IMPERIAL COLLEGE LONDON

B.Sc. Examination 2017

This paper is also taken for the relevant examination for the Associateship of the Royal College of Science

CELL BIOLOGY

Thursday 2nd February 2017 10.00 - 13.00

FOR FIRST YEAR STUDENTS IN BIOCHEMISTRY AND BIOTECHNOLOGY

Please use the **MCQ ANSWER SHEET PROVIDED FOR SECTION A** and a **SEPARATE ANSWER BOOK FOR EACH QUESTION IN SECTION B**. All parts of a question in Section B carry equal weighting unless otherwise specified.

SECTION A

Answer all **TWENTY FIVE** questions on the **separate MCQ answer sheet provided**. This section is worth 25% of the total marks. Candidates should allow up to 45 minutes for this section. **Some questions in this section have more than one correct answer**. Credit will be given for all correct answers, but you will be penalised with a negative mark for incorrect choices. You will not be penalised if you do not select an answer.

1. Which of the following statements about biological membranes is/are TRUE?

A) The membrane is composed of a complex mixture of lipids
B) The membrane structure is maintained through the formation of covalent bonds between the lipid molecules
C) The membrane will undergo a phase transition at a temperature dependent on the length of the fatty acid tails of the lipids
D) Organised domains of lipids within membranes are always composed of phosphatidylcholine and phosphatidylethanolamine
E) The membrane has a three-layered appearance

2. Which of the following statements about ion channels is/are TRUE?

A) They are able to transport at up to 10^9 ions/second
B) They may require dehydration of charged ions prior to transport
C) The selectivity filter is always a charged residue at the entrance to the pore
D) Each ion channel can transport a range of molecular species of the same charge
E) All ion channels are voltage gated

3. During mitosis, microtubules are largely responsible for which of the following?

A) Activation of separase
B) The spindle
C) Centrosomal separation
D) Chromosome segregation
E) Mitochondrial distribution to daughter cells

4. Which of the following are characteristics of transmembrane α-helices?

A) They always contain a regular alternating arrangement of hydrophobic and hydrophilic residues
B) The comparatively hydrophilic peptide backbone region is shielded from the hydrophobic lipid environment by the surrounding amino acid side chains
C) Their overall structure is typically stabilised by H-bonds between residue n and residue n + 3
D) They are typically 20-30 amino acid residues in length
E) They have a fixed orientation relative to the membrane

5. UapA is a secondary active transporter. Which of the following statements is/are TRUE for UapA?

A) It is an α-helical protein
B) It uses ATP hydrolysis to drive transport across the membrane
C) Transport through UapA is independent of the electrochemical gradient
D) It must undergo relatively large conformational changes associated with the transport cycle
E) It contains a discrete substrate binding site

6. Which of the following is/are characteristic of most cells undergoing apoptosis?

A) Enhanced DNA replication
B) Reduced mitochondrial membrane potential
C) Laddering of genomic DNA on agarose gel analysis
D) Elevated caspase activity
E) Rupture of the plasma membrane and release of cellular contents into the surroundings

7. Cancer cells are generally:

A) Aneuploid
B) Quiescent
C) Immobile
D) Genetically stable
E) Unlikely to undergo apoptosis

8. Which of the following is/are factors that drive the import/export of proteins into the nucleus?

A) The concentration gradient of Ran-GTP
B) The localisation of Ran-GEF
C) The folded-state of proteins
D) The nuclear concentration of ATP
E) The amino acid sequence of nuclear pore complex proteins

9. What is the default pathway for a protein made in the cytosol of a cell (i.e. without a signal peptide)?

A) Transport to the nucleus
B) Transport to the endoplasmic reticulum
C) Transport to the lysosome
D) Secretion from the cell
E) None of the above

10. The sec translocon is involved with which of the following?

A) Co-translation translocation into the endoplasmic reticulum (ER)
B) Post-translation translocation into the ER
C) Insertion of trans-membrane domains into the ER
D) Translocation of protein aggregates out of the ER
E) Retention of proteins in the ER

11. Which of the following are part of the vesicle trafficking machinery?

A) COPI
B) Ran
C) Clathrin
D) Dynamin
E) SNAREs

12. Which of these statements about the critical concentration is/are TRUE?

A) The critical concentration is greater at the barbed (+) end of the actin filament than it is at the pointed (-) end of an actin filament
B) The critical concentration is less at the barbed (+) end of the actin filament than it is at the pointed (-) end of an actin filament
C) At a concentration of ATP-actin between the barbed (+) end and pointed (-) end critical concentration's actin filaments will treadmill
D) At a concentration of actin between the barbed (+) end and pointed (-) end critical concentration's actin filaments will spontaneously disassemble
E) The critical concentration is the same for ADP and ATP-actin monomers

13. Certain viruses co-opt microtubules within a cell to reach the nucleus. How do they do this?

A) By mimicking the protein N-WASP
B) By hijacking dynein motors
C) By interacting with kinesin motors
D) By mimicking a nuclear localisation signal (NLS)
E) By interacting with alpha and beta-tubulin

14. What are the two main types of eukaryotic exocytosis?

A) Phagocytosis
B) Constitutive exocytosis
C) Gated exocytosis
D) Regulated exocytosis
E) Autophagic exocytosis

15. What are mast cells specialised to do?

A) Pinocytosis
B) Phagocytosis
C) Constitutive exocytosis
D) Endocytosis
E) Regulated exocytosis

16. Which of these are NOT types of endocytosis?

A) Pinocytosis
B) Regulated secretion
C) Fluid-phase endocytosis
D) Phagocytosis
E) Neurotransmitter release at synapses

17. Where would the receptor for a small hydrophobic signal molecule be?

A) In clathrin-coated pits
B) On the cell surface
C) On the Golgi apparatus membrane
D) In the cytoplasm
E) On the endoplasmic reticulum membrane

18. How could a cell reduce its sensitivity to a particular signal molecule?

A) Traffic more receptors that can bind the signal molecule to its plasma membrane
B) Express a protein that can inhibit the receptor for the signal molecule
C) Endocytose some of the signal receptors for the signal molecule
D) Hydrolyse some of the receptors for the signal molecule in a lysosome
E) Generate more of the signal molecule

19. What does a GTPase activating protein (a 'GAP') do?

A) Phosphorylates ADP
B) Drives the hydrolysis of GTP to GDP and 'switches on' a GTP-binding protein
C) Exchanges GDP for GTP and 'switches off' a GTP-binding protein
D) Exchanges GDP for GTP and 'switches on' a GTP-binding protein
E) Drives the hydrolysis of GTP to GDP and 'switches off' a GTP-binding protein

20. Which of these would you find in a peroxisome?

A) Short fatty acids (<8 C)
B) Acyl CoA oxidase
C) Very long chain fatty acids (>20 C)
D) Catalase
E) mRNA

21. What types of proteins can make up the mammalian extracellular matrix?

A) Small globular proteins
B) Proteoglycans
C) Collagen
D) Lipoproteins
E) Noncollagen glycoproteins

22. Which of these families of cell-adhesion molecules interact in a heterophilic way?

A) Laminins
B) Selectins
C) Cadherins
D) Integrins
E) Ig-superfamily of CAMs (cell adhesion molecules)

23. Which of the following is/are pathogenic Gram-positive bacterial species?

A) *Bacillus subtilis*
B) *Streptococcus pyogenes*
C) *Escherichia coli*
D) *Pseudomonas aeruginosa*
E) *Lactobacillus lactis*

24. Regarding sporulation of a Gram-positive bacterium such as *Bacillus anthracis*, which of the following is/are TRUE?

A) The master regulator Spo0A is activated
B) Chromosome division occurs after the spore is formed
C) The vegetative cell undergoes asymmetric division
D) The spore (also termed an endospore) is susceptible to heat, UV light and dessication
E) The spore grows and divides slowly in the environment prior to germination

25. Which of the following are parts of the bacterial flagellum?

A) Type IV pilus
B) Teichoic acid
C) Basal body
D) Fimbriae
E) Flagellin

SECTION B
ANSWER THREE QUESTIONS.
This section is worth 75% of the marks. Please use a SEPARATE answer book for each question. You should devote approximately 45 minutes to each question.

26. Describe the structure of a typical G-protein coupled receptor. With the aid of diagrams explain the overall mechanism of action of G-protein coupled receptors providing details on how the receptor and the G-protein are both activated and inactivated. Include details of how the receptor signal is initiated in the cell.

27. Describe the molecular changes that occur when a quiescent cell is stimulated to proliferate. Describe the events up to and including the restriction point (70%). Explain which of the proteins that you have described can be mutated to promote cancer, distinguishing oncogenes and tumour suppressors (30%).

28. Describe the process by which a protein, destined for the endoplasmic reticulum and downstream secretory pathway, gets into the lumen of the endoplasmic reticulum.

29. Compare and contrast the nucleation of an actin filament by Arp2/3 complex with nucleation of a microtubule by the gamma-tubulin ring complex.

30. Describe the structure and functions of cadherin cell adhesion molecules (70%). Using diagrams if you like, describe how cadherins are used in one named specialised cell type (30%).

31. Describe the composition and functions of the basal lamina.

32. Compare and contrast the structures of the Gram-positive and Gram-negative cell wall from named bacterial species. Your answer should include diagrams and should refer to the mechanism of action of antibiotics that target the cell wall.

End of paper