BIOL 266/2/01 -- CELL BIOLOGY
MIDTERM TEST (October 9, 2012)

NAME:_____ I.D.#:_____
(please print)

THESE EXAM PAGES MUST BE HANDED IN

PART A - Short answers: Answer all questions (2 points each).

1. Name three types of the endoplasmic reticulum. What is the structural (morphological) difference between them? Name the function that each of these three different types of ER performs within the cell.

(1) Rough ER: Flattened cisternae covered with ribosomes; synthesizes proteins.

(2) Smooth ER: The network of tubules; synthesizes lipids.

(3) Transitional ER: ER compartment from which secretory vesicles carrying proteins are formed.

2. Briefly describe the process of ribosome assembly in the nucleolus.

(1) Ribosomal proteins are imported into the nucleus from the cytoplasm
(2) These ribosomal proteins are then delivered to the nucleolus and assemble on the pre-ribosomal RNA (pre-rRNA)
(3) The pre-rRNA is cleaved to form several ribosomal RNAs
(4) Ribosomal proteins and rRNA assemble to form the 40S and 60S ribosomal subunits.
(5) These subunits are exported to the cytoplasm.

3. Name three lipids that are synthesized in the smooth ER, two lipids whose synthesis occurs within the Golgi complex, and a lipid that is formed inside the peroxisome.

(1) Smooth ER: Fatty acids, phospholipids, cholesterol
(2) Golgi: Glycolipids, Sphingomyelin
(3) Peroxisome: Plasmalogens.

4. Why do mutations in the genes that encode lysosomal acid hydrolases cause human genetic disorders? Briefly describe the molecular basis of Gaucher's disease.

* Because undegraded material (proteins, nucleic acids, lipids) accumulates within lysosomes of affected individuals.
* Gaucher's diesease results from a mutation in the gene encoding a lysosomal enzyme required for the hydrolysis of the glycolipid glucocerebroside to glucose and ceramide.

5. Briefly explain why a fluorescent molecule always emits light at the wavelength that is <u>longer</u> than its excitation wavelength.

After being excited by absorbing a photon of energy ($E_{ex} = \frac{hc}{\lambda_{ex}}$), the fluorescent molecule first dissipates part of the energy and then emits a photon of a lower energy ($E_{em} = \frac{hc}{\lambda_{em}}$) than E_{ex}. Because $E_{em} < E_{ex}$, $\lambda_{em} > \lambda_{ex}$.

6. Why does a mouse that has a proofreading-deficient version of mitochondrial DNA polymerase gamma ages prematurely?

During replication of mitochondrial DNA, the sequence of DNA copy is <u>not</u> corrected if wrong nucleotides have been included. Therefore, the frequency of mutations in mitochondrial DNA in the mutant mouse is increased by 5-8 fold. The increase in the frequency of mutations in mitochondrial DNA impairs the normal function of mitochondria, thus causing apoptosis of post-mitotic cells and premature aging

7. Name four processes that take place in the stroma of chloroplasts. Name three processes that occur in the membrane of thylakoids.

*Stroma:

(1) "Dark" reactions of photosynthesis (the conversion of CO_2 to carbohydrates)
(2) DNA replication
(3) Transcription of chloroplast DNA
(4) Protein synthesis

* Thylakoid membrane:

(1) Light absorbtion by chlorophyles
(2) Electron transport
(3) ATP and NADPH synthesis

8. Name two protein complexes of the chloroplast that pump protons during photosynthesis. Where in the chloroplast each of these two protein complexes resides? Where in the chloroplast each of these two protein complexes releases protons?

(1) Cytochrome bf: releases protons to thylakoid lumen
(2) ATP synthase: releases protons to chloroplast stroma

both protein complexes reside in the thylakoid membrane

9. Name processes that take place in the outer and inner membranes of mitochondria and in the matrix of these organelles.

* Outer membrane:

Conversion of lipids (i.e., fatty acids) into forms that can cross the outer membrane

* Inner membrane:

Electron transport and ATP synthesis

* Matrix:

TCA cycle (Krebs cycle), DNA replication, protein synthesis

10. Why do mitochondrial disorders most seriously impact muscle and nerve tissues?

because these tissues are in a very high demand of ATP, which is mostly produced in mitochondria

11. Name <u>three</u> microscopy-based techniques that are used to determine the cellular location of proteins.

(1) Immunogold electron microscopy
(2) Immunofluorescence microscopy
(3) Cytochemical staining

12. Name two genes mutations in which result in Emery-Dreifuss muscular dystrophy. Briefly explain <u>why</u> these mutations cause the disorder.

(1) Gene encoding <u>emerin</u>
(2) Gene encoding <u>lamin</u>
The mutations impair the correct interactions of lamins with the nuclear envelope, which is essential for normal tissue-specific transcription of certain genes.

13. Name <u>three</u> "light reactions" and <u>the only</u> "dark reaction" of photosynthesis. Name the membrane and/or the internal compartment of the chloroplast in which <u>each</u> of these four photosynthetic reactions occurs.

* <u>"Light" reactions</u>:
(1) Light absorption
(2) Electron transport
(3) Synthesis of NADPH and ATP

} Membrane of the thylakoid

* <u>"Dark" reactions</u>:
Synthesis of carbohydrates (sugars) using the atmospheric CO_2 and ATP + NADPH formed in "light" reactions

} Stroma of the chloroplast

14. Name <u>five</u> major groups of proteins that are imported to the nucleus through the nuclear pore.

(1) DNA-binding proteins (histones, non-histone proteins, activators and repressors of transcription)
(2) mRNA-binding proteins
(3) Lamins (components of the nucleus)
(4) Ribosomal proteins
(5) Shuttling nuclear receptors ("importins")

PART B - Multiple choice questions: Circle clearly ONE correct answer per question (2 points each).

1. The emission wavelength of a fluorescent molecule is always longer than its excitation wavelength because:

A. the speed of light for a photon emitted by a fluorescent molecule is lower than that for a photon absorbed by this molecule
B. the speed of light for a photon emitted by a fluorescent molecule is higher than that for a photon absorbed by this molecule
C. the energy of a fluorescent molecule is decreased when such a molecule absorbs a photon
D. the energy of a photon emitted by a fluorescent molecule is higher than that of a photon absorbed by this molecule
(E.) the energy of a photon emitted by a fluorescent molecule is lower than that of a photon absorbed by this molecule
F. the value of Plank's constant for a photon emitted by a fluorescent molecule is lower than that for a photon absorbed by this molecule

2. In a typical plant cell, proteins are glycosylated:

A. after being completely synthesized on free ribosomes in the cytosol
(B.) inside the Golgi apparatus
C. in the lumen of thylakoids
D. in the stroma of chloroplasts
E. in the thylakoid membrane
F. in the intermediate space between the inner and outer membranes of chloroplasts

3. Actin filaments:

A. pull the duplicated chromosomes in opposite directions and distribute them equally to the two daughter cells during cell division
B. can be found only in the close proximity to the nucleus
C. serve to strengthen the cell mechanically
(D.) generate contractile forces inside muscle cells
E. are built of the protein called tubulin
F. are assembled from many protein molecules that are synthesized on ribosomes bound to the rough ER

4. The *trans* Golgi network directs vesicle-mediated protein transport to:

A. medial cisterna of the Golgi apparatus
B. the nucleus
C. the endoplasmic reticulum
D. peroxisomes
(E.) lysosomes
F. the *cis* Golgi network

5. In a typical animal cell, the Golgi apparatus serves as a site for:
   A. biosynthesis of plasmalogens
   B. conversion of fatty acids to carbohydrates
   C. biosynthesis of cholesterol
   D. protein glycosylation
   E. biosynthesis of the complex polysaccharides of the cell wall
   F. none of the above

6. Free ribosomes in the cytosol synthesize:
   A. enzymes that catalyse reactions of the synthesis of sphingomyelin
   B. all transport proteins in the plasma membrane
   C. enzymes that catalyse reactions of the synthesis of phospholipids
   D. lysosomal proteases
   E. enzymes that catalyse reactions of glycolysis
   F. enzymes that catalyse reactions of the synthesis of glycolipids

7. In plant cells, the oxidation of fatty acids that does not lead to the formation of ATP occurs in:
   A. the cytosol
   B. the chloroplast
   C. the mitochondrion
   D. the vacuole
   E. the peroxisome
   F. the smooth ER

8. In theory, the resolution of an electron microscope should be 100,000 times greater than that of a light microscope. In reality, it is only 1,000 times greater. The inability of currently available electron microscopes to achieve the highest possible resolution is due to:
   A. lack of a condenser lens
   B. low values of the numerical aperture for electromagnetic lenses
   C. extremely high electric potential of the cathode
   D. lack of objective lenses
   E. inability to achieve the shortest possible wavelength of an electron
   F. none of the above

9. Lamins are proteins that are attached to:
   A. the transitional ER
   B. the nuclear pore
   C. the nucleolus
   D. the rough ER
   E. the inner nuclear membrane
   F. the outer nuclear membrane

10. Ribosomes bound to the rough endoplasmic reticulum synthesize proteins for:

A. peroxisomes
B. mitochondria
C. chloroplasts
D. the nucleus
(E) lysosomes
F. actin filaments

11. In a typical plant cell, all proteins that can be found in the plasma membrane are synthesized on:

A. ribosomes bound to the transitional endoplasmic reticulum
B. ribosomes in the lumen of chloroplasts
C. ribosomes in the lumen of the endoplasmic reticulum
D. ribosomes attached to the smooth endoplasmic reticulum
(E) ribosomes bound to the rough endoplasmic reticulum
F. free ribosomes in the cytosol

12. In a typical yeast cell, proteins synthesized on free ribosomes in the cytosol are transported to:

A. lysosomes
B. the *cis* Golgi network
C. the plasma membrane
D. the rough endoplasmic reticulum
(E) the nucleolus
F. chloroplasts

13. Nuclear lamins:

A. are membrane proteins that are indirectly attached to the outer nuclear membrane by interactions with emerin and lamin B receptor
B. activate transcription of the genes that are located in chromatin regions attached to the nuclear lamina
(C) repress transcription of the genes that are located in chromatin regions attached to the nuclear lamina
D. are membrane proteins that are directly attached to the inner nuclear membrane
E. are components of nuclear pore complexes
F. are essential for the export of ribosomal subunits from the nucleolus to the cytoplasm

14. After their synthesis on free ribosomes in the cytosol, proteins can be imported:

A. into the lumen of the ER
B. into the cis-Golgi network
C. into the trans-Golgi network
D. into lysosomes
(E) into the mitochondrial matrix
F. into the medial compartment of the Golgi stack

15. The inner mitochondrial membrane:
A. is the principal site of NADH production
B. is the principal site of the synthesis of mitochondrial proteins
C. contains enzymes responsible for the oxidative breakdown of carbohydrates and lipids
D. is the principal site of CO_2 production
E. contains enzymes that convert lipid substrates into forms that are subsequently metabolised in the mitochondrial matrix
(F) contains ATP synthase

16. Peroxisomes play a critical role in:
A. ATP synthesis
(B) the decomposition of hydrogen peroxide
C. the "light reactions" of photosynthesis
D. protein secretion
E. NADH synthesis
F. protein degradation

17. Large particles, including bacteria and aged cells, are taken up from outside the cell and delivered to lysosomes for degradation by:
A. autophagy
B. endocytosis
(C) phagocytosis
D. transport vesicles
E. early endosomes
F. late endosomes

18. After their synthesis in the smooth ER, lipids in a plant cell are:
A. transported to the outer membrane of chloroplasts
B. transported to the inner membrane of chloroplasts
C. transported to the thylakoid membrane
D. transported to the peroxisomal membrane
(E) all of the above
F. none of the above

* if A, B, C or D: = 1 point
* if E: = 2 points

19. Endocytosis is a cellular process for:
A. delivery of bacteria taken up from outside the cell to lysosomes for degradation
B. delivery of proteins to the extracellular medium
(C) delivery of proteins taken up from outside the cell to lysosomes for degradation
D. delivery of defective mitochondria to lysosomes for degradation
E. delivery of the glycolipid glucocerebroside to lysosomes for its hydrolysis to glucose and ceramide
F. delivery of proteins to the endoplasmic reticulum

20. Cytochemical staining of cytochrome c oxidase is used:

A. to visualize mitochondria in living cells using bright-field microscopy
B. to visualize mitochondria in dead cells using Nomarski microscopy
C. to visualize mitochondria in dead cells using phase-contrast microscopy
(D) to visualize mitochondria in dead cells using bright-field microscopy
E. to visualize peroxisomes in living cells using bright-field microscopy
F. to visualize peroxisomes in dead cells using bright-field microscopy

21. The excitation wavelength of fluorescein is 470 nm. The emission wavelength of fluorescein is 540 nm. If fluorescein is used as a reporter molecule for fluorescence microscopy, the second barrier filter in a fluorescence microscope:

A. lets through only the light with a wavelength between 450 nm and 490 nm
B. lets through only the light with a wavelength below 450 nm
(C) lets through only the light with a wavelength between 520 nm and 560 nm
D. lets through only the light with a wavelength above 560 nm
E. lets through only the light with a wavelength of 470 nm
F. lets through only the light with a wavelength below 520 nm

22. The complexes of messenger RNAs and mRNA-binding proteins are exported from the nucleus to the cytosol via:

A. the inner nuclear membrane
B. the smooth endoplasmic reticulum
C. the nuclear lamina
D. the rough endoplasmic reticulum
(E) the nuclear pore complexes
F. the outer nuclear membrane

23. Electromagnetic projector lenses in a transmission electron microscope:

A. focus electrons from a cathode onto the specimen
B. pick up electrons passed through the specimen
(C) pick up electrons focused on the focal plane of the objective lenses
D. focus the electrons passed through the specimen on the focal plane of the objective lenses
E. create a magnified image of the specimen on the focal plane of the objective lenses
F. accelerate electrons emitted by a cathode

24. Autophagy is a cellular process for:
A. delivery of bacteria taken up from outside the cell to lysosomes for degradation
B. delivery of proteins to the extracellular medium
C. delivery of proteins taken up from outside the cell to lysosomes for degradation
(D) delivery of defective mitochondria to lysosomes for degradation
E. delivery of the glycolipid glucocerebroside to lysosomes for its hydrolysis to glucose and ceramide
F. delivery of proteins to the endoplasmic reticulum

25. Acid hydrolases within lysosomes degrade:
A. nuclear proteins of bacteria delivered to lysosomes by phagocytosis
B. lipids of bacterial plasma membrane delivered to lysosomes by endocytosis
C. messenger ribonucleic acids of peroxisomes delivered to lysosomes by autophagy
D. components of the electron transport chain in mitochondria delivered to lysosomes by phagocytosis
E. components of the inner membrane of mitochondria delivered to lysosomes by endocytosis
(F) components of the outer membrane of mitochondria delivered to lysosomes by autophagy

26. The conversion of CO_2 to carbohydrates occurs:
A. in the inner chloroplast membrane
B. in the outer chloroplast membrane
C. in the intermediate space between the inner and outer chloroplast membranes
D. in the thylakoid membrane
E. in the thylakoid lumen
(F) in the stroma of chloroplasts