BIRKBECK COLLEGE

(University of London)

Advanced Certificate in the Principles of Protein Structure

Date: Wednesday 21st September 2005

Time: 3 hours

Start time as per instructions to local exam centre

Students will be expected to answer 6 of the 10 short questions in section A, and 4 of the 8 long questions in section B. They will be advised to spend 1 hour on section A and 2 hours on section B.

Short questions are worth 6 marks.

Long questions are worth 18 marks.

Section A: Short Questions

Six questions to be attempted (Suggested time 10 minutes on each)

1. Draw the covalent structure of an amino acid with a side chain that has both hydrophobic and polar character. In what kinds of protein interactions can the side chain participate?

2. Compare the three structural roles that involve sulphur containing amino acids.

3. Illustrate the following;

   i) A Type I and a Type II reverse turn {3 marks}

   ii) A tyrosine side chain {1.5 marks} and indicate the labels of the carbon atoms derived from the Greek alphabet {1.5 marks}.

4. Draw a Ramachandran Plot indicating the regions expected for right and left handed alpha helix and beta sheet. List three L-amino acid residues that often occur in the left handed alpha helical region.

5. Define a hydrogen bond, making clear the chemical nature of the interaction. Draw a typical main chain – main chain hydrogen bond, as observed in protein secondary structure, indicate the donor and acceptor atoms, and mark on it its main geometric parameters.

6. What are the characteristic geometric features of the helix and beta sheet in protein structures?

7. Describe briefly the features of the immunoglobin fold.

8. Describe briefly the mechanism by which newly synthesised extracellular proteins are released from the cell, paying particular attention to the role of the endoplasmic reticulum.

9. Illustrate the topology of gamma crystallin and the spatial arrangement of a single domain.

10. What are the essential differences between the structure and biological function of class I and class II MHC molecules?

Section B: Long Questions

Four questions to be attempted (Suggested time 30 minutes on each)

11. For the following sections;

a) Name one amino acid that is often found in each of these locations:

i) an extracellular loop within a membrane protein {1 mark}

ii) the membrane interface {1 mark}

iii) the centre of the membrane {1 mark}

b) Describe how you could use bioinformatics tools to discover, from a protein sequence alone, whether a protein is a transmembrane protein, and if so, to locate the transmembrane segments. What else can be determined about the structure and topology of a transmembrane protein from its sequence? {13 marks}

c) Name one type of transmembrane protein that cannot be identified using the methodology that you outline in part b). {2 marks}

12. Select only **four** sections from the list below to answer.

Give an example and description of a protein that exhibits the properties below for each chosen section;

i) a 2-domain polypeptide chain arisen from an ancient gene duplication event

ii) a homodimer

iii) a dimer of heterodimers

iv) a decamer

v) an oligomer with cubic symmetry

vi) a soluble non-symmetric protein assembly

vii) a fibre with helical symmetry

13. Write an essay on the heptad sequence repeat and coiled-coils in protein structure.

14. Answer both parts;

i) What are protein-protein interaction domains? {9 marks}

ii) Write in detail about the structure and function of one of them. {9 marks}

15. Describe the structure and function of three different protein domains that bind non-protein ligands. {6 marks for each domain}

16. Give a summary of the variation in chemical structures and properties of the 20 naturally occurring L-amino acids found in proteins.

17. Describe in detail the process that can be summed up in the Central Dogma of Molecular Biology, “DNA makes RNA makes Protein” as it occurs in prokaryotes. Name the main molecules that are involved in this process and include in your account a very rough diagram or explanation of the basic structure of the ribosome.

18. Describe how the lytic phase of the lambda bacteriophage is controlled? What is the structural basis of this control mechanism.