

## General instructions

Answer the questions on a separate answer sheet and make sure to label your answers unambiguously. Short and concise answers are highly encouraged.

For maximum exam points, you have to answer at least 24 questions correctly. Naturally, partially correct answers are also taken into account.

## Nucleic acids: DNA and RNA

1. How do chromosomes lose some of their protective telomere sequences during cell division?
2. What is a nucleosome?
3. What is the main functional difference between type I and II topoisomerases?
4. In terms of the integrity of the genome, what is the major difference between non-homologous end joining and homologous recombination?

## Proteins

5. In general, energy landscapes of different proteins are quite rugged. How should this be interpreted in the context of protein folding?
6. What is a collision chamber used for during tandem mass spectrometry?
7. What is the main structural difference between group I and II chaperonins?
8. Shortly explain the template model of prion propagation.

## Lipids and cell membranes

9. How does cholesterol affect the phase transition temperatures of biological membranes?
10. Which two mechanisms have been proposed for the traversal of CNTs through phospholipid bilayers?
11. Which three structural factors affect the characteristic transition temperatures of synthetic lipid bilayers made of only single type of phospholipids?
12. By which mechanisms does PEGylation increase the circulation times of liposomes in the bloodstream?
13. Why are fluorescent probes often preferred over non-fluorescent probes in single-particle tracking experiments?
14. What is the main function of translocon complexes during the synthesis of membrane proteins?

## Carbohydrates

15. List some of the functions that pectins are known to serve in the primary cell walls and middle lamellae of plant cell walls.
16. What is the meaning of the word "shielding" in nuclear magnetic resonance spectroscopy?
17. How are cellulose nanocrystals produced from cellulose fibrils?

18. How do chitosan nanoparticles adhere to mucous membranes? What is the underlying interaction mechanism?

## Photosynthesis

19. In photosystems I and II, most of the chlorophyll molecules do not participate in electron transfer reactions. What is their purpose instead?
20. Describe the structure and atomic composition of the oxygen-evolving complex of photosystem II.

## Neural signaling

21. What is the most important role of Na/K ATPase in nerve cells?
22. What is meant by the "refractory period" of action potentials?
23. Compare the
- a. structure
  - b. signaling speed
  - c. signaling directionality
- of electrical and chemical synapses.
24. Which ion triggers synaptic exocytosis in the synapses of mammalian nerve cells?
25. What is a "gigaseal", and how is it obtained?

## Molecular motors and the cytoskeleton

26. What are the two charged chemical species that most commonly drive the rotation of bacterial flagellar motors?
27. What is the main function of cadherins in formed tissues?
28. In excitation-contraction coupling, why must  $\text{Ca}^{2+}$ -ions bind to troponin?
29. Why is the movement of a dynein motor protein less synchronized than that of a kinesin protein?
30. When working with optical tweezers, why is it important to have sufficient refractive index mismatch between the trapped dielectric particle and its surroundings?

## Viruses

31. Briefly describe the structure and morphology of the tobacco mosaic virus.
32. Why is the tobacco mosaic virus a promising template in nanofabrication?
33. Name two different pinocytic pathways that viruses can use to enter cells.
34. Briefly compare the safety and efficacy of viral and non-viral vectors in gene therapy.
35. When conducting AFM studies of biological samples such as viruses, what is the main advantage of using tapping mode instead of contact mode measurements?