Biology 2120
Spring 2010
Midterm Exam #1

Name (printed): [redacted]

Recitation section or day/time 2 Wed @ 1 p.m.

This exam contains 12 pages, and the multiple choice bubble sheet. Please verify that you have all pages.
*Write your name on both this exam and the bubble sheet (Fill in the bubbles for you name).
*Write the color or your exam paper on the bubble sheet.
*Answer all questions, using only the space available for the drawings/short answer section (Part II).
*You have until 11:30 AM to finish the exam – to receive credit for taking the exam, your exam MUST be in the box at the front of class when the proctor announces that the examination period has ended.
*As indicated in the course syllabus, cheating in this course is strictly forbidden. Anyone who cheats on this exam will receive an F in the course and be referred for disciplinary action. By signing your name below, you indicate that you understand and agree to comply with this policy.

Name (signed): [redacted]

Part I. Multiple Choice. Choose the single best answer to each question.

1. Which statement best explains the difference between transcription and translation?
a. Transcription occurs in prokaryotes, translation occurs in eukaryotes
b. Transcription requires the formation of peptide bonds, translation requires the formation of ester bonds.
c. Transcription requires the unfolding of proteins, translation requires the unfolding of nucleic acids.
d. Transcription copies one nucleotide sequence to another, translation converts a nucleic acid sequence into an amino acid sequence.
e. Transcription happens in all organisms, translation occurs in eukaryotes only.

2. Can microtubules form in the absence of γTuRC?
a. Yes, they can spontaneously polymerize in a test tube.
b. Yes, they can from new branches off of existing microtubules.
c. No, they require the GTP cap created by γ-tubulin to polymerize.
d. Yes, they spontaneously polymerize around DNA to protect it.
e. No, they must use γ-tubulin as a nucleating site, even in vitro (i.e., in a test tube).

3. Which observation best illustrates *treadmilling* by microtubules?
a. Some microtubules can shrink while others simultaneously grow in the same cell.
b. Fluorescently tagged α/β tubulin subunits attach preferentially to the plus end of a microtubule.
c. α/β tubulin subunits bound to GDP cannot escape a microtubule unless they are at the plus or minus ends.
d. When α/β tubulin subunits cleave GTP to form GDP and inorganic phosphate, microtubules switch from growing to shrinking.
e. At steady state, the number of α/β tubulin subunits added to the plus end of a microtubule is balanced by loss of subunits from the minus end.

4. **Which statement best defines a nucleosome?**
   a. A nucleosome contains exactly one gene, wrapped around a core particle composed of histone proteins.
   b. A nucleosome contains double stranded DNA with both a major and a minor groove in the core particle.
   c. A nucleosome contains genes that are expressed; silenced genes are not found in nucleosomes.
   d. A nucleosome contains a segment of double stranded DNA wrapped around a core particle of histone proteins.
   e. A nucleosome is a "spool" of histone proteins; some nucleosomes have DNA wrapped around them.

5. **If cells can't express genes contained in heterochromatin, why do they bother making heterochromatin at all?**
   a. Heterochromatin is where all of the "junk DNA" is stored- there are no functional genes in heterochromatin.
   b. Heterochromatin gets separated during mitosis, and is used to build new genes in the resulting daughter cells.
   c. Heterochromatin reduces clutter in the nucleus, by storing unused DNA in the most compact form; this permits actively expressed genes to be stored in a more accessible form of DNA.
   d. Heterochromatin ensures that only the most useful genes are expressed at the tips of chromosomes, where DNA packing is lowest.
   e. Heterochromatin protects the most valuable genes from destruction- it serves as extra "padding" for essential genes.

6. **Cell biologists commonly use fluorescence microscopy to visualize molecules in or on cells, because:**
   a. Fluorescence microscopy techniques are the only light microscopes that will not kill the cells being visualized.
   b. Fluorescence microscopy techniques can detect the presence of a single type of molecule in a cell, while blocking out stray, "background" signals from other molecules.
   c. Fluorescence microscopy techniques have better resolution than other light microscopes.
   d. Fluorescence microscopy techniques can detect/visualize secondary antibodies, even if they are not linked to a fluorescent tag.
   e. Fluorescence microscopy techniques are the only light microscopes that can determine the molecular weight of a protein.

7. **If a sequence of DNA is in a form with a packing ratio of ~42, which one the following statements about it is *false*?**
   a. At least some of the nucleotides are bound to histones.
   b. Each nucleotide in the same DNA strand is attached to adjacent nucleotides by at least one phosphodiester bond.
   c. The cell containing this DNA sequence is most likely not undergoing mitosis.
   d. The double helix formed by two strands of DNA in this sequence contains both a major and a minor grove.
   e. Every gene contained in this sequence must be expressed.

8. **Using oil or water as an immersion medium provides better resolution than using air, because:**
   a. Oil and water have a higher density than air.
   b. Oil and water generate shorter wavelengths of light than air.
   c. Oil and water molecules are more compact than the molecules in air.
   d. Oil and water share more structural properties with glass lenses than air does.
   e. Oil and water have a higher diffraction coefficient than air.

9. **Which one of the following properties is shared by proteasomes and lysosomes?**
   a. Use of ubiquitin as a signal for protein degradation.
   b. Digestion of proteins in the extracellular space.
   c. Separation from the cytosol by a membrane
   d. Encoded by a single gene on chromosome 17
   e. Use of hydrolytic proteases

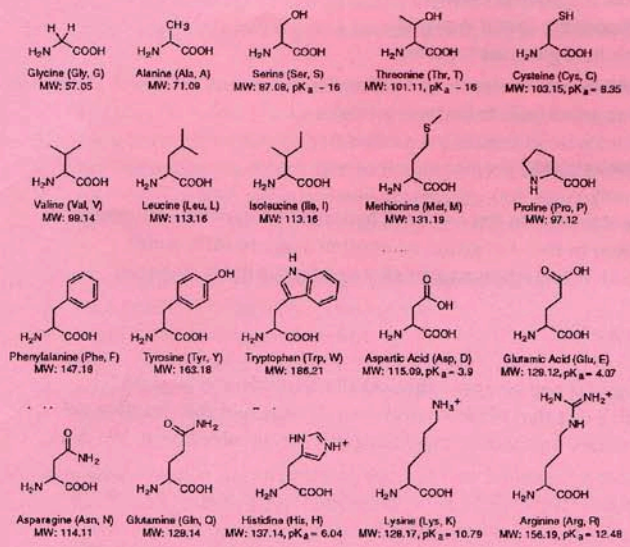
Refer to the diagram below to answer the following two questions:

11. Which amino acids would you most expect to find in a transmembrane alpha helix?

a. Serine, glutamic acid, tyrosine
b. Cysteine, leucine, methionine
c. Phenylalanine, isoleucine, glycine
d. Aspartic acid, valine, threonine
e. Alanine, tryptophan, histidine

11. Which group of three amino acid side chains can form hydrogen bonds with one another?

a. Alanine, tryptophan, histidine
b. Serine, glutamic acid, tyrosine
c. Phenylalanine, isoleucine, glycine
d. Aspartic acid, valine, threonine
e. Cysteine, leucine, methionine



Consider the structure of an antibody, at the level of detail discussed in lecture, to answer the following two questions:

12. What is the function of the disulfide bonds?

a. They hold the Fc portion in a stable configuration, which is important to conserve structural similarity in the Fc portion of all antibodies.
b. They bind the antibody to its antigen such that the antibody effectively never dissociates (i.e., "never lets go").
c. They hold two stands of a β sheet together in the antigen binding region.
d. They hold the large and small (aka "heavy" and "light") subunits of the antibody together.
e. They form α helices in the Fab portions, allowing the antibody to bind its antigen.

13. What structural property do *all* antibodies (in all organisms that make them) share?

a. They all contain antigen binding domains.
b. They all have the same quaternary structure.
c. They are all fluorescent.
d. They all contain the same primary structure.
e. They all bind to the same antigens.

14. Which one of the following statements is *false*?

a. Carbon has a valence number of four, which means it requires four covalent bonds to fill its valence shell.
b. Hydrogen bonds do not form between $-CH_3$ groups.
c. Water is a liquid at standard conditions because it forms a large number of hydrogen bonds between water molecules.
d. Ribose contains five carbons when it is in either the linear form or the ring form.
e. Every phosphate group in the backbone of a nucleic acid (including the triphosphate end) forms two ester bonds.

15. Which statement best describes the difference between α1,4 and β1,4 glycosidic bonds in polysaccharides?

a. α1,4 bonds can be broken by human enzymes; most β1,4 bonds cannot.
b. α1,4 bonds are found only in animals; most β1,4 bonds are found in plants.
c. α1,4 bonds hold riboses together; most β1,4 bonds hold glucoses together.
d. α1,4 bonds can be branched; most β1,4 bonds cannot .
e. α1,4 bonds are stronger than most β1,4 bonds.

16. Is it possible for a hydrogen bond to form between two sugars?

a. No, sugars are held together by glycosidic bonds only.
b. Yes, the δ- on the oxygen of an –OH group can be attracted to the δ+ of the hydrogen on another –OH group.
c. Yes, the –OH group of one sugar donates a hydrogen to the –OH group on another sugar to form water.
d. No, the C=O group required to form hydrogen bonds is lost when a sugar changes from a linear to a ring structure.
e. No, sugars form hydrogen bonds with phosphate groups.

17. If (1) an antibody was dissolved in a buffer containing SDS and an agent that breaks disulfide bonds, then (2) subjected to gel electrophoresis, and (3) stained with a dye that binds all proteins, what would the resulting gel band pattern look like? (Note that there are no secondary antibodies, tags, antigens, etc. involved here. We are simply separating an antibody by electrophoresis.)

a. There would be one band near the bottom of the gel, representing the small subunits, and one band near the top of the gel, representing the large subunits.
b. There would be a single band near the top of the gel, representing the large and small subunits bound together.
c. There would be more bands than we could count, each representing a different conformation of the denatured antibody.
d. There would be no bands, because the antibody cannot penetrate the gel.
e. There would be no bands, because SDS denatures the antibody.

<u>The following four questions refer to the subject matter discussed in the recitation module:</u>

18. In the "Featured EB kid/patient" article discussed in recitation, Lizie's mother compared Lizie to a burn victim. Why?

a. Lizie's skin quickly denatures, similar to the way heat denatures most skin proteins.
b. Lizie's injuries require extensive recovery times, typical of burn victims.
c. Lizie has blistering injuries on her skin and internal epithelial tissues, typical of burn victims.
d. Lizie's skin is constantly inflamed, causing her to feel as if she is on fire.
e. Lizie must be kept out of direct sunlight, because the heat from the sun can cause her skin to peel off.

...atement best defines a scientific hypothesis?

a. A scientific hypothesis is one or more testable observations that have been collected in a statistically rigorous fashion.
b. A scientific hypothesis is a set of facts that require an explanation to be validated as true.
c. A scientific hypothesis is a statistically rigorous prediction of the outcome of a proposed experiment.
d. A scientific hypothesis is a proposed explanation for a set of observations that currently cannot be linked by a mechanistic theory.
e. A scientific hypothesis is an untested theory that accurately predicts which set of facts are mechanistically related.

20. Why is the recessive dystrophic form of epidermolysis bullosa (the kind Lizie has) considered a genetic disease?

a. There is a defect in each of the two recessive alleles for the epidermolysis bullosa gene.
b. There is a defect in the gene encoding the epidermolysis bullosa protein, which attaches skin to the underlying surface.
c. There is a defect in the nucleotide sequence encoding the primary structure of at least one protein responsible for making epithelial cells adhere to the underlying surface.
d. There is a defect in the heterochromatin:euchromatin ratio in epithelial cell DNA, such that genes encoding the proteins necessary for cell adhesion are not expressed.
e. There is a defect in the genes encoding skin cell growth, so skin is very thin and fragile.

21. Which statement best summarizes the hypothesis of the research article discussed in module 1-2?

a. Electron microscopy is an effective method of diagnosing epidermolysis bullosa.
b. Some forms of epidermolysis bullosa are caused by structurally deficient hemidesmosomes.
c. Hemidesmosomes attach skin to the underlying connective tissues.
d. Mutations in DNA cause proteins to misfold, and thereby function improperly.
e. Lizie has mutations in genes encoding hemidesmosome genes.

22. Which question can be answered by using flow cytometry?

a. How many mutations does this cell have?
b. What is the function of dynein?
c. How many antibodies does this cell make?
d. How many of these cells are currently expressing Green Fluorescent Protein?
e. Why did these cells die?

23. Which observation best illustrates the fact that a biological membrane acts as a two-dimensional fluid?

a. When soap bubbles pop, they leave behind a wet spot.
b. Soap bubbles that collide often pop as a result.
c. The fluorescent signal emitted by a fluorescently tagged antibody attached to a protein in the plasma membrane emits a red color but not a green color.
d. When soap bubbles are struck by sunlight, they shine.
e. The fluorescent signal emitted by a fluorescently tagged phospholipid on the outer surface of the plasma membrane moves over the cell surface without flipping to the inner surface of the plasma membrane.

24. How is a fluorescence-activated cell sorter similar to a fluorescence microscope?

a. Both instruments can measure the molecular mass of a protein without having to use gel electrophoresis.
b. Both instruments can count thousands of cells in less than a minute.
c. Both instruments can detect binding between two proteins without having to use immunoprecipitation.
d. Both instruments can detect the presence of a specific protein in/on a cell.
e. Both instruments can find the chromosomal location of the gene encoding green fluorescence protein.

25. **Consider the following statements about biological membranes:**

i. Membranes can contain both saturated and unsaturated fatty acids in their phospholipids
ii. The α-helix is the most common secondary structure found in the transmembrane domain of membrane-spanning proteins
iii. Ethanol readily penetrates biological membranes because it passes through the hydrophobic core of membrane spanning proteins.
iv. Multispanning membrane proteins are generally more fluid than lipid-anchored membrane proteins
v. A lipid raft contains only lipids

Which of these statements is/are true?

a. i and ii
b. i, iii, and v
c. iii and iv
d. ii and iv
e. v only

26. **If a large amount of either Triton-X 100 or Sodium Dodecyl Sulfate was added to cells growing in culture, would the outcome be the same for both treatments?**

a. No, only the SDS treated cells would die, because SDS denatures most proteins while TX100 does not.
b. Yes, all the cells would die, because both detergents would solubilize phospholipids, thereby dissolving the barrier function of membranes.
c. Yes, all the cells would die, because both of these compounds are detergents, and all detergents denature proteins.
d. No, only the SDS treated cells would die, because only SDS can dissolve membranes that contain a high concentration of proteins.
e. Yes, all the cells would die, because both compounds are amphiphilic, so they both bind to cellular molecules.

27. **According to the description of cell migration given in lecture, what is the function of filament anchoring proteins?**

a. They form at the base of filopodia and align actin filaments into bundles
b. gThey cause actin filaments to slide past one another, generating force.
c. They cap the plus ends of microtubules, stabilizing them.
d. They remove the phosphate group from intermediate filaments, allowing them to polymerize.
e. They secure actin stress fibers to the plasma membrane.

28. **How are restriction endonucleases used to combine genes from different organisms?**

a. They generate fragments of DNA that have matching 5' and 3' ends, thereby allowing the fragments of one organism to spontaneously attach to the fragments of another organism.
b. They convert heterochromatin to euchromatin, thereby allowing the DNA strands to recombine.
c. They cut the phosphodiester bonds between deoxynucleotides, generating extra 3' ends where new genes can be built by cells.
d. They control the activity of kinesin, thereby controlling the separation of chromosomes on the mitotic spindle.
e. They remove histones from nucleosomes, thereby allowing DNA to adopt the completely unwound state required for genetic recombination.

29. **Which statement about nuclear lamins is false?**

a. When they dissociate from each other, the entire nuclear envelope fragments.?
b. They are found in most eukaryotic cells.
c. When they are phosphorylated, they denature.?
d. They contain a higher percentage of α-helices than most other proteins.
e. They form a protective layer on the inside surface of the inner nuclear membrane.

...tatement best summarizes the meaning of this research article title: "Deficiency of the integrin β4 subunit ...ctional epidermolysis bullosa with pyloric atresia: consequences for hemidesmosome formation and ...hesion properties"?

a. Loss of adhesion of cells *is caused by* EB and leads to malformation of a structure called a hemidesmosome.
b. We hypothesize that EB *is caused by* mutations in a protein subunit found in a structure called a hemidesmosome.
c. EB causes loss of adhesion of cells and *leads to* mutation of a subunit of a protein.
d. Something called pyloric atresia *results from* loss of adhesion by cells that have EB disease.
e. Mutation of a subunit of a protein *is associated with* EB and correlates with malformation of a structure called a hemidesmosome and the adhesion of cells.

31. What property of intermediate filaments makes them so resistant to tensile force (pulling)?

a. They form filamentous polymers like other elements of the cytoskeleton.
b. They attach to hemidesmosomes.
c. They are not dissolved by most detergents.
d. They contain more disulfide bonds than most other proteins.
e. They form coiled-coil dimers, which resemble strands in a rope.

32. Which statement best describes an intermediate filament tetramer?

a. It consists of four intermediate filament proteins arranged as a ring of protofilaments.
b. It looks like a tetris piece.
c. It consists of two overlapping, intermediate filament dimers arranged in a staggered orientation lacking structural polarity.
d. It consists of four intermediate filament proteins that, when bound to GTP, are either part of a growing filament; or when bound to GDP, form a free-floating complex that is not attached to any other proteins.
e. It contains four membrane spanning α-helices and thus is classified as a multisubunit membrane protein.

33. What is the difference between G actin and F actin?

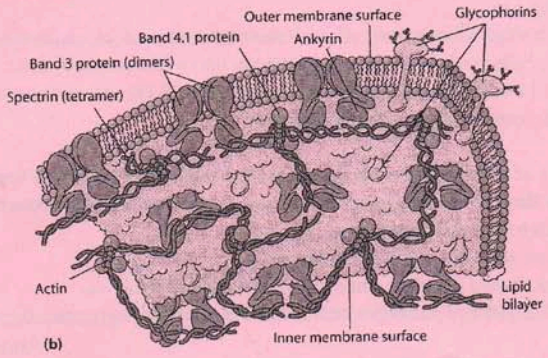
a. G actin forms globular clusters of actin proteins while F actin forms filamentous clusters of actin proteins.
b. G actin keeps the endoplasmic reticulum spread out in the cytoplasm, F actin condenses the Golgi apparatus near the nucleus.
c. G actin bings GTP, F actin binds ATP
d. G actin is used to keep a cell stationary, F actin is used to propel a cell forward.
e. G actin is the monomeric form of actin, F actin is the polymeric form of actin

34. Which statement best describes the functional difference between actin bundling proteins and actin crosslinking proteins?

a. Bundling proteins keep clusters of actin filaments aligned in the same direction, crosslinking proteins keep criss-crossed networks of filaments connected.
b. Bundling proteins function in the nucleus, crosslinking proteins function in the cytosol.
c. Bundling proteins link bundles of actin to microtubules, crosslinking proteins link actin filaments to intermediate filament networks.
d. Bundling proteins allow a cell to contract, crosslinking proteins allow a cell to spread.
e. Bundling proteins help create the MTOC, crosslinking proteins help create the plasma membrane

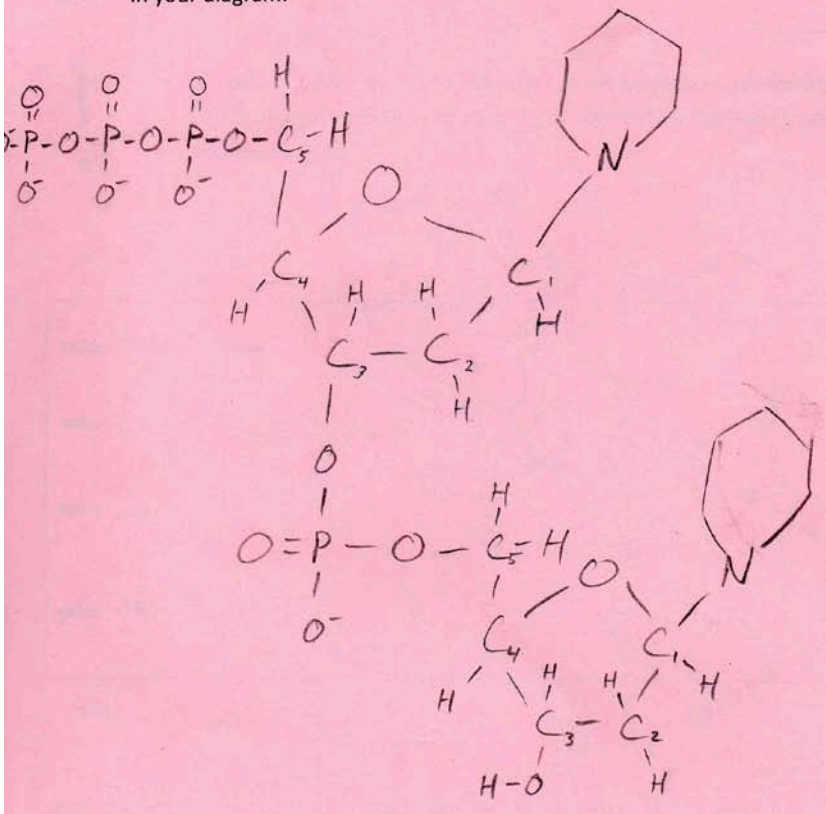
35. **Which statement best describes the drawing at right?**

a. This is a diagram of the nuclear membrane, illustrating the intermediate filament network that protects DNA.
b. This is a diagram of the hemidesmosome, which leads to epidermolysis bullosa when it is damaged.
c. This is a diagram of the fluid mosaic model, illustrating the principle of a lipid raft.
d. This is a diagram of the actin filament network in most eukaryotic cells, illustrating how it is connected to the plasma membrane.
e. This is a diagram of the red blood cell membrane, illustrating how peripheral membrane proteins form a network that protects the membrane from damage by shear forces.



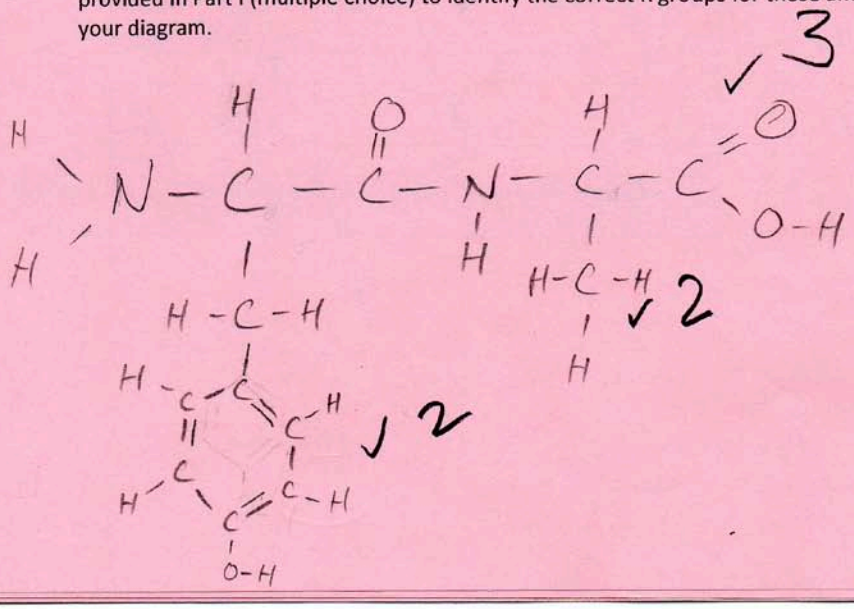
rawings/Short Answer. Use only the space provided for your answers. Think carefully before you draw, and your drawings, to ensure you don't run out of room then have to erase and redraw.

1. (7 points) Draw a dinucleotide composed of two deoxyribonucleotides, and assume the 5' end is not connected to anything else (i.e., it is the 5' end of a polymer). Include all atoms in your drawing, except the atoms other than nitrogen in the attached base. Add NUMBERS to your diagram, indicating the names of each of the carbons in your diagram.



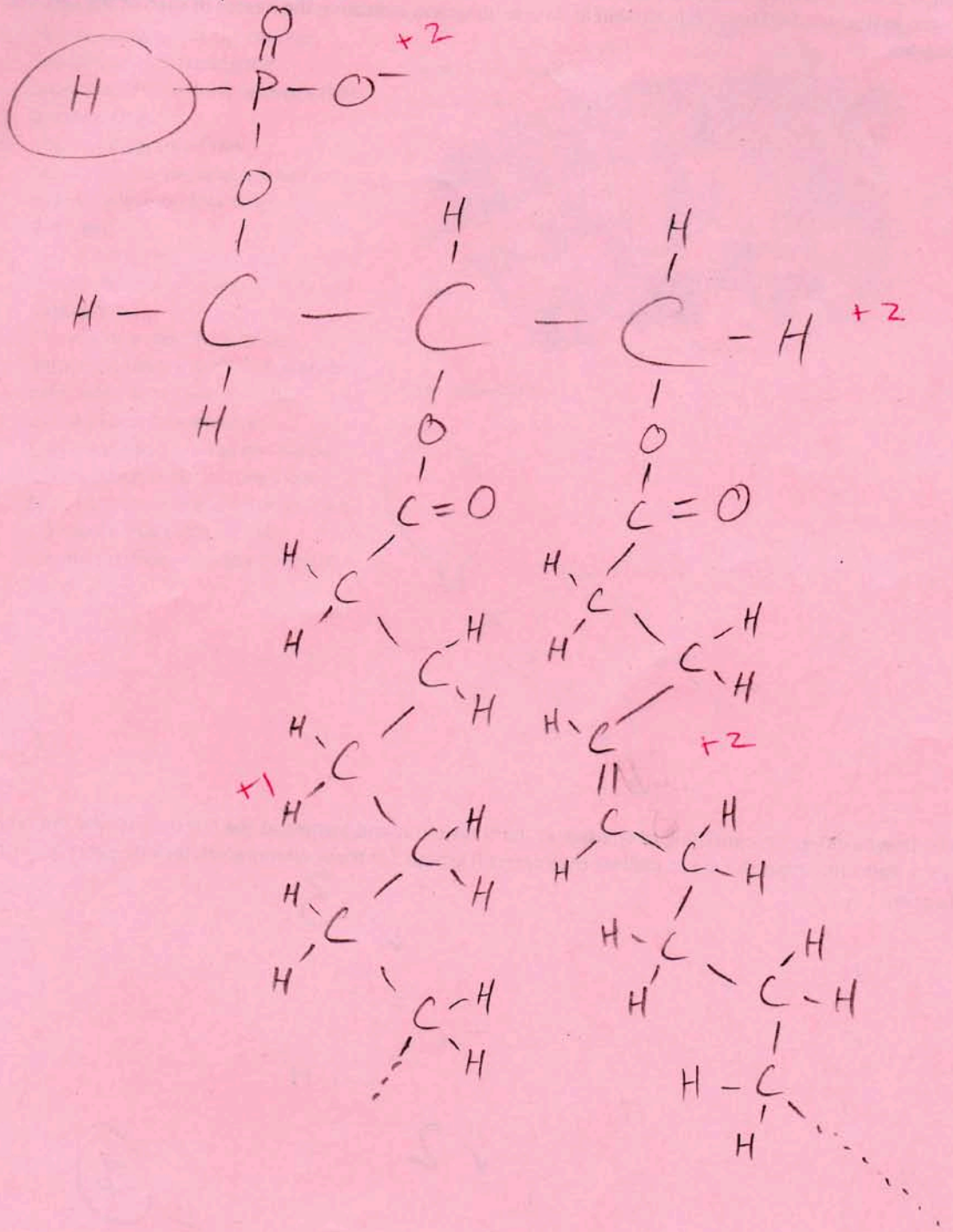
(7)

2. (7 points) Draw a dipeptide consisting of tyrosine at the N terminus and alanine at the C terminus. Use the table provided in Part I (multiple choice) to identify the correct R groups for these amino acids. Include every atom in your diagram.



✓3 ✓2 ✓2 = (7)

3. (7 points) Draw a phospholipid containing two acyl groups with at least six carbons each (you can use "..." to indicate more than six). Make one acyl group a fully saturated fatty acid and one an unsaturated fatty acid with a single cis bond at the fourth carbon from the acid group. Include <u>every atom</u>, except the Head Group, which can be abbreviated by the letter H.



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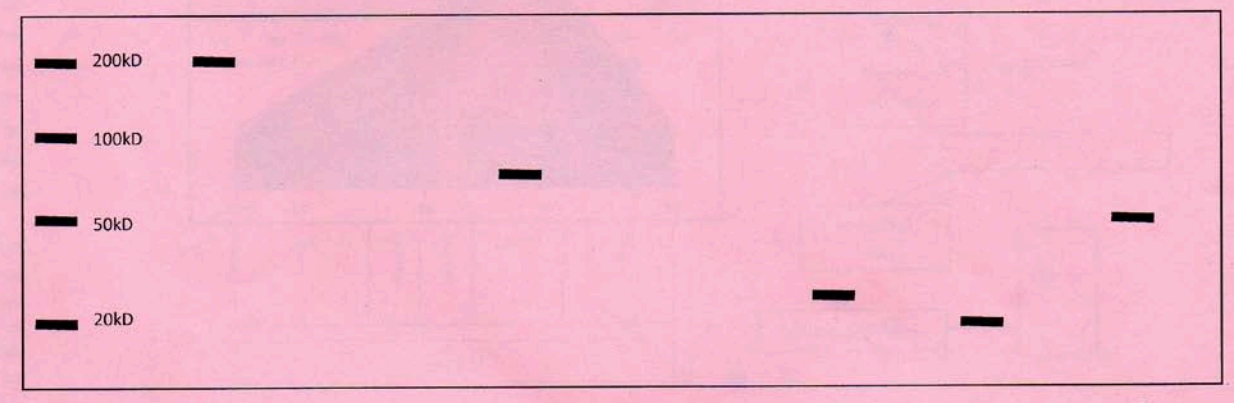
K

****Answer THIS version of the question, NOT the one stapled to your exam***
Make sure to put your name on this version and staple it to your exam when you hand it in. Sorry about the mix-up!

4. (7 points) Given the following results from an immunoprecipitation-western blotting experiment, indicate which proteins attach to each other by completing the table below. Molecular weight markers are provided on the left edge.

	1	2	3	4	5	6	7
IP:	A	B	D	G	C	F	E



WB:	C	E	A	D	F	B	G

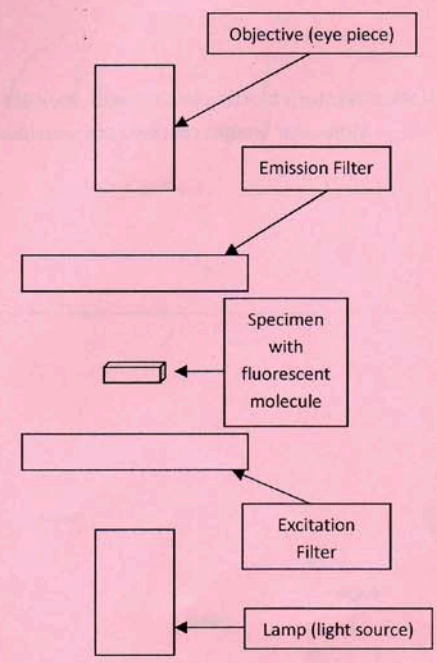
Protein...	...has a molecular mass of...	... and binds to...
A	200 75	C, D BF
B	→ 20 20	~~F~~ A D
C	→ 200 200	A, F BD
D	75 —	F, A BC
E	50 —	G
F	→ 30 ✓	B, C AD
G	→ 50 ✓	E
Example: if X is 55 kD in size and binds Q and R, the entry would be:		
X	55	Q, R

A - C G
| | |
D F E
|
B

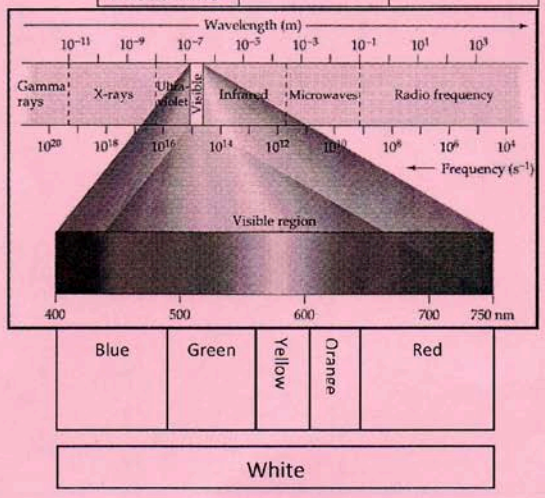
3

-3.5 -1

1. (7 points total) Imagine that the diagram below represents the path of light in a conventional (not confocal) fluorescence microscope (lenses are omitted on purpose). Given the following traits of the fluorescent molecules being visualized, answer the questions below:



Fluorescent tag	Fluorescence excitation peak (nm)	Fluorescence emission peak (nm)
DAPI	400	460
Tetramethyl Rhodamine	550	570



1. Would an emission filter that blocks all wavelengths of light except 400-500 nm allow you to visualize DAPI and Tetramethyl Rhodamine at the same time? (Answer YES or NO) NO (1 pt)

2. If you are visualizing Tetramethyl Rhodamine, what **color** of light will strike the specimen? green (3 pts)

3. Would a lamp that emits light in the green spectrum be able to induce Tetramethyl Rhodamine to fluoresce? (Answer YES or NO) YES (1 pt)

4. If you are visualizing DAPI, what wavelength(s) of light will pass through the emission filter? 460 nm (2 pts)

(7)

Part I 32 **+ Part II** 31 **= out of 70 points total** (63)

= 90%