Name: MIDTERM EXAM ANSWER KEY [ANSWERS IN RED]

Biology 200 - Section 921
Midterm Examination - June 29, 2006
Duration of Examination: 50 minutes
Total marks: 50 (25 % of course grade)

IMPORTANT INSTRUCTIONS:

1. ANSWER ALL QUESTIONS ON THE EXAMINATION BOOKLET
2. Read carefully, think, then begin to answer the question.
3. Fill in your Name and Registration Number at the top of **every** page.
4. Please use **pen** only, **not** pencil.
5. Please make sure that the examination booklet has a total of **7 questions** and **5 pages**.

Question	1	2	3	4	5	6	7	Total
Student mark								
Marks available	7	4	15	10	6	2	6	50

Genetic Code Table

1st position	2nd position: U	2nd position: C	2nd position: A	2nd position: G	3rd position
U	UUU--Phe	UCU--Ser	UAU--Tyr	UGU--Cys	U
	UUC--Phe	UCC--Ser	UAC--Tyr	UGC--Cys	C
	UUA--Leu	UCA--Ser	UAA--stop	UGA--stop	A
	UUG--Leu	UCG--Ser	UAG--stop	UGG--Trp	G
C	CUU--Leu	CCU--Pro	CAU--His	CGU--Arg	U
	CUC--Leu	CCC--Pro	CAC--His	CGC--Arg	C
	CUA--Leu	CCA--Pro	CAA--Gln	CGA--Arg	A
	CUG--Leu	CCG--Pro	CAG--Gln	CGG--Arg	G
A	AUU--Ile	ACU--Thr	AAU--Asn	AGU--Ser	U
	AUC--Ile	ACC--Thr	AAC--Asn	AGC--Ser	C
	AUA--Ile	ACA--Thr	AAA--Lys	AGA--Arg	A
	AUG--Met	ACG--Thr	AAG--Lys	AGG--Arg	G
G	GUU--Val	GCU--Ala	GAU--Asp	GGU--Gly	U
	GUC--Val	GCC--Ala	GAC--Asp	GGC--Gly	C
	GUA--Val	GCA--Ala	GAA--Glu	GGA--Gly	A
	GUG--Val	GCG--Ala	GAG--Glu	GGG--Gly	G

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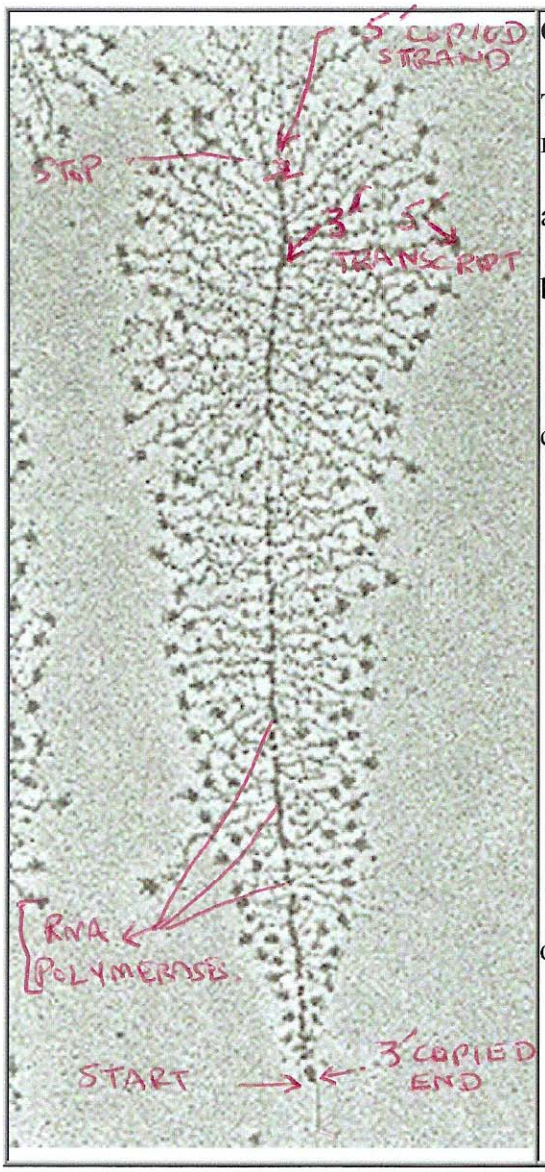


Question 1. (7 marks)

This is an electron micrograph of a gene encoding mRNAs being transcribed in a eukaryote.

a. Where in the cell would you find it? (Be specific): nucleus (1)

b. Which direction the RNA polymerases were moving before the sample was fixed for viewing in the electron microscope? (1)
Down to up.

c. Name the three mRNA processing steps and briefly mention precise function(s) of each step. (3)
1. RNA capping (7-methylguanosine) on the 5' end. It increases mRNA stability, aids its export to cytosol, helps its recognition by translational machinery.
2. Polyadenylation at the 3' end of mRNA. It increases mRNA stability, aids its export to cytosol, helps its recognition by translational machinery.
3. RNA splicing. It removes introns and facilitates joining of exons. It may also form new proteins due to recombination between exons of different different genes.

d. Identify the following on figure:
- RNA Polymerase molecules 0.5
- transcription start and stop sites 0.5
- 5' and 3' ends of DNA strand being transcribed 0.5
- 5' and 3' ends of transcript 0.5

Question 2. (4 marks). The following mRNA sequence was used as a template to translate into a protein.

5' CCUAUGGGUAGGCUAC 3'

if this is template, then 3'-
3'-CAUCGGAUGGGGUAUCC-5'
5'-GUAGCCUACCCAUAGG-3'

A) If you were told that this segment of RNA was close to the 3' end of an mRNA that encoded a large protein, would you know which reading frame was used [see Genetic code table on page 1]?

CC UAU GGG UAG GCU AC
Tyr Gly Stop

B) If you were told that this segment of RNA was close to the 5' end of an mRNA that encoded a large protein, would you know which reading frame was used?

CCU AUG GGU AGG CUA C
Met Gly Arg Leu

Question 3. (15 marks). Short answers (**attempt five):**

a. Without a continual input of energy, animal cells will burst. Why?

Animal cells contain high concentration of many molecules that will cause the osmotic influx of water. Unless ions are constantly pumped out (e.g. Na+ pumped out by Na+-K+ pump) to maintain an osmotic balance, cells will eventually burst.

b. How do histones interact with DNA to form nucleosome?

Histones have a high proportion of positively charged amino acids (lysine and arginine). These positive charges help the histones bind tightly to the negatively charged sugar-phosphate backbone of DNA.

c. What is the role of flippases in generating the lipid asymmetry in cell membranes?

Flippases are the enzymes, which catalyze the selective transfer of specific phospholipid molecules from one monolayer to the other opposite monolayer in a lipid bilayer membrane. This creates asymmetry in the bilayer membranes.

(Some students may draw a figure to illustrate the mechanism of flippases action)

d. Plant cells, fungi and bacteria do not have the Na^+-K^+ pumps in their plasma membrane. Explain how the symport-mediated transport of ions takes place in plant cells, fungi and bacteria.

Plant cells, fungi and bacteria use H^+- ATPase (H^+-pump) on their plasma membrane for symport-mediated transport. H^+- ATPases pump H^+ out of the cell, thus creating an electrochemical proton gradient (proton conc. higher outside than inside). The import of many molecules (sugars and amino acids) is driven by H^+ symports, which use the electrochemical gradient of H^+ across the plasma membrane (similar to electrochemical gradient of Na^+ in case of animal cells).

e. Briefly describe the key structure-function relationship of aminoacyl-tRNA synthetases.

Structure: are the enzymes with two binding sites, one for a specific amino acid and the other for a specific tRNA.

Function: catalyze the ATP-mediated covalent coupling of an amino acid to its appropriate set of tRNA molecules

f. Briefly describe the key structure-function relationship of spectrin protein in human red blood cells.

Structure: Long, thin, flexible rod-like proteins linked to specific transmembrane proteins in plasma membramne; main component of the cell cortex.

Function: Provides support for the plasma membrane; maintains cell shape.

Question 4. (10 marks). Name one major similarity and one major difference between the following **(attempt 5)**:

A. The large and small subunits of ribosome

Similarity(ies): Both are made up of rRNA and proteins; participate in translation.

Difference(s): Size: The large subunit (60S) and small subunit (40S)

Function: The small subunit matches the tRNA yo the codons of the mRNA. The large subunit catalyzes the formation of the peptide bond between amino acids to form a polypeptide chain.

B. Na^+-driven Glucose Pump and Glucose uniport carrier

Similarity(ies): Both are carrier type of membrane-bound transporters. Both transport glucose.

Difference(s): Na^+-driven Glucose Pump uses energy in Na+ gradient to pump glucose against its concentration gradient. Glucose uniport carrier facilitates passive transport of glucose from its high to low concentration.

C. Scanning and transmission electron microscopy

Similarity(ies): Both use a beam of electrons to visualize structures. Have high resolution power. Both require samples that have been chemically fixed.

Difference(s): Scanning microscopy provides 3-dimensional images and greater details of surface of the structure(s). TEM provides greater resolution between two subcellular structures.

D. Proteasome and lysosome

Similarity(ies): Both lysosome and proteasome degrade/hydrolyze proteins.

Difference(s): Lysosome is a membrane-bounded organelle which contains a number of digestive enzymes including protein-degrading enzymes, proteases active at low pH. Proteasome is a large protein complex in the cytosol that degrades cytosolic proteins that have been marked for destruction by ubiquitin.

E. Protein domain and protein subunit:

Similarity(ies): Both protein domain and subunit are parts of protein structure.

Difference(s): A protein domain is a compact and stable folded region of a polypeptide. A protein subunit is a folded polypeptide that interacts with other subunits to form a quaternary protein structure in a multi-subunit protein.

F. The α helix and the β sheet

G. Similarity(ies): Both α helix and the β sheet represent secondary protein structures.

Difference(s): An α helix represent a linear sequence of amino acids folded into a right-handed helix stabilized by internal H-bonds between backbone atoms (H of amino and O of carboxyl). A β sheet represents a folding pattern in which polypeptide chains associate with each other through H-bonds.

Question 5. (6 marks). For the following carrier proteins, write the carrier type (e.g. uniport, symport or antiport), cellular location, energy source, and function(s):

a. $Na^{\pm}$-$K^{\pm}$ pump ($Na^{\pm}$-$K^{\pm}$ ATPase)
   - (i) Type of carrier: Antiport
   - (ii) Cellular location(s): plasma membrane of most animal cells
   - (iii) Energy source: ATP hydrolysis
   - (iv) Function(s): Active export of $Na^+$and import of K^+

b. Bacteriorhodopsin
   - (i) Type of carrier: Uniport
   - (ii) Cellular location(s): plasma membrane of some bacteria
   - (iii) Energy source: light
   - (iv) Function(s): active export of H^+ out of the cell

c. Ca^{2+} -pump (Ca^{2+} ATPase)
   - (i) Type of carrier: Uniport
   - (ii) Cellular location(s): plasma membrane (and ER membrane) of eukaryotic cells
   - (iii) Energy source: ATP hydrolysis
   - (iv) Function(s): active export of Ca^+

Question 6. (2 marks). Fill in the blanks:

a. Molecular chaperones are large proteins which assist proper folding of other polypeptides.

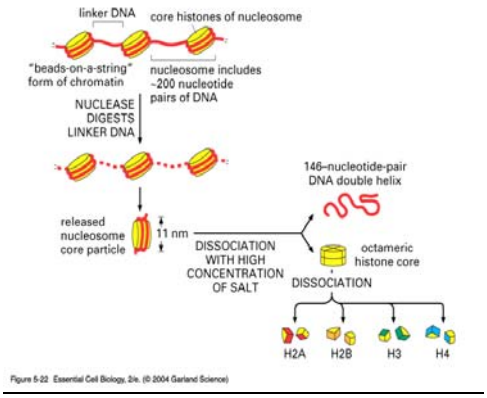
b. The most highly condensed form of interphase chromatin is called heterochromatin.

c. All the lipids found in membranes are said to be amphipathic because they have one hydrophilic end and one hydrophobic end.

d. Each group of three consecutive nucleotides in RNA is called a codon.

Question 7. (6 marks). Name and briefly explain the experimental methodology to study the following biological structures/processes (**attempt one**):

a. Macromolecular composition of nucleosomes



1. Nuclease digestion of linker DNA
2. Dissociation of proteins and DNA by high [Salt]
3. Dissociation of individual histone subunits
4. SDS-Page, amino acid sequencing or Mass Spec (MS)

b. Investigate the mobility of a lipid within plasma membrane

Its mobility in the membrane can be studied by the florescence dye or radiactive labelling and the FRAP technique. Labelling with florescence dye,→ photobleaching selective lipids in the membrane, → recovery of fluorescence after certain time. Half marks if proteins are labelled.

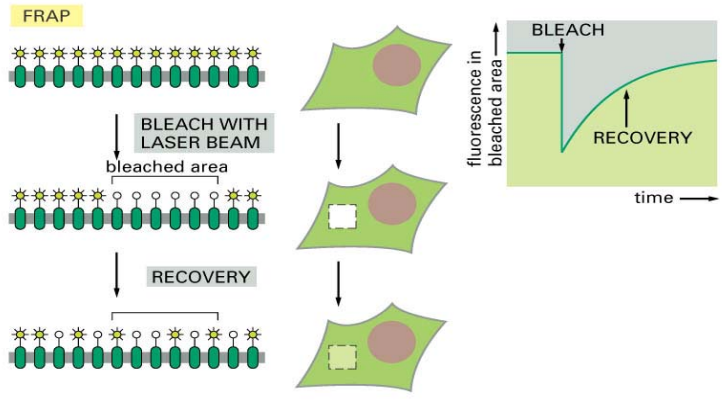


Figure 11-36 Essential Cell Biology, 2/e. (© 2004 Garland Science)