

**BSc. Biological Chemistry study programme**  
**State exam Biology of Microorganisms (as compiled/collated 2. 8. 2022)**  
**Students are randomly picking ONE topic.**

**1. Importance of microorganisms on our planet and abiotic theory of the origin of life**

- a) What is the current estimate for when the first microbes appeared on our planet and what type of metabolism did they have? Discuss the first metabolisms of prokaryotic and eukaryotic microorganisms
- b) Describe the evolution of the first cells according to the abiotic theory. Discuss the possible role of RNA, DNA, other biomolecules in first cellular structures
- c) What are the main properties of living organisms (list and describe them)?
- d) Describe and discuss the endo-symbiotic theory of mitochondria and chloroplast evolution
- e) Describe the difference between "selection" and "genetic drift" in the theory of community assembly and evolution?

**2. Diversity of microorganisms**

- a) Describe main taxonomic and functional groups of microorganisms (what are the main domains of life)?
- b) Why were the archaea called that way and why did it take so long to discover them
- c) What are the main cell morphologies of microorganisms?
- d) If there are so few shapes of microorganisms, how did we identify millions of species?
- e) Eukaryotes are limited in their energy metabolism, but prokaryotes can do much more. Name, and briefly describe, at least three ways of gaining energy. Which ones are unique to prokaryotes?

**3. History of microbiology**

- a) Discuss the first scientists to construct a microscope?
- b) Describe and explain Pasteur's experiment for proving life does not originate spontaneously
- c) Describe and explain Koch's postulates
- d) What is enrichment culturing, and why do we use this technique?
- e) What is a Winogradsky Column? What does it demonstrate?
- f) Describe in what ways has DNA sequencing technologies revolutionized the field of microbiology

#### 4. Microscopical techniques

- a) Describe and discuss main differences between light microscopy, phase contrast, darkfield microscopy, and electron microscopy.
- b) Staining is a common practice in microscopy. Why is it needed? Describe the advantages/disadvantages of staining microbes.
- c) Describe the basic principle of fluorescence microscopy (give several examples of fluorescent staining). What is autofluorescence and where you can find it?

#### 5. Microbial cell structures

- a) Describe the main differences between prokaryotic (Archaea, Bacteria) and eukaryotic cell structure. Discuss the main cellular components
- b) Describe the cell as a coding device and machine
- c) Describe primary microbial ecosystems
- d) Describe the principle of quorum sensing in microorganisms
- e) What confines the size of a bacterial cell?
- f) Describe and discuss the ways how are small/large and charged/uncharged compounds transported in/out the microbial cell

#### 6. Microbial metabolism

- a) Describe the differences between endergonic/ exergonic reactions and anabolism/ catabolism. Describe the principle of redox reactions, enzymes, the role of electrons and protons.
- b) Which molecules connect anabolism with catabolism? (What does the cell need to perform anabolism?)
- c) Describe phototrophic-chemotrophic organotrophic-lithotrophic and autotrophic-heterotrophic lifestyles
- d) Discuss the difference between aerobic respiration, anaerobic respiration, and fermentation. Explain the difference between substrate-level phosphorylation and oxidative phosphorylation
- e) Discuss the principle and function of the respiration chain
- f) What is the difference in the reactants and products between oxygenic and anoxygenic photosynthesis?

## **7. Microbial pathogenicity**

- a) Discuss the main ways in which microbes can be pathogenic to other organisms. In what ways can a microbe penetrate the body of its host?
- b) List three mechanisms for antibiotics to work against microbes.
- c) How can you test if a novel substance has antibiotic properties?
- d) Name the primary mechanisms for bacterial resistance against antibiotics. How did antibiotic resistance emerge and spread so quickly among different bacteria?

## **8. Microbial biotechnology**

- a) In wastewater treatment plants, anaerobic treatment is applied to get rid of excess nitrogen. Which process is it?
- b) Diverse bacteria, fungi, and a few green algae can oxidize petroleum products aerobically. If that is the case, why is cleaning up a petroleum spill so challenging?
- c) Why are so many xenobiotics (pesticides, polychlorinated biphenyls (PCBs), munitions, dyes, and chlorinated solvents, etc.) undegradable or degrade very slowly in nature?