diarrhea. It occurs more frequently in black people. It can occur as a consequence of a diffuse defect of mucosa in coincidence with other diseases.

7.10.2 Inadequate absorption (malabsorption)

The inadequate absorption can appear in normal intact digestion. Most frequently it is caused by a reduced surface for absorption of substances. It develops after intestinal resection due to mesenterial infarction, bypass due to morbid obesity, or due to Crohn's disease.

In other cases, the surface necessary for absorption may be sufficiently large, but insufficiently involving the processes of absorption per se. These impairments are caused by the defects in mucosal cells (inborn or acquired). Examples of this condi-

tion can include the selective defect in absorption of particular amino acids in cystinuria, or the defect in absorption of fat in coincidence with alphalipoproteinaemia induced by an intracellular defect of the synthesis of apolipoproteins. A selective defect in absorption of calcium can occur due to insufficient synthesis of 1,25 dihydroxycholecalciferol in the kidneys.

However, the cause of malabsorption more frequently resides in impairments of intestinal mucosa and submucosa. Sometimes the cause remains unknown, or obscure. Such state might involve immunity or allergic impairments (gluten enteropathy – coeliac disease). Malabsorption occurs also in coincidence with infections. In Whipple's disease, the submucosa contains activated macrophages. The patients can develop fever, arthralgia, lymphadenopathy and neurologic symptoms. It is a rare disease. Giardia lamblia can just as well cause malabsorption. The symptoms include flatulence, nausea and diarrhoea. Deconjugation of bile acids due to bacterial overgrowth can represent a further cause of malabsorption. Sometimes the cause of malabsorption resides in a diffuse infiltration of mucosa in systemic diseases. The wall of the small intestine may become undesirably attenuated due to irradiation. The cause of malabsorption in these cases resides in altered functions of mucosa, abnormal motility and bacterial overgrowth.

After resorption of fatty acids, triglycerides are resynthesized in enterocytes. Triglycerides enter the lymphatic system as chylomicrons. Therefore, the defects of the lymphatic system result in appearance of malabsorption.

The origin of malabsorption is often enhanced by a simultaneous impact of several factors. They include defective digestion together with an impaired intestinal motility and absorption. Such a picture can be induced by administration of drugs and toxic substances (antacids, neomycine, tetracycline, alcohol). Some patients develop a severe absorption impairment resulting from hyperabsorption. E.g., haemochromatosis is an inborn disease involving hyperabsorption of iron, and D hypervitaminosis involves excessive absorption of calcium.

Malabsorption may concern defective absorption of a single substance. This condition occurs in pernicious anaemia.

It is very difficult to confirm the presence of malabsorption. There are several tests which allow to detect particular types of malabsorption.

Confirmation of fat in stool can be performed by quantitative tests. A more precise assessment can be achieved by a quantitative test which sets the amount of fat in stool within a period of three days. The patient receives 80–100 g of fat daily. Under physiological conditions the amount of fat in stool does not exceed 6 g per 24 hours (the usual average value is below 2.5 g per 24 hours). The content of fat above 6 g per 24 hours (steatorrhea) indicates to malabsorption, although it does not suggest any hint of its cause. Examination of the pancreatic exocrine function can reveal the possible cause of steatorrhea.

Absorption of sugars can be judged by the xylose test. Patients are administered 125 g of D-xylose. This sugar is straightly absorbed in the proximal part of the small intestine. After administration of 125 g of D-xylose, under normal conditions, an amount of 4,5 g is eliminated by urine in five hours. The eliminated amount decreases with age. Abnormal results of the xylose test occur most frequently in malabsorption, a decrease, however, may be possibly caused by impaired renal function and bacterial overgrowth in the intestine.

X-ray examinations of the stomach in patients with malabsorption display almost normal findings. Some unspecific changes as attenuation of mucosa and intestinal distension can be present. Strictures, fistulae, blind intestinal loops and diverticula are detected. **Neither the peroral biopsy of small intestine provides precise specific findings confirming malabsorption**. The changes displayed in X-ray pictures are not specific to malabsorption. However, the symptoms of the coeliac disease always include atrophy of the intestinal mucosa.

Valuable results can be provided by the investigation of the absorption of vitamin B_{12} (Schilling's test). After its binding with the intrinsic factor, vitamin B_{12} is selectively absorbed in the distal ileum (detail information is analysed in the chapter on megaloblastic anaemia). Abnormalities in vitamin B_{12} resorption can imply from several facts:

a) impairment of distal ileum (Crohn's disease)

b) intrinsic factor insufficiency

c) impaired exocrine function of pancreas (pancreatic trypsin is necessary for the release of cobalamine from the bond with R-protein in gastric

juice in order to be able to bind with the intrinsic factor)

d) increased consumption of cobalamin in coincidence with bacterial overgrowth

Malabsorption can occur in many systemic diseases. Patients with hyperthyroidism often display moderate steatorrhea. Its main cause assumedly resides in a high intake of fat in consequence of hyperphagia and faster motility of the digestive tract. Furthermore, steatorrhea can be enhanced by gastric, biliary and pancreatic secretions and by changes in the jejunal morphology.

Malabsorption is less frequently associated with hypothyreosis. Malabsorption in hypothyreosis is ascribed to pancreatic impairment. Patients with diabetes mellitus can develop malabsorption in coincidence with the bacterial overgrowth which appears in consequence of delayed passage caused by autonomous neuropathy. Systemic sclerosis may be accompanied by bacterial overgrowth together with consequent malabsorption. Malabsorption in systemic vasculitis can be determined by partial atrophy of the villi, in rheumatoid arthritis by amyloidosis.

7.11 Diarrhea

Diarrhea is a state of abnormally liquid faeces. The amount of stool exceeds 200 g per day. An increased number of bowel evacuations can occur, accompanied with a sensation of defecatory urgency and perianal discomfort. Faecal incontinence can be present.

The intestine receives 8 to 10 l of fluid daily. Out of this amount, 1500 to 2000 ml are included in food. The remnant is constituted by the secretions of salivary, gastric, pancreatic, biliary nad intestinal secretory glands. Out of this amount, the small intestine absorbs approximately 1 l. The large intestine absorbs 90 % of fluid. A volume of 100 to 150 ml of fluid per day is eliminated by stool.

Absorption of water depends on absorption of solutes. Basically, the water within intestines is moved passively in the direction of the osmotic gradient. Therefore, e.g. the presence of weakly absorbable and osmotically active solutes in intestinal lumen deters absorption of water, or even causes secretion of water.

The mechanisms responsible for **absorption of solutes** vary in individual parts of the intestine. In general however, salts and other substances are absorbed by specific mechanisms. Several substances are absorbed in dependence on the sodium transport. The latter involves both the entrance of substances into, and their elimination from enterocytes. The sodium transport involves a large amount of components including protons, chlorides, glucose, amino acids, bile acids and other substances. Secretion of bicarbonates is associated with the sodium-hydrogen exchange. The chyme in the ileum is moderately alkaline. Jejunal and ileal contents attain significant values of ions as follow: Na^+ – 1140 mmol, K^+ – 6,0 mmol, Cl^- – 100 mmol, HCO_3^- – 30 mmol.

The **absorption of solutes in the large intestine** takes place in a partially different manner. It is limited by the presence of electrolytes. Absorption is carried out through specific sodium channels where the electric potential is developed in the membranes. The membrane potential is the basis of chlorides absorption and potassium secretion. The large intestine contents yields high concentration of potassium. Organic acids produced by colonic bacteria and bicarbonates release organic anions and CO_2 from non-absorbable saccharides and fat. The fluid in the large intestine contains: Na^+ – 40 mmol, K^+ – 90 mmol, Cl^- – 15 mmol, HCO_3^- – 30 mmol and organic anions – 85 mmol.

In addition to the above mentioned processes, the small and large intestines simultaneously secrete electrolytes and water. The secretion in small intestine is associated with the entrance of chlorine anions. Sodium and water are thereafter passively transported in accordance with the electric and osmotic gradients.

Diarrhea can occur in consequence of several changes:

1. decreased absorption of solutes and water
2. increased secretion of electrolytes
3. the presence of hardly absorbable and osmotically active solutes in the intestinal lumen
4. abnormal intestinal motility