

NATURAL SCIENCES TRIPOS Part 1A

Tuesday 6 June 2017 9 to 12

BIOLOGY OF CELLS - THEORY

Answer **Question 1** (Section A) and **three questions** from Section B.

Section A carries 33% of the marks and Section B carries 67% of the marks for this paper.

Write your examination number on each answer booklet cover.

Section A: put all short question answers from Question 1 into one or more 20 page answer booklets, tied up in a single bundle.

Section B: start a new 8 page answer booklet for each question and write the question number clearly on its cover. When using more than one answer booklet for a question, tie together the answer booklets containing parts of the same answer.

Yellow coversheet: enter the numbers of the 3 essay questions you answered from Section B and leave this loose on top of your pile of answer booklets.

STATIONERY REQUIREMENTS

Answer booklets (1 x 20 page and 3 x 8 page)

Rough work pad

Yellow coversheet

Tags

SPECIAL REQUIREMENTS

Approved calculators allowed

**You may not start to read the questions
printed on the subsequent pages of this
question paper until instructed that you may
do so by the invigilator.**

SECTION A

(Answer all parts of Question 1. Each part carries equal marks. Suggested total time: not more than one hour. Lengthy answers are not required.)

Question 1

- (a) What is the function of a ribosome? How could you demonstrate that a single RNA molecule may be bound by multiple ribosomes?
- (b) Draw a diagram to explain how a competitive inhibitor changes the kinetics of an enzyme that obeys Michaelis-Menten kinetics. What is the effect of this inhibitor on the enzyme's K_m and V_{max} ?
- (c) In protein structure, why are β -sheets made of antiparallel β -strands more stable than those of parallel strands? Why therefore is a $\beta\alpha\beta$ super-secondary structure common?
- (d) How can “flip-flop” of a phospholipid in a bilayer be demonstrated?
- (e) Most unsaturated carbon bonds of membrane phospholipids are in the *cis* formation. Why is this important?
- (f) Briefly describe the chemiosmotic theory and the requirements for its operation.
- (g) In metabolic pathways that release energy why do the first steps often require the investment of Gibbs Free energy prior to the production of ATP?
- (h) When mapping two genes that are far apart on the same *Drosophila* chromosome, the maximum recombination frequency is 50%. With the aid of diagrams explain why this is the case.
- (i) How do histone proteins contribute to DNA packaging in the nucleus of the eukaryotic cell?
- (j) What are the three major post-transcriptional modifications of eukaryotic mRNA? Briefly outline a function for each modification.
- (k) Outline the genetic problems created by having differentiated sex chromosomes (such as the X and Y in humans).

- (l) Name two defining characteristics of an animal stem cell. What are the possible alternative fates of a dividing stem cell?
- (m) Describe the Notch signalling pathway involved in the formation of *Drosophila* wings.
- (n) What are three different mechanisms important in establishing the early (initial) polarity of an egg? For each answer identify a model system in which the mechanism occurs.
- (o) What is a maternal effect mutation? How can maternal effect mutations be identified?

SECTION B

(Answer three questions, each in a separate answer booklet. All questions carry equal marks. Suggested total time for this section: two hours.)

- 2. Describe the structure of a eukaryotic flagellum, and explain how it generates movement. Briefly describe how you could test whether a protein encoded by a newly identified gene is a structural component of a flagellum?
- 3. How do membrane proteins regulate the entry of solutes into cells?
- 4. Electron transport chains are associated with metabolism across the tree of life. Outline the unifying principles associated with their function and describe how they can differ from one another.
- 5. After performing a series of breeding experiments using pea plants differing in one or two characters, Mendel set out his description of the mechanism of inheritance. Subsequent experiments by other investigators revealed the existence of genetic linkage and sex linkage. Explain why these subsequent observations conflicted with Mendel's ideas and to what extent it was necessary to modify his theory to incorporate them.
- 6. In 1957, Francis Crick first proposed the central dogma of the flow of genetic information. Describe the role of polymerases in the modern interpretation of the central dogma.

(TURN OVER)

7. How is genetic variation used to identify human disease genes?
8. Describe the structural features of eukaryotic chromosomes that are essential for their replication and segregation.
9. Describe the eukaryotic cell cycle and the cell cycle control systems.
10. How can *E. coli* swim towards attractants when their cell length is too small to sense directly chemical gradients?

END OF PAPER