

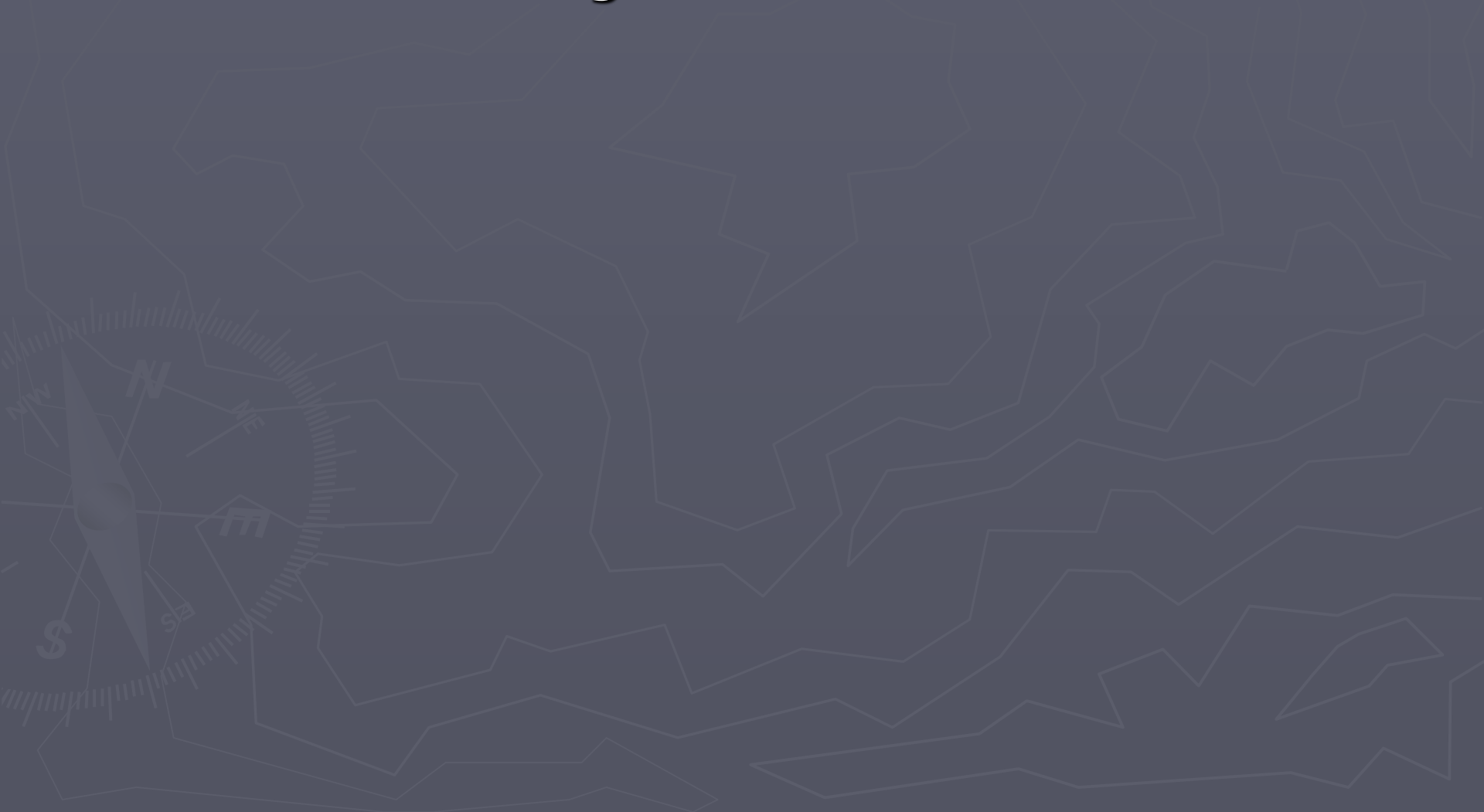
# Coenzymes



Coenzymes require the second enzymatic protein for regeneration



Prosthetic groups require the second substrate for regeneration



## Vitamins (1912)

**Vitamins** – organic compounds with diverse structure indispensable for life. They play important functions, among others catalytic and are exogenous for humans and animals.

**Provitamins** – precursors which are converted into vitamins in living organisms.

Carotens → vitamin A

Ergosterol i 7-dehydrocholesterol → vitamins D2 i D3

**Antyvitamins** – molecules that act contrary to vitamins



# Vitamins - insufficiency

- ▶ Insufficient amounts in food
- ▶ Disturbances in absorption:
  - Cholestasis – the lack of bile may lead to alterations in absorption of lipid soluble vitamins
  - Diseases of intestine
  - Pernicious Anemia (caused by the lack of internal factor)

# Vitamins - insufficiency

- ▶ Defects in use of vitamins
  - insufficiency of transport proteins in plasma
  - the lack of possibility to convert vitamins into its active form
- ▶ The increase in demands (maturation, pregnancy, lactation, wound healing)
- ▶ The increase in excretion (the loss of blood, diarrhoea)
- ▶ Insufficiency induced by drugs (after treatment with antibiotics, interactions of drugs with food)

# Coenzymes of oxidoreductases



# Nicotinamide coenzymes

The transportation of hydrogen atoms from donors to acceptor

nicotinamide oxidised  $\leftrightarrow$  nicotinamide reduced



(lactate  $\leftrightarrow$  pyruvate)



Glucose-6 phosphate  $\leftrightarrow$  glucono-lactone-6-phosphate

This conversions can be measured spectrophotometrically

NMN – coenzyme of transferases (transports adenyl residues in NAD synthesis)

## PP Vitamin, niacin, nicotinic acid amide (1867)

Is present in arachidonic nuts, meat, fish, cereal seeds. May be formed during the metabolism of tryptophane. The insufficiency leads to the disturbances in glycolysis, Krebs cycle and oxidative chain.

The insufficiency causes pelagra (skin changes), disturbances of digestive tract (gastritis, the lack of hydrochloric acid, diarrhoea) and nervous system (neuritis, the loss of memory)

Kardiamid – derivative of nicotinic acid amide used as stimulator of respiratory tract

# Flavin Coenzymes

The transportation of hydrogen atoms from donor to acceptor

Hydrogen atoms bind to N-1 and N10 isoalloxasine

FMN

FAD

Participate in oxidoreductive reactions:

- Majority of aminoacids to ketoacids
- Active saturated fatty acids into not saturated

Yellow-coloured flavin coenzymes converted into reduced form become colourless (spectrophotometric determinations)



## Vitamin B2, riboflavin (1933)

Is present in yeast, meat, milk products, cereal seeds, eggs. The demand increases during maturation, pregnancy, lactation, wound healing

Insufficiency results in pathologic changes in oral cavity – damage to mucosa, inflammation, oedema, as well as corneitis, cloudiness of lens.

# Ubichinon, coenzyme Q10

The transportation of hydrogen atoms from donor to acceptor. Posses the ability to bind only one electron - undergo one-electron reduction.

Lipid soluble molecule with chinone structure. Synthesised in living organisms from phenylalanine and tyrosine



## **Vitamin K** (chinon structure)

Indispensable in protrombin synthesis

Insufficiency results in alterations in clotting

## **Vitamin E** (chinon structure)

Antioxydant

Insufficiency causes the disturbance in reproduction

# Cytochromes

Transporters of electrons by use of changes in the iron oxidative state ( $\text{Fe}^{3+} + \text{e}^- \leftrightarrow \text{Fe}^{2+}$ )

Derivatives of porphyrins containing iron

Cytochrome Oxidase transports electrons to oxygen and reduces it.

# Coenzymes of transferases and isomerases



# Coenzyme A

Thioethanolamid of phosphopantothenic acid conjugated with 3,5 - adenin diphosphonucleotide. Active group is SH group from decarboxylated cysteine.

Participates in:

- ▶ the transportation of acyl residues
- ▶ the activation of fatty acids
- ▶ oxidative decarboxylation of 2-oxoacids

# Vitamin B5, pantothenic acid (1931)

It is present in yeast, meat, mushrooms, eggs, can be synthesised by intestinal bacteria.

Biologically active forms - coenzyme A and protein carrier of acyl groups

Insufficiency causes headache and abdominal pain, weakness, diarrhoea, fatigue, weakness, convulsions, decreased resistance to infections, changes in skin, hair, fur, feathers. The degeneration in nervous system and ulceration in digestive tract may appear.

# Thiamin coenzymes

Diphosphothiamin (DPT) transports aldehydes and ketones, it participates in:

- ▶ decarboxylation of 2-oxoacids
- ▶ aerobic metabolism of phosphorylated monoses

# Vitamin B1, thiamin (1912)

Is present in meat, vegetables, yeast, grain products,

Insufficiency causes beri-beri – polyneuronal inflammation and changes in nervous system (pyruvate is cumulated), alterations in digestive tract and cardiovascular system

# Lipoic acid

Transports hydrogen atoms and acyl groups  
Cooperates with DPT and CoA in the process of  
oxidative decarboxylation of 2-oxoacids



# Pyridoxal coenzymes

Pyridoxal phosphate (PLP) participates in:

- ▶ transamination
- ▶ decarboxylation
- ▶ breakdown of glycogen (glycogen phosphorylase)

# Vitamin B6 (1934)

Is present in meat, vegetables, fish, cereals,

Insufficiency results in skin inflammation, oral cavity mucosa irritation, insomnia, apathy



# Biotin coenzymes

Biotin participates in the transportation of carbon dioxide with an ATP energy cartridge.

Biotin  $\leftrightarrow$  carboxybiotin

- ▶ is the donor of carbon dioxide for acetyl-CoA and participates in the biosynthesis of fatty acids
- ▶ is the donor of carbon dioxide in carboxylation of pyruvate to oxalacetate
- ▶ participates in transcarboxylation and decarboxylation

# Vitamin H, biotin (1936)

Is present in milk products, eggs, meat, some fruits, nuts. Is synthesised by intestinal bacterial flora in adequate amounts.

„white egg syndrome“ – avitaminosis caused by avidin which forms permanent complex with biotin what makes impossible its absorption and leads to insufficiency.

Insufficiency results in depression, apathy, drowsiness, anxiety, muscle pains and sensory hypersensitivity.

Congenital defects of biotin enzymes are similar to biotin deficiencies.

# Tetrahydrofolate coenzymes

Transport one carbon fragments:

- ▶ formyl ( $-\text{CHO}$ )
- ▶ hydroxymethyl ( $-\text{CH}_2\text{OH}$ )
- ▶ formimin group ( $-\text{CH}=\text{NH}$ )
- ▶ participate in the synthesis of purine and pyrimidine bases

# Folic acid (1941)

Stimulates hematopoietic processes in living organisms. It is present in liver, spinach, salad, synthesised by intestinal bacteria.

The symptom of deficiency is anemia and the reason of deficiency is insufficient supply, pregnancy, overuse of alcohol, disturbances in intestinal absorption.

Deficiencies are reflected in the slowing down DNA synthesis and the incorporation of uracil instead of thymine into DNA.

Sulfonamids – inhibitors of folate metabolism

Trimetoprim – antibacterial

Metotrexate – anti cancer

# Nucleosidophosphates

Cooperate with enzymes in the transportation of groups, the synthesis of new bounds or in epimeric conversions of monoses.

ATP participates in the reactions of transportation:

- ▶ gives one phospho residue to another molecule
- ▶ carries diphospho residue
- ▶ is a donor of adenosylmonophosphate or adenosin

Active sulphate – is a donor of sulphate residue for polysaccharides

S-adenosylmethionine – is a donor of methyl group in transmethylation



# Nucleosidophosphates

UTP activates glucose and enables its conversion into another sugar or the formation of glycosidic bonds

CTP reacts with phosphorylated serine or phosphorylated nitric base creating adequate conjugated compound indispensable for the synthesis of phospholipids



# Coenzyme B12

Participates in the reactions of two enzymes:

- ▶ methylmalonyl CoA mutase
- ▶ homocystein methyltransferase

The lack of methylcobalamine leads to the insufficiency of folate coenzymes

# Vitamin B12 (1947)

Is present in liver, kidney, heart, egg yolk.

Specific extra and intracellular proteins are indispensable for the absorption, storage, transportation and the metabolism of cobalamins.

Pernicious anemia manifests itself by the decrease in red blood cells number with constant amount of hemoglobin. It is connected to the alterations in secretive activity of stomach and the insufficiency of specific carrier protein ( Castle`s factor).

Long lasting vegetarian diet may lead to the insufficiency of B12.

# Pangamic acid, vitamin B15

Gluconic acid esterified by dimethylglycin

Participates in methylation, the synthesis of keratin, influences the activity of respiratory enzymes in respiratory chain

## Vitamin C (1933)

Is present mainly in fruits and vegetables  
Insufficiency manifests itself in scruvy –  
anemia, oedema and bleeding of gingiva  
as well as muscle pain, susceptibility to  
infection, alterations in metabolism of  
proteins (weakening of collagen  
structures, the increase in bone fragility)

# Vitamin C

- ▶ participates in the hydroxylation of proline and lysine during the synthesis of collagen in fibroblasts
- ▶ participates in the synthesis of adrenalin and noradrenalin
- ▶ is antioxydant
- ▶ supports the absorption of iron

# Vitamin C

Is synthesised in animals (the exception guinea pig) from glucose



# Case 2

50 years old man suffers from photosensitive rash, abdominal pain and diarrhea. Short-term memory disorders and mild cognitive impairment are noticed as well.

Few years ago disease of Leśniewski-Crohn was diagnosed. The concentrations of folic acid and vit B12 in plasma are physiological.

# Daily demand for vitamins

