

# BIO1140 Introduction to Cell Biology

Professor: Dr. Caroline Petit-Turcotte

## Midterm Exam 2 – Version B: Monday March 19<sup>th</sup>, 2018

PLEASE DO NOT OPEN EXAMS UNTIL YOU ARE INSTRUCTED TO DO SO.

MAKE SURE YOU HAVE A COMPLETE EXAM PACKAGE – 1 QUESTIONNAIRE (14 PAGES) AND 1 SCANTRON SHEET

General Instructions:

1. This exam is worth 12.5% of your final mark.
2. You will have 1 hour and 15 minutes (**75 minutes**) to write the exam.
3. Write your name and student number within the spaces provided on **all 14 pages**.
4. You should only have writing material and this exam on your desk, nothing else.
5. When you have finished, you may return your exam and leave the room.

Part A Instructions (20 marks): Multiple Choice.

1. **Use pencil.** On the Scantron, write down your exam version code (**BIO1140 B**) in the course code field. Also write your student number and name, and be sure to fill in the bubbles accordingly.
2. Indicate only one answer for each of the 20 multiple choice questions, directly on the computer scan sheet (**Scantron**). *Do not attempt to change an answer if you use ink.* This will be recorded as 'incorrect'. You will need a new scan sheet.
3. **Please transfer all your answers to the Scantron sheet prior to the end of the exam.** You will not be given extra time to do so and the proctors will not do it for you. **Only the Scantron will be marked.**
4. Follow instructions on the computer scan sheet.

Part B Instructions (45 marks): Long Answers.

1. You may write in ink or in pencil. If you choose to answer in pencil, a marking review may not be awarded and is at the discretion of the professor or course coordinator.
2. Please provide a written answer for all questions **within the space provided**. You may use point form as long as these points are clear and complete.
3. Marks will not be given for irrelevant or illegible writing. Organize your thoughts carefully.
4. You may use a diagram as an aid, but **a diagram alone will not constitute a complete answer.**

***Cellular phones, unauthorized electronic devices or course notes are not allowed during this exam. Phones and devices must be turned off and put away in your bag. Do not keep them in your possession, such as in your pockets. If caught with such a device or document, the following may occur: You will be asked to leave immediately the exam, academic fraud allegations will be filed which may result in you obtaining a 0 (zero) for the exam.***

***By signing below, you acknowledge that you have ensured that you are complying with the above statements and instructions.***

Student Name:   **MARKING SCHEME**   / Signature: \_\_\_\_\_

Student Number: \_\_\_\_\_

Section B Student number: \_\_\_\_\_

**Section A – Multiple Choice Questions (20 questions – 1 mark each)**

**Please transfer your answers, in pencil, to the Scantron sheet provided – we will not transfer answers and will not grade the exam questionnaire for this section.**

1. This is a question for pedagogical research purposes only and you will get 1 mark regardless of your answer. ***Please answer it honestly.*** Thank you.

For this exam I feel I am:

- a) Better prepared than for the 1<sup>st</sup> midterm
- b) Prepared the same as for the 1<sup>st</sup> midterm
- c) Not as well prepared as for the 1<sup>st</sup> midterm
- d) I did not write the 1<sup>st</sup> midterm

2. Which of the following is found in both animal and plant cells?

- a) Central vacuole
- b) Mitochondria**
- c) Chloroplasts
- d) None of the above

3) Which of the following is a statement of the first law of thermodynamics?

- a) Energy cannot be created or destroyed.**
- b) The entropy of the universe is decreasing.
- c) The entropy of the universe is constant.
- d) Kinetic energy is stored energy that results from the specific arrangement of matter.
- e) Energy cannot be transferred or transformed.

4) The active site of an enzyme is the region that

- a) binds allosteric regulators of the enzyme.
- b) is involved in the catalytic reaction of the enzyme.**
- c) binds noncompetitive inhibitors of the enzyme.
- d) is inhibited by the presence of a coenzyme or a cofactor.

5) The molecule that functions as the reducing agent (electron donor) in a redox or oxidation-reduction reaction

- a) gains electrons and gains potential energy.
- b) loses electrons and loses potential energy.
- c) gains electrons and loses potential energy.
- d) loses electrons and gains potential energy.
- e) neither gains nor loses electrons, but gains or loses potential energy.

6) Where does the citric acid cycle take place in eukaryotic cells?

- a) mitochondrial matrix
- b) mitochondrial outer membrane
- c) mitochondrial inner membrane
- d) mitochondrial intermembrane space
- e) cytosol

7) Substrate-level phosphorylation accounts for approximately what percentage of the ATP formed by the reactions of glycolysis?

- a) 0%
- b) 2%
- c) 10%
- d) 38%
- e) 100%

8) Energy released by the electron transport chain is used to pump  $H^+$  into which location in eukaryotic cells?

- a) cytosol
- b) mitochondrial outer membrane
- c) mitochondrial inner membrane
- d) mitochondrial inter-membrane space
- e) mitochondrial matrix

9) Protein kinases are enzymes that transfer the terminal phosphate from ATP to an amino acid residue on the target protein. Many are located in/on the plasma membrane as integral membrane proteins or peripheral membrane proteins. What purpose may be served by their plasma membrane localization?

- a) Membrane localization allows for unique protein folding of the protein kinases.
- b) Protein kinases can more readily encounter and phosphorylate other membrane proteins.
- c) Membrane localization lowers the activation energy of the phosphorylation reaction.
- d) Protein kinases flip back and forth across the membrane to access target proteins on either side.
- e) Protein kinases require phospholipids as a cofactor.

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10. What are the 2 second messengers produced when activating the Phospholipase C (PIP2) pathway by a GPCR?

- a) cAMP (cyclic AMP)
- b) cGMP (cyclic GMP)
- c) DAG (diacylglycerol)
- d) IP3 (inositol triphosphate)
- e) Both c and d are correct

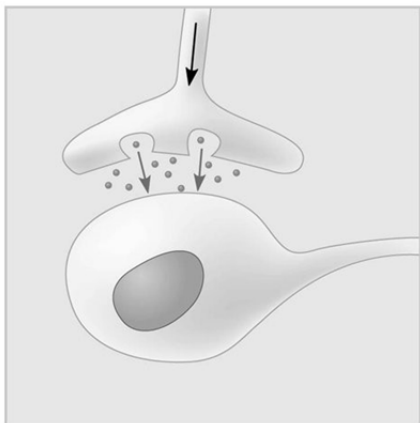
11. cAMP is produced by:

- a) adenylate cyclase, phosphodiesterase and 5'-AMP.
- b) ATP and 5'-AMP.
- c) adenylate cyclase and ATP.
- d) ADP and phosphodiesterase.
- e) a cAMP-dependent protein kinase.

12. Which of the following does *not* occur in prokaryotic gene expression, but *does* in eukaryotic gene expression?

- a) mRNA, tRNA, and rRNA are transcribed.
- b) RNA polymerase binds to the promoter.
- c) RNA polymerase requires a primer to elongate the molecule.
- d) Transcription can begin as soon as translation has begun even a little.
- e) A poly-A tail is added to the 3' end of an mRNA and a cap is added to the 5' end.

Use the following image to answer questions 13 and 14:



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13) Which of the following types of signalling is represented in the figure?

- a) autocrine
- b) paracrine
- c) hormonal
- d) synaptic
- e) long-distance

14) In the figure, the dots in the space between the two structures represent which of the following?

- a) receptor molecules
- b) signal transducers
- c) neurotransmitters
- d) hormones
- e) pheromones

15. In eukaryotes there are several different types of RNA polymerase. Which type is involved in transcription of mRNA for a cytosolic protein?

- a) ligase
- b) RNA polymerase I
- c) RNA polymerase II
- d) RNA polymerase III
- e) primase

16. Which components of the following transcript will be found in the mRNA in the cytosol?

Transcript: 5' UTR Exon<sub>1</sub>-Intron<sub>1</sub>-Exon<sub>2</sub>-Intron<sub>2</sub>-Exon<sub>3</sub>-Intron<sub>3</sub>-Exon<sub>4</sub> UTR 3'

- a) 5' UTR Intron<sub>1</sub> Intron<sub>2</sub> Intron<sub>3</sub> UTR 3'
- b) 5' Exon<sub>1</sub> Exon<sub>2</sub> Exon<sub>3</sub> Exon<sub>4</sub> 3'
- c) 5' UTR Exon<sub>1</sub> Exon<sub>2</sub> Exon<sub>3</sub> Exon<sub>4</sub> UTR 3'
- d) 5' Intron<sub>1</sub> Intron<sub>2</sub> Intron<sub>3</sub> 3'
- e) 5' Exon<sub>1</sub> Intron<sub>1</sub> Exon<sub>2</sub> Intron<sub>2</sub> Exon<sub>3</sub> Intron<sub>3</sub> Exon<sub>4</sub> 3'

17) A transcription unit that is 8000 nucleotides long may use 1200 of those nucleotides to make a protein consisting of approximately 400 amino acids. This is best explained by the fact that;

- a) many noncoding stretches of nucleotides are present in pre-mRNA.
- b) there is redundancy and ambiguity in the genetic code.
- c) many nucleotides are needed to code for each amino acid.
- d) nucleotides break off and are lost during the transcription process.
- e) there are termination exons near the beginning of mRNA.

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18. You have recently designed a technique that allows you to create a fusion between two operons, namely the zryptophan (zyp) and malactose (mal) operons (shown in the figure below) and express it in a strain of bacteria.

|       |       |       |       |       |                                                  |       |
|-------|-------|-------|-------|-------|--------------------------------------------------|-------|
| mal y | zyp E | zyp D | zyp C | mal z | zyp regulatory region<br>(promoter and operator) | mal a |
|-------|-------|-------|-------|-------|--------------------------------------------------|-------|

In the presence of the zryptophan substrate, which of the genes in your transcript will your bacteria be able to transcribe?

- a) All of the genes will be transcribed
  - b) Only mal a**
  - c) Only zyp E, zyp D, and zyp C
  - d) All except mal a
  - e) None of the genes will be transcribed
19. If a lethal point mutation occurs in an intron, what will be the ultimate outcome for the organism?
- a) The organism will not be able to survive
  - b) It will depend on how the pre-mRNA is matured
  - c) It will be of little consequence as the intron will be spliced**
  - d) It depends on what impact that intron corresponds to during translation
20. Which of the following corresponds to the end of transcription in prokaryotes.
- a) RNA polymerase II reaches the poly-A signal sequence
  - b) RNA polymerase II reaches the termination sequence
  - c) An RNA endonuclease digests the RNA polymerase
  - d) RNA polymerase catches up to the Rho factor and detaches from DNA**
  - e) RNA polymerase reaches the promoter of the next gene

**Make sure you have transcribed all your answers to your Scantron**

**Continue to the next page for written answer questions – section B**

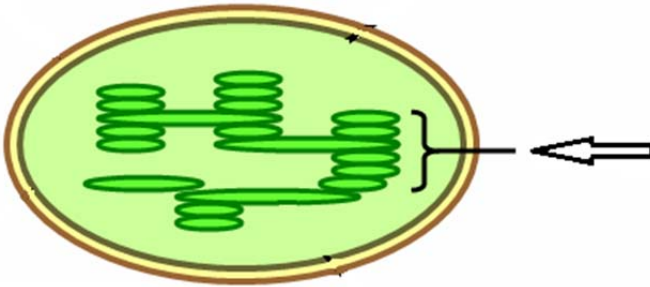
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**Section B – Written answers ()**

**Please answer within the provided space – make sure your answer is clear and legible**

1. In this figure, the arrow points to a specialized structure. (1 mark)

Name this structure: \_\_\_\_ **Granum (0.5 marks for Thylakoid stack)** \_\_\_\_\_



2. For each of the following, provide a specific example: (2 marks)

|   | Statement               | Example                                                                                                                                                                            |
|---|-------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| A | An oxidizing agent      | Anything that gains an electron (eg complex I , H <sub>2</sub> O <sub>2</sub> , H <sub>2</sub> O, N <sub>2</sub> O, O <sub>2</sub> , NAD <sup>+</sup> , FADH, H <sup>+</sup> ,etc) |
| B | Kinetic energy          | Use of ATP to do work; passage of ions across a channel; motor proteins involved in transport, etc...                                                                              |
| C | Amplifier enzyme        | Adenylate cyclase, phospholipase C                                                                                                                                                 |
| D | Guanine exchange factor | Sos                                                                                                                                                                                |

3. In chloroplasts, where is chemiosmosis achieved and what is it used to accomplish? (2 marks)

- in the inner thylakoid space (NOT Stroma)  
- acts as a proton motive force (The H<sup>+</sup> gradient built) that powers ATP synthase to produce ATP in the stroma.

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4. What makes the nematode *C. Elegans* a good model to study apoptosis? Provide two reasons. (2 marks)

1 mark each for a maximum of 2 marks

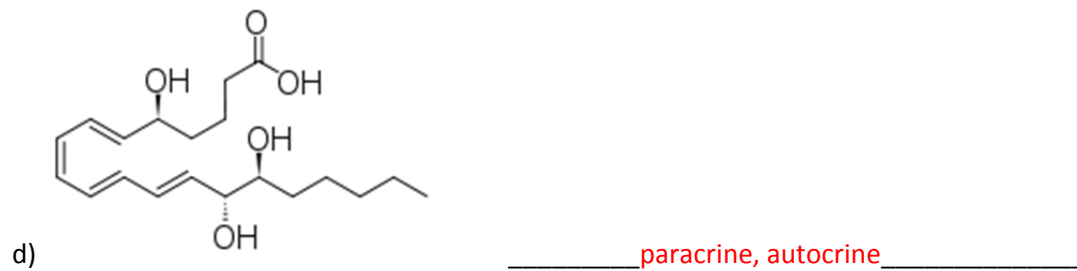
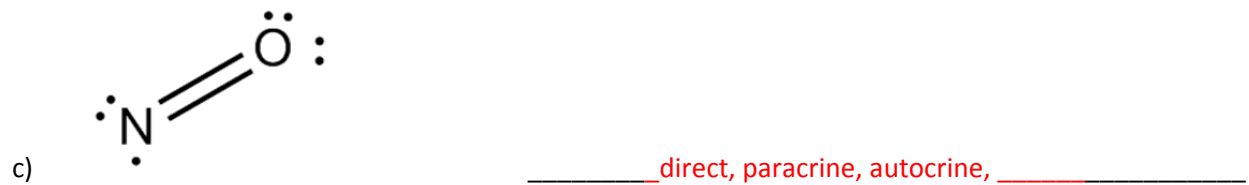
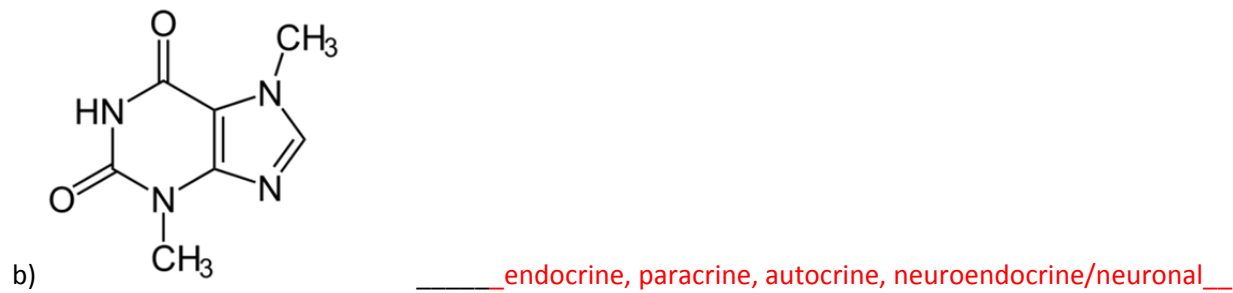
- Same number of cells in each organism (131 cells = 0.5 marks)
- Development of each cell and progeny is well known OR the same cells die through apoptosis
- Genes and associated proteins involved are identified
- Genes and associated proteins involved have conserved homologs in most species

5. How is transcription initiated in prokaryotes? (2 marks)

The sigma factor binds to the regulatory region (promoter) of the gene, which positions RNA polymerase in the correct location to begin transcribing exactly at the start site.

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6. Identify the communication path most likely used by the following messengers (4 marks)



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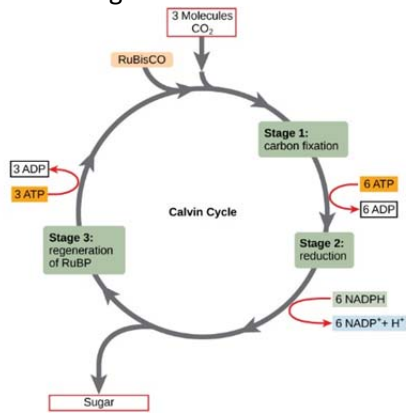
7. A mouse's liver cells are under an unusual amount of oxidative stress. Many of the mitochondria within these cells become damaged. How will these cells respond to ensure their survival and the survival of the liver? Be sure to name the process and provide an explanation for the key steps involved. (6 marks)

For a maximum of 6 marks:

- The damaged mitochondria will undergo mitophagy. (Mitophagy 1 mark)
- Specific proteins will promote fission of the healthy and damaged portions of the mitochondria. (fission of damaged and healthy portions 1 mark)
- The healthy portions will fuse together to form functional mitochondria. (concept of rescuing the healthy portions is sufficient 1 mark)
- The damaged portions will induce the expression of PINK on the outer mitochondrial membrane. (1 mark)
- PINK will phosphorylate MFN2 (1 mark)
- MFN2 will recruit a ubiquitin ligase (Parkin) (1 mark)
- Parkin allows the addition of ubiquitin groups (ubiquitination) to the membrane. (1 mark)
- This will label the damaged mitochondria and signal the lysosome to conduct autophagy. (1 mark)
- Remaining healthy mitochondria reproduce via binary fission

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8. Use this figure to answer the next 3 questions: (3 marks)



a) Relative to ATP, how would you interpret what is depicted in the picture?

ATP acts as an intermediary to store energy for cellular work

b) What is the benefit for cells to use a cycle such as the one depicted above?

Cells can combine cellular cycles to recycle ADP and phosphate and electron carriers, which can be used to produce ATP.

c) Provide another example of a cycle used to produce and recycle ATP in a cell.

Many possible answers;

Motor proteins hydrolyse ATP to exert motion

Myosin and actin in muscle contraction

Phosphorylation by kinases

Primary active transport

Etc.

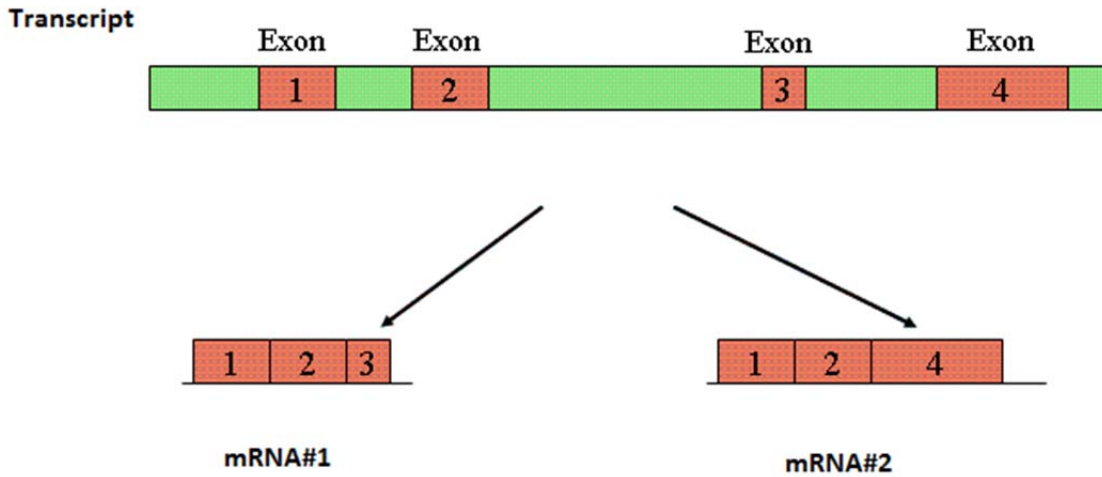
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9. Which of the following is a *correct* association? T or F Justify if F (4 marks)

|                                                              | T (True) or F (False) | Justify if False (F)                                                              |
|--------------------------------------------------------------|-----------------------|-----------------------------------------------------------------------------------|
| Adenylyl cyclase activity and conversion of ATP to cAMP      | T                     |                                                                                   |
| Phosphodiesterase activity and removal of phosphate groups   | F                     | Phosphodiesterase responsible for cAMP to AMP                                     |
| GTPase activity and hydrolysis of GDP to GTP                 | F                     | Hydrolysis of GTP to GDP or no phosphorylation but rather exchange of GTP for GDP |
| Autophosphorylation activity and addition of tyrosine groups | F                     | Autophosphorylation Adds phosphate OR phosphorylates Tyrosine                     |

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10. Using the image below, name the mechanism depicted **and** provide an explanation of all the steps required to achieve both mRNA#1 and mRNA#2 as in the diagram. (5 marks)



This is alternative splicing. (1 mark)

The pattern of splicing is dependent on the snRNPs present in the spliceosomes in the cells, because they recognize different docking (complimentary/consensus) sequences in introns. (1 mark)

A spliceosome contains snRNPs and proteins that: (0.5 marks each)

- Recognize specific sequences at the beginning and end of introns
- Cut the nucleotide bond at the exon-intron position
- Release the intron (as a lariat or loop)
- Ligase the exons so that the matured mRNA is a continuous sequence of coding RNA

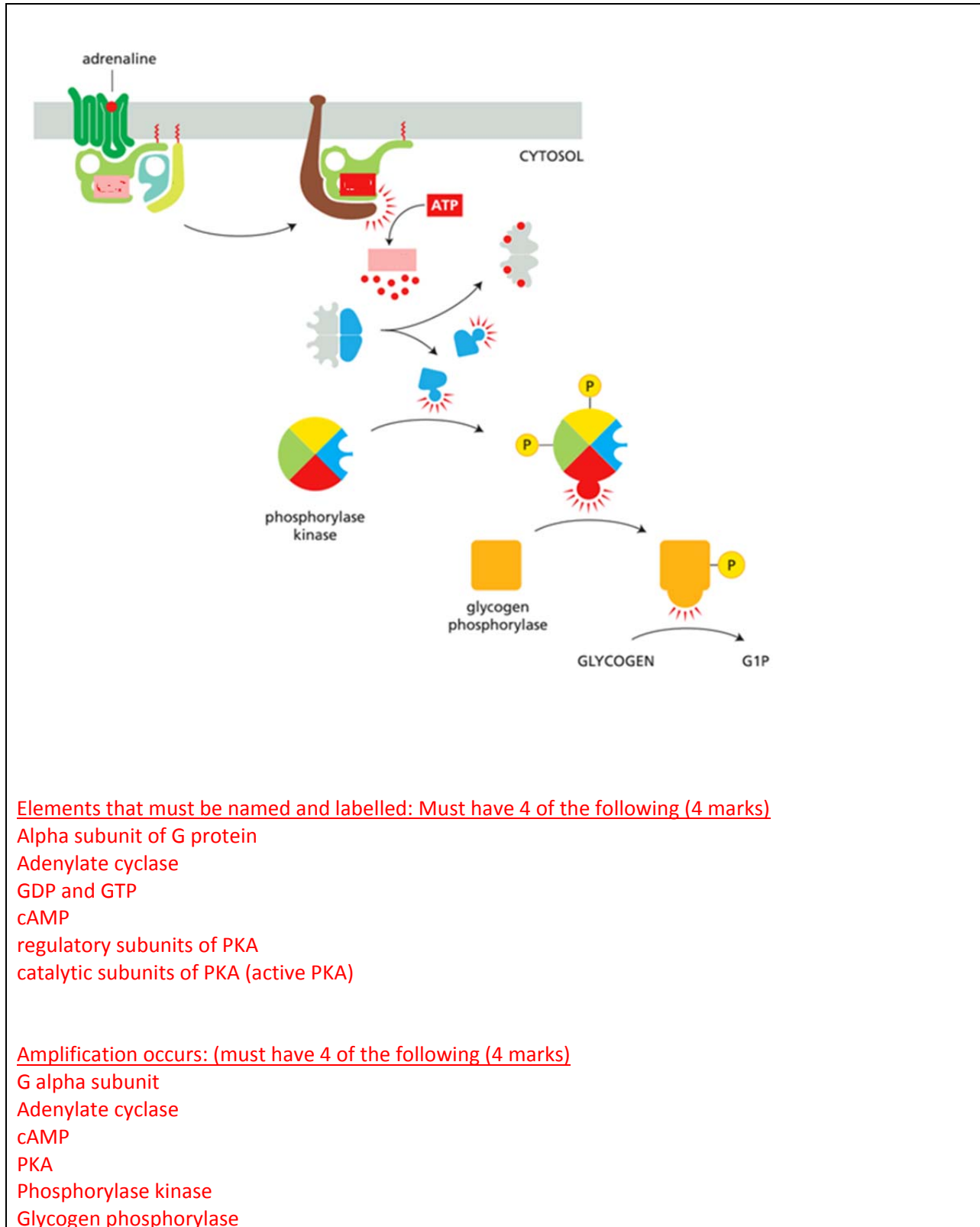
The difference between mRNA #1 and #2 is the sequences the snRNPs recognized:

mRNA #1: intron 1, intron 2, intron 3, start of intron 4 to end of intron 5 (0.5 marks) (exon 1, 2, 3)

mRNA #2: intron 1, intron 2, Intron 3 to end of intron 4 (0.5 marks) (exons 1, 2, 4)

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11. Complete this diagram by **naming and labelling** each element of the signaling cascade and indicating where amplification occurs. (8 marks)



Elements that must be named and labelled: Must have 4 of the following (4 marks)

- Alpha subunit of G protein
- Adenylylate cyclase
- GDP and GTP
- cAMP
- regulatory subunits of PKA
- catalytic subunits of PKA (active PKA)

Amplification occurs: (must have 4 of the following (4 marks))

- G alpha subunit
- Adenylylate cyclase
- cAMP
- PKA
- Phosphorylase kinase
- Glycogen phosphorylase

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12. A cell's survival is threatened by binding a lethal ligand that leads to the dephosphorylation of a key regulatory protein; the cell will die. Name this process and describe the steps leading to its demise. (6 marks)

Name of the process: Apoptosis (1 mark)

Max 5 elements out of the 8 below (1 mark each):

- Dephosphorylation of 14-3-3 / Bad complex activating the pro-apoptotic protein Bad
- Bad activates Bax/Bak and inhibits Bcl2
- IP3 binding to IP3-gated calcium channel on ER allows release of a high concentration of Ca<sup>2+</sup>
- Mitochondria takes up Ca<sup>2+</sup> (up to 1000 fold in concentration) and reaches threshold concentration that opens the PTP (permeability transition pore)
- Cristae rearrange and release cytochrome c
- Cytochrome C binds to Apaf 1 and Caspase 9 (initiator caspase) to form an apoptosome
- Caspase 9 activates the executioner caspases that will contribute to the hallmarks of apoptosis
- Hallmarks of apoptosis: cell adhesion loss, disassembly of nuclear envelope, changes in cytoskeleton, DNA laddering/fragmentation, activate scramblase and flip phosphatidylserine to outer layer of membrane, blebbing, formation of apoptotic bodies.

*Congrats! You have completed the second midterm exam.*