Several Sample exams with Solutions

Sample exam

1) What are the 3 main kinds of bonds important in molecular structure,
list them in increasing order of strength - *weakest to strongest*.

Hydrogen bonds < Ionic bonds < Covalent bonds

2) Explain **why** it is believed that the earliest life forms probably consisted of RNA, and not protein.

What function can RNA serve that proteins can't?

Replication; can copy itself by complementary template

What function can RNA serve that it was previously thought that ONLY proteins could accomplish?

Enzymes can be made of RNA.

3) Suppose that you had a chemical equilibrium in which A + B = C + D
If we started from a situation in which the concentrations of all 4 substances were in equilibrium with each other, and then we **added more of substance A**, then which of other 3 substances would increase in concentration and which would decrease? If in doubt, explain why.

Concentration of B would decrease ; concentrations of C and D would increase.

4) The chemical structure drawn below is pyruvic acid: **how would we need to change this structure to produce alanine** (remove what? and replace it by what?)

Replace the =O on the middle carbon by a NH_2

5) What is believed to be the **evolutionary origin of chloroplasts**?

Chloroplast evolved from commensal blue-green algae (procaryotes)

6) The ATP molecules that are used to transfer energy between chemical reactions can also be used for what other important function (that could not occur without ATP)?

-phosphate-ribose-phosphate-ribose-phosphate-ribose
a subunit in the **synthesis of RNA** adenine guanine cytosine

7) At a molecular level, what is meant by saying that one molecule recognizes another?
For example, when a hormone receptor recognizes its corresponding hormone.

They fit together because of complementary shapes of surfaces.

8) What effect, if any, do enzymes have on the ratio of concentrations of reactant versus product molecules at equilibrium? (e.g. if the reaction were A = B, and the concentration of B was 50 times the concentration of A with no enzyme present; when what would this ratio be with an enzyme present? HINT: What about the speed of approach to equilibrium?)

Enzymes do NOT change the ratio of concentrations at equilibrium; but can increase/speed up the rate at which equilibrium is reached

9) How can **phosphate** be used to cause temporary changes in the properties of enzymes or other cytoplasmic proteins?

Covalent binding of phosphates to serines in a protein can cause it to change configuration.

10) **On the back of this page, sketch an average human cell** (not an egg cell, nor nerve or anything special); include a couple of **mitochondria**, a few **ribosomes**, and draw in a **scale bar labeled in fractions of a meter**. For example 1/10,000 meter, or 1/1,000,000,000 meter or whatever is appropriate.

Sample exam

1) What would happen to a eucaryotic cell if it lost the genes for telomerases?

DNA sequences would gradually be lost at the ends of its chromosomes.

2) What happens to the energy of ATP molecules that bind to **myosin**? (what is it used for?)

"Used to drive active sliding along actin fibers" "To produce contraction of muscle" OK

3) What is the function of binding between **GTP**and the **ras** protein?

Causes temporary change in shape/conformation of the ras protein; which signals etc.

4) Briefly explain the special defining property of a **zinc finger** transcription factor.

A loop-shaped length of amino acid chain has one or more zinc ions attached between the two sides of the loop, which reinforces this protrusion, the function of which is to bind to DNA.

5) Think back to that video of the flourescent microtubules, in which the newt cells had been injected with fluorescently-labled subunits of microtubule proteins. The apparent thickness of the lines was a little less than half a micrometer, even though the real diameter of microtubules (seen by electron microscopy) is only about a fortieth of a micrometer. Explain why they looked as if they were so much thicker.*(hint, what if the microscope*

had had a lower numerical aperture)

Because of the maximum resolving power of light microscopes can only distinguish between objects that are about a fifth of a micrometer apart, things that are smaller than that are "blurred" by about a 5th or quarter micron, which makes things look about 0.4 or 0.5 wider than they actually are. *(regarding the hint; they don't have to give the answer to that part, but if they DO, then that part of the answer shoud be that reducing the NA would widen the fluorescent lines.*

6) What method might you use to separate proteins or other molecules based on differences in their **isoelectric points**? (Name the method, and briefly describe the mechanism.)

"Isoelectric focusing" : Put molecules in a gradient of pH=acidity
and then subject them to electrophoesis = a voltage gradient, with the positive electrode put at the more acidic end of the pH gradient;
Molecules will have zero net charge (only) when located in the part of the pH gradient where the pH is the same as their own isolectric point. At other locations, the pH will cause them to have whichever charge will cause them to be pulled toward this zero-charge location.

7) If an enzyme is **monomeric**, then sketch the graph describing % of enzyme bound to substrate as a function of substrate concentration.

8) What are **proteasomes**?

Multi-enzyme complexes in the cytoplasm that selectively digest proteins; break them down to amino acids.

9) What does it prove that cells can be put into tissue culture from carrots, eventually grown as individual cells, with whole carrot plants eventually being grown from such individual cells?

Those differentiated cells had all the genes; and by extension, differentiated cells in general have the complete set of genes.

10) Suppose that a protein binds to two different ligands, A and B; and suppose binding to A changes the shape of the protein in such a way that it then has a higher affinity for ligand B; then what can you be sure of about the effect of binding to B, in relation to the protein's affinity for A?

Can be sure that binding to B will increase the affinity for A.

Sample exam

1) Explain what would it mean if the amino acid sequence of a certain protein has two regions where there are about 20 or so leucines, valines and isoleucines in a row (with no hydrophillic amino acids among them) but lots of hydrophillic amino acids in other parts of the protein?

Would mean that this is an integral membrane protein,

and that those two regions pass through some membrane, either the plasma membrane or some other, from one side to the other.

2) How do integral membrane proteins "know" which of the different kinds of cellular membranes to become a part of? *(Hint: what part of their genes would have to be mutated in order to cause them to become part of the wrong kind of membrane?)*

Signal peptide(or sometimes "signal patch")

3) What is the function of of the protein named **clathrin**? (where does it become concentrated, and what effect does it have?)

Binds to the inner surface of the (plasma) membrane;
causes inward bending and formation of pinocytotic vesicles

4) What is the function of **symports**, and from what do they derive the energy to produce their effects?

Active transport of some particular kind of molecule through a (plasma) membrane (for example, perhaps a sugar)
The energy comes from allowing diffusion of some ion, perhaps sodium, diffusing down its diffusion gradient in the same direction as the sugar or other molecule is being pumped.

5) What process provides the energy to **ATP synthase** in mitochondria and chloroplasts?

Diffusion of hydrogen ions through membranes from high to low concentrations

6) Permeability of plasma membranes to what ion causes development of the resting potential? *(spell out the name, rather than just the symbol, please)*

Potassium

7) In order to propagate **ction potentials**, a cell's plasma membrane needs to contain channels that are gated" by (=open in response to) what?

Voltage (="electrical potential", would be equally correct)
half credit for "sodium concentration"

8) And what do these channels (in the previous queston) allow to diffuse through the plasma membrane?

Sodium ions;
calcium ions is often true, also So don't take off if they also say calcium. but only half credit if they only say "calcium" or only say "cations"

9) In photosynthesis, is fixation of carbon dioxide into sugars part of the "dark reactions" or not?
Explain briefly.

Yes, it is one of the dark reactions:
it uses energy from ATP (and NADPH), and can **continue in the dark**

10) What is the "**freeze cleaving**" technique?

An electron microscopy method for fixing cells by freezing and then breaking/cracking/cutting through the cells
and looking at the shape of the cracked/cut surfaces

Sample exam

1) What are two different mechanisms that electrical depolarization of one cell can be transmitted to a second cell? (in other words, two mechanisms of electrical communication between cells)

synaptic transmission=secretion of chemicals by one cell that cause opening of sodium, or other ion channels in the other cell
AND:
gap junctions, that allow free diffusion of ions & small molecules

2) Imagine dimers of tubulin self-assembling into microtubules. Later, these dimers will disassemble again into free tubulin. The question is, when these dimers eventually disassemble, at which end of the tubulin will this diassembly occur?
The same end? The opposite end? Sometimes one and sometimes the other?
sometimes one and sometimes the other

What names do you call these processes, in the two cases?
if same end-then called "dynamic instability" when opposite end called "treadmilling"

Can you give a **specific example** where in the cell, & during what process, each of these processes occur?

in interphase (non-mitotic cells) dynamic instability
in mitosis, kinetochore microtubules apparently undergo treadmilling

3) What is meant by the **start" checkpoint**?

between G2 and S periods of the cell cycle

And is a specific property of the cell that is "checked" at this checkpoint, to determine if the cell should go on to the next stage of the cell cycle?

check for damage to DNA
(also check volume of the cell)

4) What part of each chromosome becomes physically attached to the mitotic spindle?

The **kinetochore** *(how much credit for "centromere", instead?)*

5) What is the distinction between **mitosis** and **cytokinesis**?

mitosis moves the chromosomes apart , sometimes called "nuclear division"
cytokinesis is division of the cytoplasm into two parts, by constriction, or otherwise

6) If there were a mutation in the gene for collagen that caused substitutions of tyrosine in place of many of the repeated glycines, **how would this affect the protein's structure**?

It would not form the triple helix

7) To what protein does **E-cadherin**bind specifically? (outside the cell)

Other molecules of **E-cadherin**; in other words, it is homophillic

8) To which two other proteins does **fibronectin** bind selectively?
(hint: one ON the cell, and the other in the extracellular matrix)

Integrin Collagen (also fibrin, heparin, and some others)

9) What mechanisms are used by eggs to prevent fusion with more than one sperm?
(briefly describe two such mechanisms)

* electrical depolarization
* formation of fertilization membrane
* enzymatic digestion of binding sites for sperm.

10) What is an **acrosome**? And what cell type has an acrosome?

a sack of enzymes in sperm cells

Sample exam

1) The electrical voltage across the plasma membrane of an average animal cell is about
how many volts? (or fraction of a volt; decimals accepted) *(ONE POINT)*

ABOUT 70 MILLIVOLTS = 0.07 VOLTS OR 1/14TH OF A VOLT WOULD BE OK

Which side of which membrane is positive?

POSITIVE OUTSIDE (ONE POINT)

Diffusion of which ion causes this voltage?

POTASSIUM (ONE POINT)

2) How do **local anaesthetics** work?

THEY BLOCK SODIUM CHANNELS, SO NO ACTION POTENTIAL CAN OCCUR

4) What is meant by **chemiosmosis**? And what 3 places does it occur?

ENERGY COUPLING BY PUMPING IONS (HYDROGEN IONS, NEARLY ALWAYS) ACROSS A MEMBRANE, AND THEN USING THE RETURN DIFFUSION OF THESE IONS TO DRIVE ATP SYNTHESIS (TWO POINTS FOR WHAT IT IS)
MITOCHONDRIA; CHLOROPLASTS; PLASMA MEMBRANES OF PROCARYOTES
ONE POINT FOR WHERE IT OCCURS (THEY DON'T NEED TO SAY INNER MEMBRANE OF MITOCHONDRIA, OR THYLAKIOD MEMBRANES OF CHLOROPLASTS

5) In which 3 places is **DNA** found in eucaryotic cells?

NUCLEUS; MITOCHONDRIA; CHLOROPLASTS (ONE POINT EACH)

6) In **photosynthesis**, does the O_2 produced come from CO_2 or from H_2O, or both, or neither?

FROM THE H_2O

7) What kinds of organisms use **auxin**? (Indole acetic acid)

PLANTS *(ONE POINT)*

And **what function** do they use it for?

CONTROLLING CELL ENLARGEMENT *(ONE POINT)*
IN RELATION TO DIRECTION OF GRAVITY AND LIGHT
(ONE POINT)

8) In "**rough endoplasmic reticulum**" what has caused the ribosomes to attach to membranes of the endoplasmic reticulum?

SIGNAL PEPTIDES

9) What are "**clathrin triskelions**" and what function do they serve?

THEY ARE A CERTAIN KIND OF PROTEIN; FUNCTION IS INWARD BENDING OF PLASMA MEMBRANE IN SOME FORMS OF PINOCYTOSIS

10) If you know the amino acid sequence of a certain protein, by what criteria could you estimate **hether it is a transmembrane protein**?

IF THE AMINO ACID SEQUENCE CONTAINS REGIONS OF ABOUT 20 AMINO ACIDS IN A ROW, ALL OF WHICH ARE HYDROPHOBIC.

11) What is the relationship (and the distinction) between "**cytosol**" and "**cytoplasm**"?

CYTOSOL IS THE FLUID IN CELLS THAT IS NOT ENCLOSED BY THE NUCLEUS, MITOCHONDRIA, ER, CHLOROPLASTS OR OTHER ORGANELLES "CYTOPLASM" WOULD

INCLUDE THE VARIOUS ORGANELLES, TOO (EXCEPT THE NUCLEUS, PROBABLY; BUT DON'T MIND THAT)

12) **Aspirin** and **ibuprofen** reduce pain and inflammation by selectively inhibiting an enzyme needed for the synthesis of what?

PROSTAGLANDIN, AND OTHER EICOSANOIDS (EXCEPT NOT LEUCOTRIENES) BUT LETS GIVE FULL CREDIT EITHER FOR EICOSANOIDS OR ANY SPECIFIC ONE.

13) What role does **sensory adaptation** serve in the type of **chemotaxis used by bacteria** to move to and remain concentrated in areas where there are more food molecules?

BACTERIA KEEP SWIMMING IN STRAIGHT LINES SO LONG AS THEY DETECT INCREASING CONCENTRATIONS OF THE ATTRACTANT CHEMICAL

14) What is the distinction between "**treadmilling**" as opposed to "**dynamic instability**" in cytoskeletal protein fibers?

IN TREADMILLING: SUBUNITS (OF ACTIN OR TUBULIN) ASSEMBLE ON TO ONE END OF FIBERS, AND DISASSEMBLE OFF OF THE OTHER END(ONE POINT) IN DYNAMIC INSTABILITY, SUBUNITS ASSEMBLE ON ONE END, THEN DISASSEMBLE FROM THAT SAME END.*(ONE POINT)*P>

What is the source of the energy that drives both of these processes?

HYDROLYSIS OF ATP OR GTP *(ONE POINT)*P>

15) If a cell's "start" **checkpoint mechanism** is abnormal and defective, how might that contribute to the cells being cancerous?

GROW AND DIVIDE WITHOUT CONTROL *(TWO POINTS)*

How could these same defects also make such a cell more susceptible to being killed by cancer chemotherapy?

WILL NOT DELAY S-PERIOD OF CELL CYCLE UNTIL DNA DAMAGE HAS BEEN REPAIRED, THEREBY CAUSING EVEN WORSE DAMAGE TO DNA (ONE POINT)

16) What happens to **cyclin** proteins, just after they have accumulated to a sufficient concentration to initiate the next stage of the cell cycle?

THEY ARE BROKEN DOWN INTO AMINO ACIDS = "PROTEOLYSIS" BUT TAKE OFF ONE OR TWO POINTS IF THAY SEEM TO THINK THAT THIS BREAKDOWN IS JUST A MATTER OF SEPARATION OF PROTEINS FROM EACH OTHER.

17) What do **cyclic GMP**, **calcium ions**, and **diacylglycerol** have in common (in terms of function)?

"SECOND MESSENGERS" *I ACTUALLY GAVE FULL CREDIT FOR "INTRACELLULAR SIGNALLING"*

18) Can you resolve shorter distances with light microscopes using red light, or blue light?

BLUE LIGHT (ONE POINT)

What distances can be resolved using red light? Blue light? (Please state these distances in terms of nanometers)

ABOUT 0.3 OR 0.35 FOR RED LIGHT (ONE POINT) AND ABOUT 0.2 FOR BLUE LIGHT (ONE POINT)

19) Briefly describe the mechanism that creates the parts of the **antibody genes** that code for the binding sites of antibody proteins.

SPLICING OF SHORT LENGTHS OF DNA (V, D AND J REGIONS; BUT THIS TERMINOLOGY ISN'T NECESSARY IF THEY SEEM TO UNDERSTAND THE CONCEPT) I TOOK AWAY THE WHOLE 3 POINTS FOR ONE EXAM THAT SAID "RECOMBINATION AT THE SYNAPTONEMAL COMPLEX" SINCE IT'S NOT THAT KIND OF RECOMBINATION

20) What is an **autoimmune disease**? (in the sense of what goes wrong, and why the patient is sick)

What are **two specific examples of autoimmune diseases**?

21) What is the function of **telomerase**(enzyme)?

22) To which 3 amino acids are phosphates sometimes covalently bound? (Name them)

What structural feature do these amino acids have in common (that allows attachment of phosphates?)

23) How is **ATP** related to RNA synthesis?

24) What is meant by an **allosteric protein**?

And what are "**allosteric transitions**"?

25) What are **hox genes**? And do people have any of them?

26) Some kinds of **viruses** have genes very similar in structure and effect to the human **oncogene bcl-2: what advantage does this gene confer on such viruses**?

27) What is **neurulation**?

And **what does it subdivide** into two parts (actually 3 parts but you don't know about the third)

28) What is a **neural projection**; and what is a specific example?

29) What is different about the **time of meiosis** in **eggs** as compared with **sperm**?

30) Compare **eucaryote flagella** and cilia with **bacterial flagella**.

(Both in structure and the origin of their driving force.)

31) Please draw the chemical structures of any 4 amino acids (your choice) and include the name of each one that you draw.

32) Suppose that you had some tissue culture cells that were cancerous in behavior and come other tissue culture cells that were normal (non-cancerous), and suppose that you fused these cells with each other to produce cells containing one complete set of chromosomes from each kind of cell. The resulting cells sometimes turn out to be cancerous in behavior, but usually are not cancerous. **Use your knowledge of oncogenes to explain whether you are or are not surprised by this result** *(Carry over onto the back of this page; or as many pages as you want)*

33) What do embryologists mean by "**primordial germ cells**"?

34) How many different kinds of membranes can you list (taking the example of a eucaryotic plant cell) *(Carry over onto the back of this page; or as many pages as you want)*