BIO1140 Introduction to Cell Biology
Professor: Dr. Caroline Petit-Turcotte
Midterm Exam 2 – Section A: Tuesday March 20th, 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 1hour 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 A) 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 A Student number: _____

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

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

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 1st midterm

b) Prepared the same as for the 1st midterm

c) Not as well prepared as for the 1st midterm

d) I did not write the 1st midterm

2) Which kind of metabolic molecule would most directly interfere with glycolysis?

a) an agent that reacts with oxygen and depletes its concentration in the cell
b) an agent that binds to pyruvate and inactivates it
c) an agent that closely mimics the structure of glucose but cannot be metabolized
d) an agent that reacts with NADH and oxidizes it to NAD^+
e) an agent that blocks the passage of electrons along the electron transport chain

3) Inside an active mitochondrion, most electrons follow which pathway?

a) glycolysis → NADH → oxidative phosphorylation → ATP → oxygen
b) citric acid cycle → $FADH_2$ → electron transport chain → ATP
c) electron transport chain → citric acid cycle → ATP → oxygen
d) pyruvate → citric acid cycle → ATP → NADH → oxygen
e) citric acid cycle → NADH → electron transport chain → oxygen

4) In chloroplasts, chemiosmosis translocates protons from

a) the stroma to the photosystem II.
b) the matrix to the stroma.
c) the stroma to the inner thylakoid space.
d) the intermembrane space to the matrix.
e) the inner thylakoid space to the stroma.

5) Which of the following statements best describes the relationship between photosynthesis and respiration?

a) Respiration runs the biochemical pathways of photosynthesis in reverse.
b) Photosynthesis stores energy in complex organic molecules, whereas respiration releases it.
c) Photosynthesis occurs only in plants and respiration occurs only in animals.
d) ATP molecules are produced in photosynthesis and used up in respiration.
e) Respiration is anabolic and photosynthesis is catabolic.

Section A Student number: _____

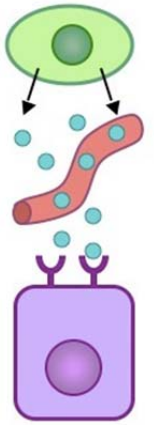
6) Which of the following would most likely increase the yield of producing biodiesel from algae?

a) lowering the light level during algae growth
b) increasing the sunlight available to the algae
c) increasing the respiration rate of the algae
d) supplementing the algae with carbohydrates
e) none of the above

7) Phosphorylation cascades involving a series of protein kinases are useful for cellular signal transduction because

a) they are species specific.
b) they always lead to the same cellular response.
c) they amplify the original signal many fold.
d) they counter the harmful effects of phosphatases.
e) the number of molecules used is small and fixed.

Use the following figure to answer questions 8 and 9 below:



8) Which of the following types of signaling is represented in the figure?

a) autocrine
b) paracrine
c) exocrine
d) synaptic
e) endocrine

9) In the figure, the dots represent which of the following?

a) receptor molecules
b) signal transducers
c) neurotransmitters
d) primary messengers
e) second messengers

10) What might be one approach to design a drug to maintain low blood sugar levels?

a) activate epinephrine receptors
b) increase cAMP production in liver cells
c) block G protein activity in liver cells
d) increase phosphorylase activity
e) increase membrane fluidity

11) During puberty, an adolescent female body changes in both structure and function of several organ systems, primarily under the influence of changing concentrations of estrogens and other steroid hormones. How can one steroid hormone, such as estrogen, mediate so many effects?

a) Estrogen is produced in very large concentration and therefore diffuses widely.
b) Estrogen has specific receptors inside several cell types, but each cell responds in the same way to its binding.
c) Estrogen is kept away from the surface of any cells not able to bind it at the surface.
d) Estrogen binds to specific receptors inside many kinds of cells, each of which have different responses to its binding.
e) The subcomponents of estrogen, when metabolized, can influence cell response.

12) Which of the following statements best describes the termination of transcription in prokaryotes?

a) RNA polymerase transcribes through the polyadenylation signal, causing proteins to associate with the transcript and cut it free from the polymerase.
b) RNA polymerase transcribes up to the terminator sequence, until Rho catches up causing the polymerase to separate from the DNA and release the transcript.
c) RNA polymerase transcribes through an intron, and the snRNPs cause the polymerase to let go of the transcript.
d) Once transcription has initiated, RNA polymerase transcribes until it reaches the end of the chromosome.
e) RNA polymerase transcribes through a stop codon, causing the polymerase to stop advancing through the gene and release the mRNA.

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

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

14) In eukaryotes, there are several different types of RNA polymerase. Which type is involved in transcription of mRNA that will be used for translation of a protein?

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

Section A Student number: _____

15) 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.

16) Alternative splicing…

a) is a mechanism for increasing the rate of transcription.
b) can allow the production of proteins of different sizes from a single pre-mRNA.
c) can allow the production of similar proteins from different RNAs.
d) is a mechanism for increasing the rate of translation.
e) occurs only in prokaryotes.

17) Which components of the following transcript will be found in the mRNA in the cytosol?
Transcript: 5' UTR $Exon_1$-$Intron_1$-$Exon_2$-$Intron_2$-$Exon_3$-$Intron_3$-$Exon_4$ UTR 3'

a) 5' UTR $Intron_1$ $Intron_2$ $Intron_3$ UTR 3'
b) 5' $Exon_1$ $Exon_2$ $Exon_3$ $Exon_4$ 3'
c) 5' UTR $Exon_1$ $Exon_2$ $Exon_3$ $Exon_4$ UTR 3'
d) 5' $Intron_1$ $Intron_2$ $Intron_3$ 3'
e) 5' $Exon_1$ $Intron_1$ $Exon_2$ $Intron_2$ $Exon_3$ $Intron_3$ $Exon_4$ 3'

18) What is the major difference between signal transduction cascades using intracellular receptors when compared to transmembrane receptors?

a) The ligand and receptor are both part of the transduction events
b) The ligand is irrelevant
c) The receptor does not have a ligand binding domain
d) The cascade does not lead to any changes in the cell
e) There are no differences between these cascades

19) A mutation to Grb2's SH3 domain prevents it from interacting with Sos. What will be the most likely consequence to that cell?

a) The activation of Ras and the MAPK pathway will not be possible
b) The tyrosine kinase receptors will no longer be functional
c) The cell will not be able to respond to growth factors
d) Grb2 will directly activate Ras

Section A Student number: _____

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

zyp regulatory region (promoter and operator)	zyp E	zyp D	zyp C	mal z	mal y	mal a

Under which of the following conditions do you expect your bacteria to be able to express permease (whose gene is mal y)?

a) None of the genes will be transcribed
b) Only when malactose is present
c) Only when malactose and zyptophan are present
d) Only when zyptophan is absent
e) Only when zyptophan is present

Make sure you have transcribed all your answers to your Scantron

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

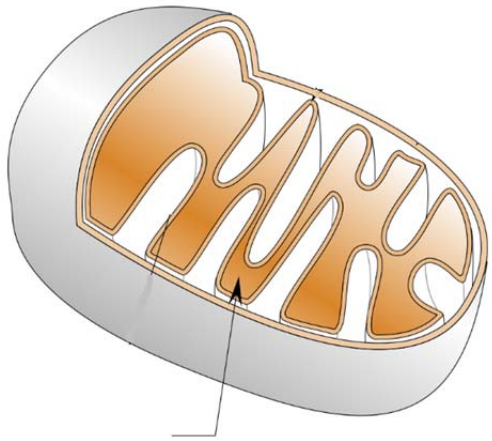
Section A Student number: _____

Section B – Written answers (Total 50 marks)

Please answer within the provided space (answers outside the box will not be graded) – make sure your answer is clear and legible.

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

Name this structure: ____Matrix_____



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

	Statement	Example
A	A reducing agent	Anything that loses an electron (eg NADH, $FADH_2$, 2-Mercaptoethanol)
B	Potential energy	Concentration gradient of an ion across membrane (an ion is NOT acceptable)
C	Second messenger	Ras, cAMP, DAG, IP3, calcium
D	Adaptor protein	Grb2,

3) Explain what the electron transport chain is and its function? (2 marks)

- a series of electron carriers and transmembrane protein complexes
- that carry electrons or perform redox reactions to a final electron acceptor molecule

Section A Student number: _____

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

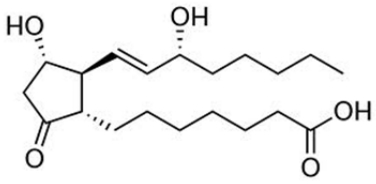
5. Explain what the TATA box is and its role. (2 marks)

- A DNA sequence located in the promotor of eukaryote genes (1 mark)

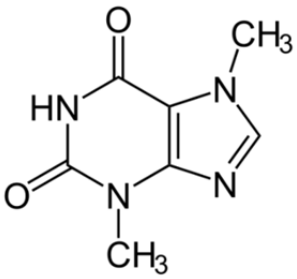
- It is involved in establishing the Transcription Initiation Complex, (0.5)
- which positions RNA polymerase II in the correct location to begin transcribing exactly at the start site. (0.5)

Section A Student number: _____

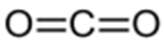
6. Identify the **messenger class** the following molecular structures belong to (**Be as specific as you can**) (4 marks):

a) 

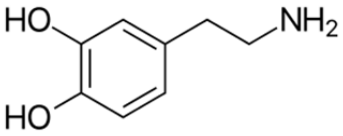
_____eicosanoid_____

b) 

_____purine_____

c) 

_____gas_____

d) 

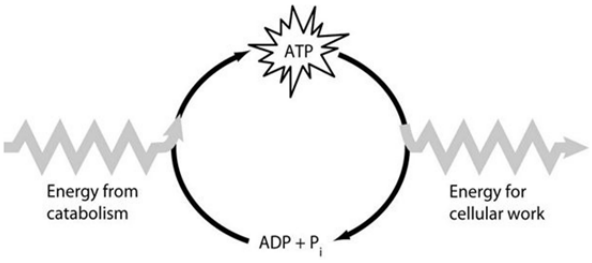
_____amine_____

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

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 use the cycle to recycle ADP and phosphate, which can be used to produce ATP.

c) Provide an example of such a cycle being used in a cell.

Section A Student number: _____

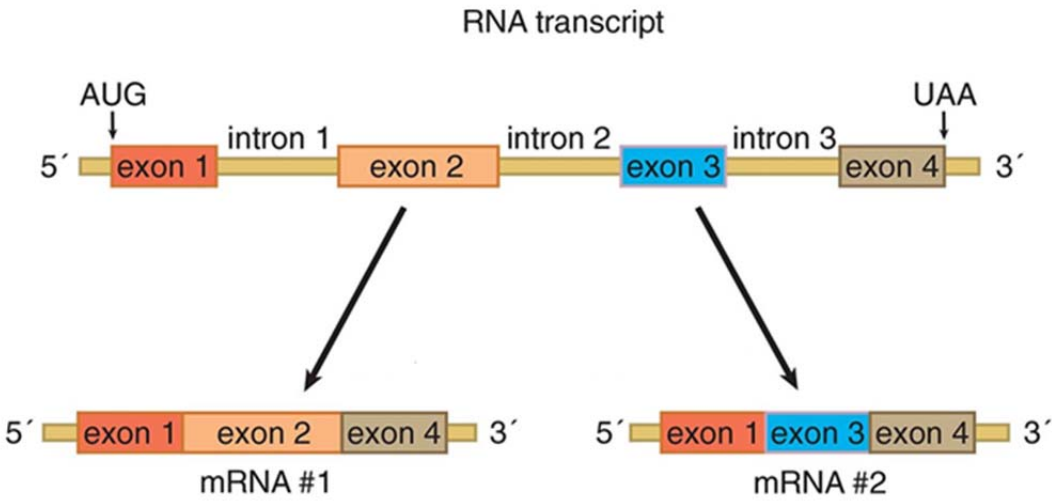
Many possible answers;
Motor proteins hydrolyse ATP to exert motion
Myosin and actin in muscle contraction
Phosphorylation by kinases
Primary active transport
Etc.

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)
Kinase activity and addition of tyrosine	F	Add phosphate
Phosphodiesterase activity and removal of phosphate groups	F	Phosphodiesterase responsible for cAMP to AMP
GTPase activity and hydrolysis of GTP to GDP	T	---
Adenylyl cyclase activity and conversion of cAMP to AMP	F	Adenylyl cyclase responsible for ATP to cAMP

Section A Student number: _____

10. The image below represents an important mechanism in genetic expression. Name this mechanism **and** provide an explanation of all the steps that occurred to achieve mRNA#1 and mRNA#2 depicted 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)

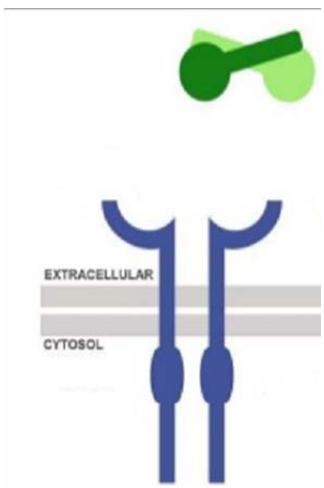
A spliceosome contains snRNPs and proteins that: (0.5 marks each)

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

Section A Student number: _____

11. The following cell line has been modified to no longer express any phospholipase C. Complete this diagram by **drawing and labelling** each element of the growth factor signaling cascade and describing the key steps, and provide one example of a possible cellular response. (8 marks)



1 mark for accurate, labelled and complete drawing

Max 6 marks from elements below (1 mark each):

- Dimerization of the Trk receptor monomers
- and autophosphorylation of tyrosines in catalytic domains
- Binding of adaptor protein Grb2 to P-tyr via SH2 domain
- Recruit Sos (a Guanine Exchange Factor) via SH3 domain
- Recruit Ras-GDP to Sos
- Change in conformation leads to exchange of GDP for GTP and activates Ras
- Ras phosphorylates various proteins including Raf, MEK, MAPK
- This leads to activation of transcription factor

Example of cellular responses: (1 mark)

- AP1 can increase the expression of various survival and growth proteins including Bcl2, actin, tubulin, etc.
- MAPK contributes to maintaining Bad and 14-3-3 complex phosphorylated and inactive

12. In a cell, the concentration gradients are tightly regulated to maintain homeostasis. If a cell's membrane loses its integrity and becomes highly permeable to ions and water, it will likely die. Name the process and describe the steps leading to its demise. (6 marks)

1 mark : Necrosis via Cathepsin – Calpain pathway

Max 5 among each of these 8 elements (1 mark each): (5 marks)

- Membrane integrity damaged
- Organelles empty their calcium stores (particularly ER)
- Rise in intracellular calcium concentration
- Calcium activates Calpain (stress mentioned worth 0.5 mark)
- Calpain degrades lysosmal membrane
- Cathepsins released and activated and digest cellular content
- Cathepsins are active in slightly less acidic pH then lysosome OR more acidic then healthy cell (cytoplasm)
- Cellular swelling and lysis

Congrats! You have completed the second midterm exam.