

4/8/10

Biology 2120
Spring 2010
Midterm Exam #2

Section 2

Name (printed):

Recitation day/time: Wed 1:00pm

This exam contains 10 pages, *plus the multiple choice bubble sheet*. Please verify that you have all pages.

1. Write your name on both this exam *and* on the bubble sheet (fill in the bubbles for your name)
2. Write the *color* of your exam paper on the top edge of the bubble sheet
3. Answer all questions, using only the space available for the drawings/short answer section (part II).
4. 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.
5. 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):

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

☒ 1. An important difference between carrier protein-mediated diffusion and channel-mediated diffusion is:

- a. Carrier protein-mediated diffusion dissipates gradients, channel-mediated diffusion builds gradients.
- b. Carrier protein-mediated diffusion transports ions, channel-mediated diffusion transports sugars.
- c. Carrier protein-mediated diffusion is saturable, channel-mediated diffusion is not saturable.
- d. Carrier protein-mediated diffusion occurs in epithelial cells, channel-mediated diffusion occurs in all cells.
- e. Carrier protein-mediated diffusion cleaves ATP, channel-mediated diffusion does not cleave ATP.

☒ 2. Which statement most accurately defines the extracellular matrix (ECM)?

- a. The ECM consists of integrins and the proteins they bind to in the extracellular space.
- b. The ECM consists of bone, cartilage, and other connective tissues in the extracellular space.
- c. The ECM consists of insoluble glycoproteins and proteoglycans in the extracellular space.
- d. The ECM consists of integrins, cadherins, and their ligands in the extracellular space.
- e. The ECM consists of collagens, fibronectins, elastin, and laminins in the extracellular space.

☒ 3. Proteoglycans are especially abundant in articular cartilage (e.g., in the shoulder, hip, knee) because:

- a. Proteoglycans act as "glue" that hold bones and tendons together.
- b. Proteoglycans help cells resist compressive force by attracting water.
- c. Proteoglycans usually contain more sugar than protein.
- d. Proteoglycans do not bind integrins or cadherins, so cells can slide through them.
- e. Proteoglycans are held together by hydrophilic bonds.

☒ 4. What is the function of aminoacyl-tRNA synthetase?

- a. It adds 7-methylguanosine to tRNA.
- b. It synthesizes tRNA.
- c. It proofreads synthesis of tRNA.
- d. It removes pyrophosphate from tRNA.
- e. It adds an amino acid to tRNA.

✓ 5. Elastin is elastic because:

- ☐ a. Under no stress, it forms a triple coiled coil structure; when stress is applied, the triple coiled coil unwinds. When the stress is released, the triple coiled coil spontaneously reforms.
- ☐ b. Under no stress, it is hydrophilic; when stress is applied, it becomes hydrophobic. When the stress is released, it becomes hydrophilic again.
- ☐ c. Under no stress, it forms crossbridges between collagen and fibronectin; when stress is applied, these crossbridges break. When the stress is released, the crossbridges spontaneously reform.
- ☒ d. Under no stress, it forms a globular protein held together by hydrophobic bonds; when stress is applied, these hydrophobic bonds break, and the protein elongates. When the stress is released, the hydrophobic bonds reform, collapsing the elongated protein in a globule.
- ☐ e. Under no stress, elastin forms multimeric proteins with quaternary structure; when stress is applied, the quaternary structure collapses. When the stress is released, the quaternary structure spontaneously reforms.

✓ 6. Which portion of an integrin subunit is contained in the lumen of the endoplasmic reticulum?

- ☐ a. The amino terminus, because the amino terminal signal sequence is cleaved by signal peptidase.
- ☐ b. The carboxy terminus, because the carboxy terminal signal sequence is cleaved by signal peptidase.
- ☐ c. The amino terminus, because the carboxy terminal signal sequence is cleaved by signal peptidase.
- ☐ d. The carboxy terminus, because the amino terminal signal sequence is cleaved by signal peptidase.
- ☒ e. The amino terminus, because the carboxy terminal signal sequence is not cleaved by signal peptidase.

★ 7. Which statement most accurately describes the difference between tight junctions and gap junctions?

- ☐ a. Tight junctions transfer sugars between adjacent epithelial cells; gap junctions transfer ions between adjacent epithelial cells.
- ☒ b. Tight junctions keep the contents of the intestine on the apical membrane of adjacent intestinal epithelial cells; gap junctions link adjacent intestinal epithelial cells together via cadherins.
- ☐ c. Tight junctions are formed by secreted proteoglycans located between adjacent epithelial cells; gap junctions are formed by intermediate filaments that link adjacent epithelial cells together.
- ☐ d. Tight junctions are only formed by adjacent epithelial cells, gap junctions are formed by all eukaryotic cells.
- ☐ e. Tight junctions block the transport of most extracellular materials between adjacent epithelial cells; gap junctions allow direct transfer of intracellular materials between adjacent epithelial cells.

✓ 8. What property is shared by desmosomes and hemidesmosomes?

- ☐ a. They both bind extracellular matrix proteins.
- ☐ b. They both contain integrins.
- ☒ c. They both bind to intermediate filaments.
- ☐ d. They both bind to actin filaments.
- ☐ e. They both bind to kinesin.

✓ 9. In vitro (cell culture), cells from some patients with I-cell disease can be "rescued" (restored to normal phenotype) by adding normal lysosomal enzymes to the culture medium. However, this treatment does not eliminate inclusions in cells from other I-cell patients. Which statement best explains this discrepancy?

- ☒ a. Cells that respond to the added enzymes have functional SRP receptors but faulty signal peptidase; cells that do not respond have functional mannose-6-phosphate receptors but faulty endosome proton pumps.
- ☐ b. Cells that respond to the added enzymes have functional signal peptidase but faulty t-SNAREs; cells that do not respond have functional COPI proteins but faulty COPII proteins.
- ☐ c. Cells that respond to the added enzymes have functional kinesins but faulty dyneins; cells that do not respond have functional acid hydrolases but faulty TGN sorting proteins.
- ☒ d. Cells that respond to the added enzymes have functional endosome proton pumps but faulty lysosomal enzymes; cells that do not respond have functional endosome proton pumps but faulty mannose-6-phosphate receptors.
- ☐ e. Cells that respond to the added enzymes have functional integrins but faulty intermediate filaments; cells that do not respond have functional integrins but faulty actin filaments.

The following two questions refer to Figure 1. A common form of blindness in the elderly is called age-related macular degeneration (AMD). One of the major problems in AMD patients is that a critical part of the eye called the retinal pigment epithelium (RPE) detaches from its underlying basal lamina, also called "Bruch's membrane" or the "basement membrane." The following is taken from the summary of a research article published in 2009 in *Experimental Eye Research*:

"Transplantation of retinal pigment epithelium (RPE) has been attempted in patients with age-related macular degeneration (AMD). However, inability of transplanted RPE to initially attach and subsequently proliferate on the basal lamina (Bruch's membrane) may lead to failure of RPE transplants and poor visual outcomes. Integrin $\alpha(6)\beta(4)$ functions as a receptor for laminin, the major component of Bruch's membrane, and mediates the stable attachment of most epithelial cells to the underlying basement membrane. To improve adhesion and proliferation of transplanted RPE on Bruch's membrane, we investigated whether transfer of the genes for integrin $\alpha(6)$ and $\beta(4)$ in RPE could promote adhesion and proliferation of transplanted RPE on Bruch's membrane... Modification of integrin expression by transfection of these integrin genes into RPE cells induced a significant increase in cell adhesion to laminin."

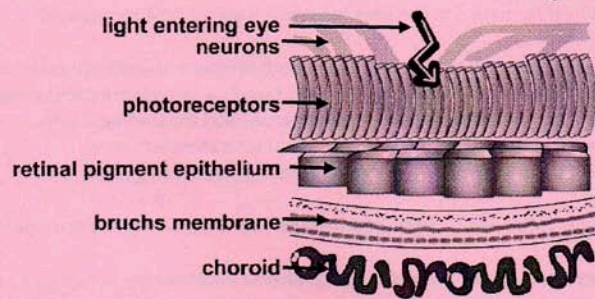


Figure 1. A cross-sectional drawing of the macula.

10. Which structure was most likely being repaired in this experiment?

- a. The basal lamina
- ☒ b. The hemidesmosome
- c. The gap junction
- d. The tight junction
- e. The desmosome

11. When the RPE cells detach from the Bruch's membrane, they remain attached to each other, and peel off as a sheet of cells. This suggests that:

- ☒ a. The tight junctions and/or adhesion belts remain functional during AMD.
- b. Focal adhesions and/or hemidesmosomes remain functional during AMD.
- c. The Na^+/K^+ ATPase is no longer functional, but the $\text{Na}^+/\text{glucose}$ symporter remains functional during AMD.
- d. Protein targeting to the plasma membrane remains functional, but protein targeting to the peroxisome is no longer functional during AMD.
- e. Kinesin and dynein are functional, but myosin is no longer functional during AMD.

12. Consider the following statements:

- i. The origin of replication is the site where transcription of a gene begins.
- ☒ ii. The basal transcription complex binds to the promoter of a gene.
- iii. RNA polymerase is phosphorylated by TFIIH, DNA polymerase is not.
- ☒ iv. The DNA replication fork contains two DNA polymerase enzymes.
- v. The pre-initiation complex on DNA establishes whether a gene will be transcribed or not.

Which of these are true?

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

✓ 13. Why is formation of the DNA loop necessary for DNA replication?

- ☒ a. The loop ensures that replication of both template strands can occur simultaneously as the replication bubble expands.
- ☐ b. The loop orients primase so that both template strands are primed simultaneously.
- ☐ c. The loop permits DNA polymerase to proofread the leading strand.
- ☐ d. The loop determines where the pre-initiation complex forms.
- ☐ e. The loop releases the negative supercoiling caused by gyrase.

✓ 14. What is the role of acidic hydrolases in the endomembrane system?

- ☐ a. They direct proton pumps to endosomes and lysosomes.
- ☐ b. They recycle mannose-6-phosphate receptors between the endosome and the TGN.
- ☐ c. They capture mannose-6-phosphate tagged proteins in the extracellular space.
- ☐ d. They cleave the signal sequence from proteins translocated into the ER lumen.
- ☒ e. They digest material in the acidic environment created by proton pumps.

✓ 15. Dolly the sheep was famous because she was the first mammal to be cloned from an *adult* cell (a mammary epithelial cell). But she died much earlier than normal sheep. After her death, the research group that created her published an article entitled "Analysis of Telomere Length in Dolly, a Sheep Derived by Nuclear Transfer." What do you think they learned?

- ☒ a. Dolly's cells had high levels of DNA polymerase, but not of telomerase.
- ☒ b. Dolly's cells had shorter telomeres than other sheep of the same age, but normal levels of DNA polymerase.
- ☐ c. Dolly's cells had longer telomeres than sheep of the same age, and high levels of DNA polymerase.
- ☐ d. Dolly's cells had high levels of telomerase, but not of DNA polymerase.
- ☐ e. Dolly's cells had low levels of DNA polymerase, and longer telomeres than other sheep of the same age.

✓ 16. Which of the following proteins must pass through the nuclear pore complex before it functions properly?

- ☐ a. SRP receptor
- ☐ b. Mannose-6-phosphate receptor
- ☒ c. Single stranded binding protein
- ☐ d. Aminoacyl tRNA synthetase
- ☐ e. Na^+/K^+ ATPase

✓ 17. Which statement best describes the hypothesis that motivated the study by Hiesberger et al., which you discussed during recitation module 2-3?

- ☐ a. Because saposins facilitate the access of the lysosomal enzymes to their substrates by lifting the latter out of the lipid bilayer of the membrane, they hypothesize that a major fraction of the newly synthesized saposin precursor is secreted from the cell and is then reinternalized by high-affinity cell surface receptors.
- ☒ b. Because cells deficient in the mannose-6-phosphate receptor continue to efficiently internalize saposin precursor, they hypothesize that low density lipoprotein receptor-related protein (LRP) is involved in the cellular re-uptake of secreted saposin.
- ☐ c. Because the low density lipoprotein receptor-related protein (LRP) mediates the major fraction of the cellular uptake of saposin precursor, they hypothesize that chloroquine will inhibit saposin uptake.
- ☐ d. Because total saposin precursor deficiency has been described in humans resulting in death during fetal development or early childhood, they hypothesize that a major fraction of the newly synthesized polypeptide is secreted from the cell and is then reinternalized by high-affinity cell surface receptors.
- ☒ e. Because the saposin precursor can be recognized by the mannose-6-phosphate receptor and shuttled directly from the secretory pathway to the lysosome, they hypothesize that the mannose-6-phosphate receptor is mediating this trafficking event.

18. In a logical argument, what is a *premise*?

- a. A fact supported by at least two theories.
- b. A conclusion based on the evidence presented in an argument.
- c. A proposition that leads to a conclusion.
- d. An explanation for at least one unexplained fact.
- e. A summary of at least one data point in a research article.

19. Which statement best describes the 7-methylguanosine cap?

- a. It is a modified nucleotide that is attached to primary transcript RNA at the intron/exon boundary.
- b. It is a modified nucleotide added to the 3' end of telomeres.
- c. It is a modified nucleotide that forms the primer for RNA polymerase.
- d. It is a modified nucleotide that converts the 3' end of a primary transcript RNA into a modified 5' end.
- e. It is a modified nucleotide that converts the 5' end of a primary transcript RNA into a modified 3' end.

20. What property distinguishes TFIIE and TFIIH from other transcription factors we have discussed?

- a. They separate double stranded DNA into two single strands.
- b. They bind to prokaryotic and eukaryotic promoters.
- c. They bind gyrase to RNA polymerase.
- d. They phosphorylate DNA polymerase.
- e. They bind initiator tRNA.

21. Which statement best describes the peptidyl transferase function of a ribosome?

- a. It moves aminoacyl tRNA from the A site to the P site.
- b. It transfers amino acids from the P site to the E site.
- c. It adds the growing polypeptide to the aminoacyl tRNA.
- d. It adds a peptidyl tRNA to the aminoacyl mRNA.
- e. It adds water to the final amino acid in a polypeptide.

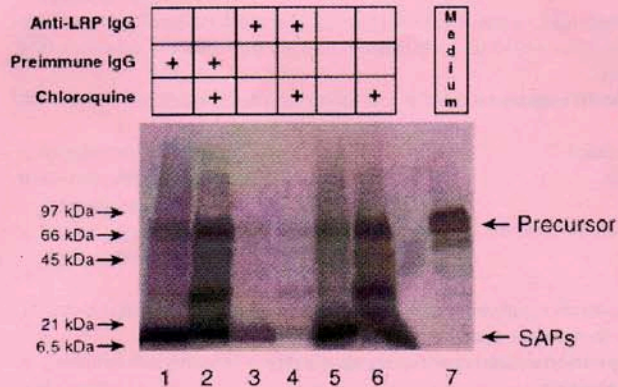


Figure 2, taken from the article discussed in module 2-3.

22. Which statement is supported by the data in Figure 2?

- a. The LRP requires chloroquine to convert precursors to SAPs.
- b. In the absence of chloroquine and presence of negative control antibodies (preimmune IgG), precursors are converted to SAPs.
- c. Anti-LRP antibodies have the same, identical effect as chloroquine: both promote the conversion of precursors to SAPs.
- d. Negative control antibodies (preimmune IgG) are more efficient than chloroquine in stimulating conversion of precursors to SAPs.
- e. Mannose-6-phosphate receptors capture precursor proteins in culture medium and stimulate their conversion to SAPs.

23. What would happen if a cell had mutated COPI proteins?

- a. ER proteins that were accidentally carried to the Golgi complex would not return to the ER.
- b. Mannose-6-phosphate would not be attached to proteins.
- c. Anaphase A would cease before anaphase B begins.
- d. Cells would develop inclusions like those seen in I-cell disease.
- e. The mitotic spindle would collapse.

G → ER

24. Which of the following events occurs during Anaphase B?

- i. Contraction of the cortical actin cytoskeleton
- ii. Shortening of kinetochore microtubules.
- iii. Shortening of astral microtubules.
- iv. Lengthening of polar microtubules.
- v. Activation of "weird kinesin"

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

25. In lecture, we discussed cotranslational passage of proteins across a membrane as one mechanism of targeting proteins in a cell. What else occurs in this mechanism?

- a. SRP binds the ribosome receptor
- b. Importin binds the NTS
- c. Transit peptidase cleaves the amino terminus of the targeted protein
- d. The translocon channel opens
- e. hsp70 cleaves GTP

26. Why does chloroquine inhibit the endocytosis pathway of the endomembrane system?

- a. Because it prevents the attachment of mannose-6-phosphate to lysosomal proteins.
- b. Because it inhibits vesicular traffic between the ER and Golgi.
- c. Because it prevents activation of acid hydrolases
- d. Because it depolymerizes microtubules.
- e. Because it raises the pH of the cytosol.

27. What function does the SRP receptor have in protein targeting?

- a. It ensures that proteins enter mitochondria in an unfolded state.
- b. It reactivates protein synthesis once a ribosome attaches to the ER membrane.
- c. It forms a channel that permits proteins to enter peroxisomes.
- d. It helps proteins that enter chloroplasts fold into their proper shape.
- e. It inhibits protein synthesis in ribosomes not attached to the ER.

28. How are experiments, hypotheses, logical arguments, and premises linked?

- a. Experiments prove premises, arguments state hypotheses.
- b. Experiments support premises, premises yield arguments, arguments support or reject hypotheses.
- c. Premises prove experiments, experiments define arguments, arguments support or reject hypotheses.
- d. Hypotheses define premises, premises define experiments, experiments support or reject arguments.
- e. Arguments define hypotheses, premises support or reject experiments.

29. Recently, a t-SNARE was found in the outer membrane of mitochondria of a cell. What are the implications of this finding?

- a. This suggests that mitochondria digest mannose-6-phosphate tagged proteins.
- b. This suggests that kinesin transports vesicles from the plasma membrane to mitochondria.
- c. This suggests that vesicles budding from the Golgi fuse with mitochondria.
- d. This suggests that mitochondria are descendants of prokaryotes that were secreted into the extracellular space
- e. This suggests that SRP binds to mitochondrial proteins.

✓ 30. Choose the proper temporal sequence of events taking place for formation of a lysosome (first→ last).

- ☐ a. Fusion of Golgi and plasma membrane vesicles, acidification of endosomes, binding of mannose-6-phosphate receptors to their ligands.
- ☐ b. Translocation of hydrolytic enzymes, acidification of lysosomes, dissociation of mannose-6-phosphate receptors from their ligands.
- ☐ c. Synthesis of acidic hydrolases, activation of these acidic hydrolases, phosphorylation of mannose.
- ☐ d. Unfolding of acidic hydrolases, binding of hsp70 to these hydrolases, acidification of lysosomes
- ☒ e. Budding of vesicles from the trans Golgi network, dissociation of mannose-6-phosphate receptors from their ligands, activation of acidic hydrolases.

✓ 31. Which statement best describes how the adhesion belt helps form the notochord in developing vertebrates?

- ☐ a. It causes the apical domain of the plasma membrane of epithelial cells to constrict.
- ☐ b. It causes tight junctions in epithelial cells to relax (loosen).
- ☐ c. It causes integrins to form focal adhesions in epithelial cells.
- ☐ d. It causes hemidesmosomes in epithelial cells to release the ECM
- ☐ e. It increases the amount of Na⁺/glucose symporters to increase in the apical domain of the plasma membrane of epithelial cells.

✓ 32. Which statement best describes the difference between direct active transport and indirect active transport?

- ☐ a. Direct active transport takes place on the plasma membrane, indirect active transport takes place in lysosomes.
- ☐ b. Direct active transport builds concentration gradients, indirect active transport does not.
- ☐ c. Direct active transport acidifies organelles, indirect active transport acidifies mitochondria.
- ☒ d. Direct active transport requires cleavage of high energy compounds like ATP, indirect active transport does not.
- ☐ e. Direct active transport is used by eukaryotic cells, indirect active transport is used by prokaryotic cells.

✓ 33. Select the one activity where dynein does not play a role:

- ☐ a. Separation of spindle poles during anaphase B
- ☐ b. Compaction of the Golgi complex near the centrosome (MTOC).
- ☐ c. Endocytosis of acid hydrolases
- ☐ d. Transport of vesicles from the cis Golgi network to the endoplasmic reticulum
- ☒ e. Transport of proteins into the nucleoplasm (interior of the nucleus).

✓ 34. Transport of protons into the endosome is an example of:

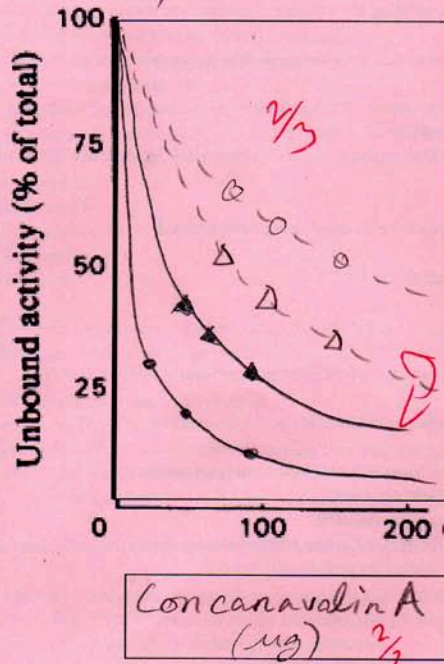
- ☐ a. Simple diffusion
- ☐ b. Carrier protein-mediated diffusion
- ☐ c. Channel-mediated diffusion
- ☐ d. Indirect active transport
- ☒ e. Direct active transport

✓ 35. What function does hsp60 have in protein targeting?

- ☐ a. It ensures that proteins enter mitochondria in an unfolded state.
- ☐ b. It reactivates protein synthesis once a ribosome attaches to the ER membrane.
- ☐ c. It forms a channel that permits proteins to enter peroxisomes.
- ☒ d. It helps proteins that enter chloroplasts fold into their proper shape.
- ☐ e. It inhibits protein synthesis in ribosomes not attached to the ER.

Part II. (7 points each)

c) α -glucosidase



1.

A. Draw the data that appear in Figure 1 of the Rousson et al. paper discussed in module 2-2 in recitation.

B. In the space at right of the graph, indicate what each of your entries in the graph represents (i.e., add labels to your data).

C. Add a label to the X axis in the box.

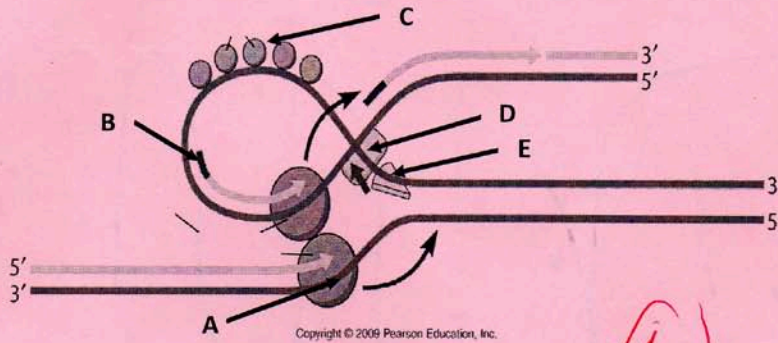
- (•, ○) control group from normal cells
(▲, △) experimental group from cells of I-cell patients (mucopolipidosis II)
(—) before treatment of neuraminidase
(---) after treatment of neuraminidase

2. Complete the table by indicating where each event takes place in the endomembrane system. Some events may take place in more than one location.

Event	Location(s)
M6P receptor binding to cargo	trans golgi network, plasma membrane
Acidification of organelle	late endosome (lysosome)
Cleavage of signal sequence	ER [membrane]
Formation of COPI-coated vesicle	golgi network
Glycosylation of dolichol	ER [membrane]

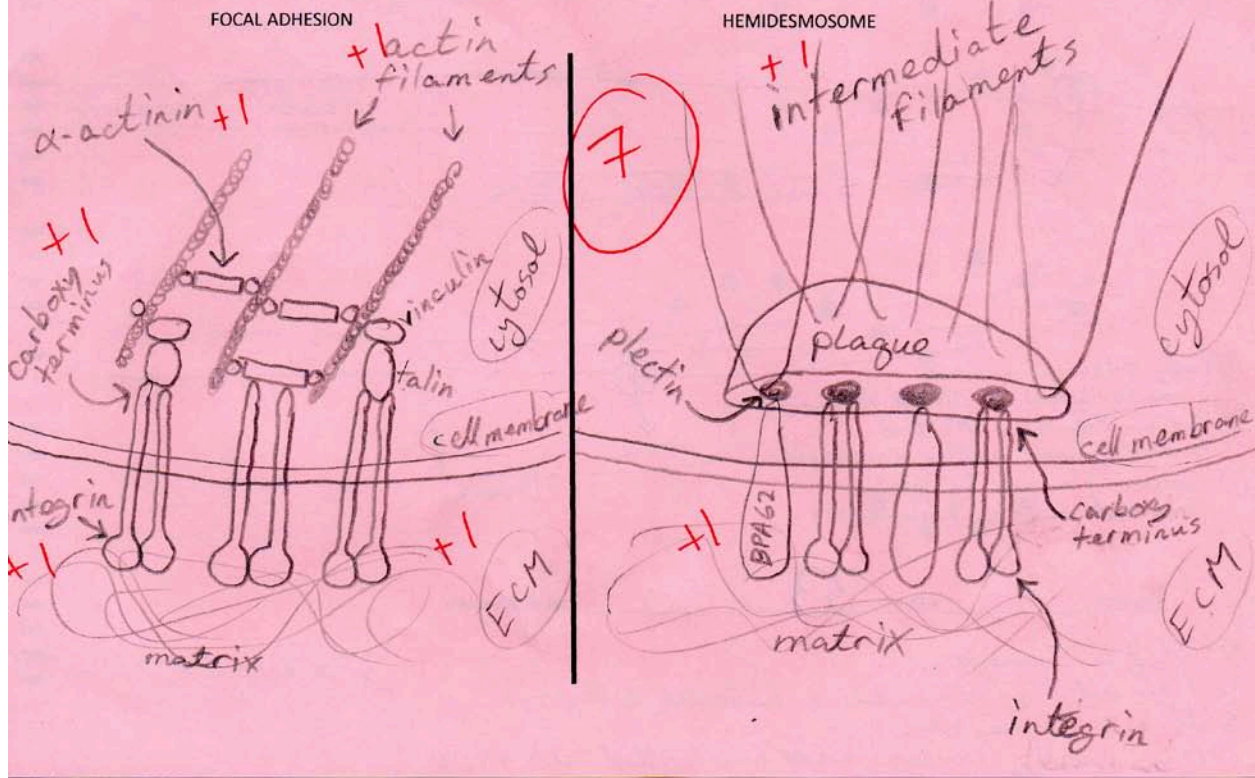
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3. Match the activities listed below with the locations indicated in the figure.

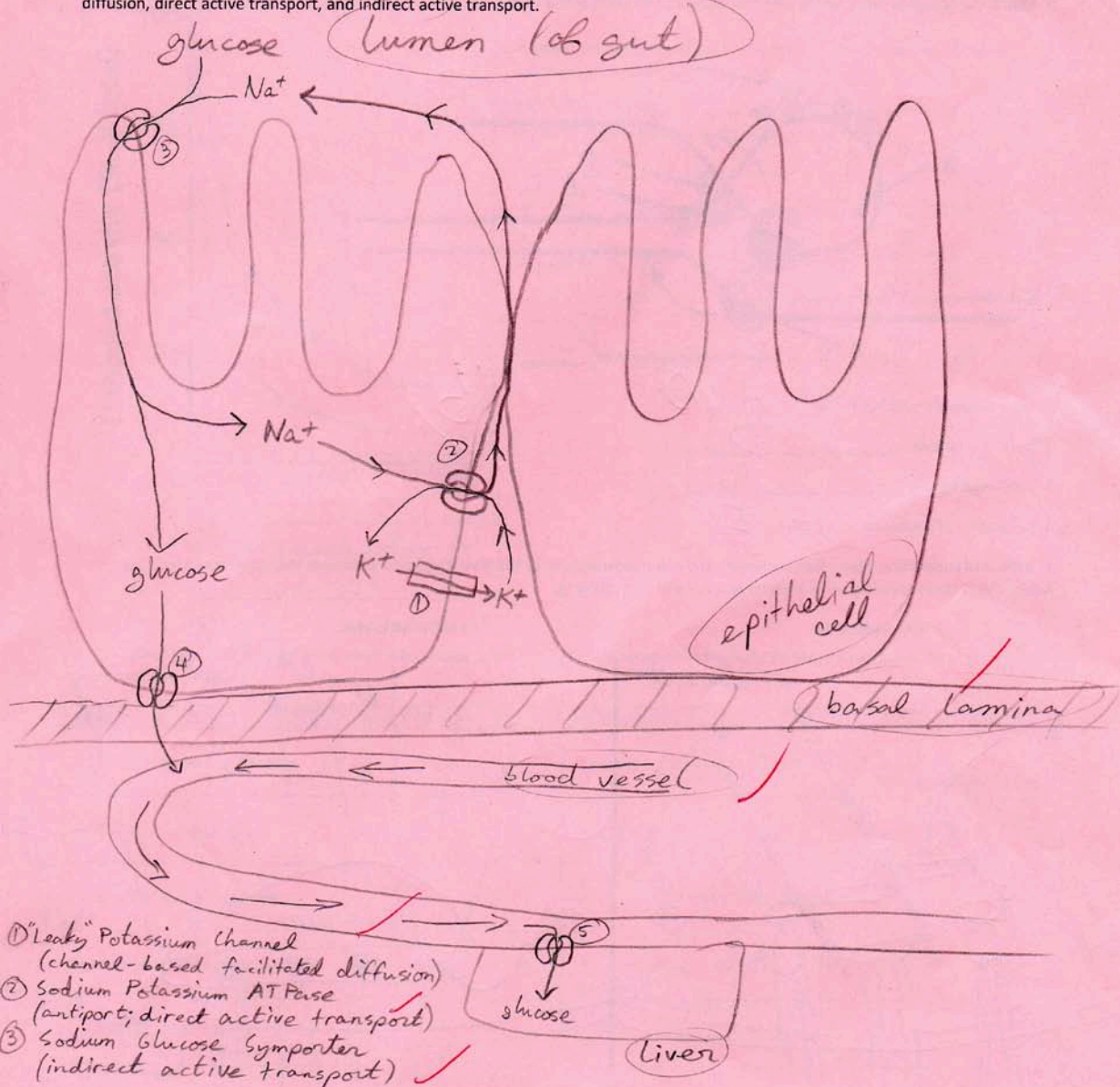


1. Generation of pyrophosphate: A ~~10~~
2. Synthesis of RNA: D
3. Proofreading: A
4. Separation of double stranded DNA: E

4. Draw and completely label a focal adhesion and a hemidesmosome at the level discussed in lecture. Use an arrow to indicate where the carboxy terminal of an integrin is located in your drawing.



5. Diagram how glucose passes from the intestinal lumen through the gut epithelial cell and into the liver. Label all molecules/structures necessary, and indicate any steps that perform channel-based facilitated diffusion, carrier-based facilitated diffusion, direct active transport, and indirect active transport.



Score: Pt I 33 + Pt II 33 = 66 out of 70 points

- ④ GLUT2 Transporter (low affinity; carrier-based facilitated diffusion).
⑤ GLUT2 Transporter (low affinity; carrier-based facilitated diffusion)

$$33 + 34 = 67 / 70 = 96\%$$