BIO1140 Introduction to Cell Biology

Professor: Dr. Caroline Petit-Turcotte

Midterm Exam 2 – Version MM: Saturday March 19th, 2016

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 20% 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. But please remain in your seat during the last 10 minutes.

Part A Instructions (20 marks): Multiple Choice.

1. Use pencil. On the Scantron, write down your exam version code (BIO1140MM) 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.
4. Follow instructions on the computer Scantron sheet.

Parts B-D Instructions (41 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 statement.

Student Name: _____MARKING SCHEME_____/ Signature: _____

Student Number: _____

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

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.

How would you rate your preparation level compared to the first midterm?

a) Less prepared

b) Somewhat the same

c) Slightly better

d) Much better

2. During cellular respiration in eukaryotes, which step does not take place in the mitochondria?

a) Oxidative phosphorylation

b) The citric acid cycle

c) Fatty acid oxidation

d) Glycolysis

e) None of the above

3. In plants, where does photosynthetic ATP synthesis, using the F-pump ATP synthase, take place?

a) The thylakoid membrane

b) The stroma

c) The thylakoid lumen

d) The cytoplasm

e) None of the above

4. Even though plant cells carry out photosynthesis, they use mitochondria to oxidize pyruvate. When and where will this occur?

a) In photosynthetic cells in the light, while photosynthesis is ongoing

b) Only in nonphotosynthesizing cells

c) Only in cells storing glucose

d) In all cells, all the time

e) None of the above

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5. Which of these cellular events is not associated with apoptosis?

a) Energy depletion

b) DNA fragmentation

c) Disruption of cell adhesion

d) Rearrangement of the cristae

e) None of the above

6. Which of the following choices does not correspond to a post-translational modification that can occur in the Golgi?

a) Glycosylation

b) Acetylation

c) Disulfide bond formation

d) Lipidation

e) None of the above

7. Using the following prokaryotic DNA sequence, choose which of the following would correspond to the result of transcription;

5' GCGATCTGA 3'
3' CGCTAGACT 5'

a) 5' UCAGAUCGC 3'

b) 3' GCGAUCUGA 5'

c) 5' GCGAUCUGA 3'

d) 3' AGUCUAGCG 5'

8. Caspases are known to:

a) Bind directly to transmembrane receptors and initiate apoptosis.

b) Deactivate other caspases.

c) Cleave essential proteins at a cysteine-aspartate site.

d) Release cytochrome c from the mitochondrion.

e) None of the above.

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9. Enzymatic receptors, such as tyrosine kinase receptors, require a sequence of events to become active. Which of these statements is correct?

a) A ligand, such as a growth factor, binds to a receptor dimer; autophosphorylation of 6 tyrosine residues provides the kinase activity of the receptor

b) A ligand, such as a growth factor, binds to a ligand binding domain; a membrane bound effector is recruited; the kinase activity of the receptor is functional

c) A ligand, such as a growth factor, binds to 2 monomeric subunits; dimerization leads to autophosphorylation of 6 tyrosine residues; the kinase activity of the receptor is functional

d) A ligand, such as a growth factor, binds to 2 monomeric subunits; dimerization recruits a kinase that will phosphorylate 6 tyrosine residues; the kinase activity of the receptor is functional

e) None of the above

10. Membrane proteins (and lipids) vital to the structure and function of the plasma membrane are typically delivered to the membrane via:

a) the constitutive secretory pathway

b) the regulated secretory pathway

c) endocytosis

d) ubiquitination

e) both a and b

11. Which of the following statements about the ACh-gated ion channel receptor is incorrect?

a) It is composed of 5 transmembrane subunits, 2 of which are identical.

b) The receptor requires both binding sites to be filled to change to its open conformation

c) These channels are mostly permeable to Na^+ and Ca^{2+}.

d) Once opened, they will activate an amplifier enzyme.

e) None of the above

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12. You have grown epithelial cells in culture, but a few of them appear to be dying. By using fluorescent microscopy, you have determined that before dying, the concentration of cytochrome C in the cytoplasm increases and their DNA is fragmented. Which of the following choices corresponds to the chronology of events for these cells?

a) Bax is released from the ER → Ca2+ rises → PTP pore is opened → cytochrome C is secreted by ER
b) Bad is dephosphorylated → BCl2 is inactivated → IP3-gated Ca2+ channel is opened → cytochrome C is released from mitochondria
c) BCl2 is activated → Ca2+ is released from the mitochondria → cytochrome C increases in cytoplasm → blebbing begins
d) Ca2+ enters the cell → mitochondria and ER increase their uptake of Ca2+ → Bad is released from mitochondria → cytochrome C is activated

13. If a nonsense 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 if 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

14. What second messenger(s) is/are 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

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15. A rodent is given an intramuscular injection of acetylcholine. Which of the following choices corresponds to the sequence of events that occurs after binding of the ligand molecule to its ionotropic receptor?

1) Calcium binds to troponin
2) Membrane depolarization
3) Sodium influx from extracellular fluid
4) Myosin binds actin
5) Calcium release from SR
6) Conformational change of tropomyosin to expose myosin binding sites
7) Muscle contraction

a) 2,5,4,3,6,1,7
b) 3,2,5,1,6,4,7
c) 2,5,1,6,4,3,7
d) 3,5,6,2,1,4,7

16. Beadle and Tatum discovered many categories of *Neurospora* mutants. Category I mutants could grow on medium with Arginine, Citrulline or Ornithine, while Category II mutants grew only on medium containing either Arginine or Citrulline, but not in the presence of Ornithine. The metabolic pathway for the synthesis of Arginine is as follows:
Precursor → Ornithine → Citrulline → Arginine
From these results, we can conclude that:

a) A single gene codes for the entire metabolic pathway
b) The genetic code is a triplet code
c) In Category I mutants, mutations occur later in the chain of nucleotides than in Category II mutants; Category I mutants have a greater number of functional enzymes
d) Category I mutants have a non-functional enzyme in the first step, while Category II mutants have a non-functional enzyme in the second step
e) Category I mutants have a non-functional enzyme at the second step, while Category II have a non-functional enzyme at the third step

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17. A cell releases a chemical messenger, and after a short time spent in the extracellular space, this messenger binds to a receptor on that cell's surface. Which communication path is this an example of?

a) Paracrine

b) Endocrine

c) Exocrine

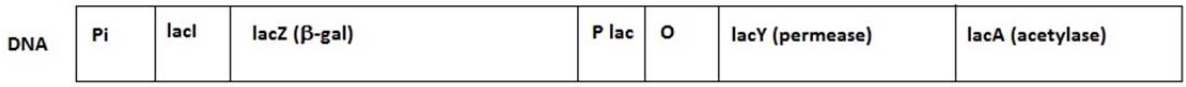
d) Autocrine

e) Direct (Gap)

18. You have recently designed a technique that allows you to move DNA sequences within a prokaryote's genome. You decide to move the promoter and operator for the *lac* operon, placing it between the β-galactosidase and permease genes.

Lac operon

Lac operon after modification



Which of the following choices is your best prediction for the outcome, when in the presence of lactose?

a) None of the genes will be transcribed

b) Only lac Z (β-galactosidase) will be transcribed

c) Only lacY (permease) and lacA (acetylase) will be transcribed

d) All three genes will be transcribed but with lac Z less than the other 2 genes

e) None of the genes will be transcribed

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19. Which of the following choices corresponds to a major difference between signal transduction cascades using intracellular receptors when compared to those using 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 is no difference

20. The amino acid proline has several possible codons, due to the degeneracy of the genetic code. This means that there is more than one possible _____ for proline.

a) DNA

b) tRNA

c) mRNA

d) rRNA

e) ribosome

YOU HAVE COMPLETED SECTION A

PLEASE TURN TO THE NEXT PAGE FOR THE REMAINDER OF THE EXAM

Student number: _____

Section B – General knowledge (Total 9 marks)

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

1. Explain what a spliceosome is and its role. (2 marks)

Combination of proteins and small nuclear RNAs (snRNPs) (1 mark) that work together to:
Remove introns (1 mark)

2. How can cell accommodate very long transmembrane domains of receptor monomers? (1 mark)

0.5 marks: With lipid rafts;
0.5 marks: they are microdomains (accept small areas or regions) of the plasma membrane that are rich in unsaturated sphingolipids (which have long FA tails) and cholesterol (to maintain fluidity).

3. Describe chronologically how the transcription initiation complex is formed? (2 marks)

Transcription factor binds to TATA box in promoter (0.5 marks)
TATA binding proteins recruited to promoter /TATA box(0.5 marks)
Additional transcription factors/ repressors/enhancers/activators bind to response elements (proximal or distal) (0.5 marks)
RNA polymerase II is recruited to promoter (transcription start site) (0.5 marks)

If elements are not in the correct order, deduct 0.5 marks

4. Define membrane potential and explain how it is maintained. (2 marks)

Unequal distribution of charge on both sides of the membrane that creates potential energy that can be measured in voltage OR -70mV (1 mark)
Maintained by the action of the Na^+/K^+/ATPase pump that exchanges 3 Na^+ for each $2K^+$ (1 mark)

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5. Name 2 of the 6 ways to terminate a signalling pathway. (2 marks)

Each worth 1 mark

- Removal of ligand by distant tissues;
- Removal of ligand by adjacent/neighbouring cells;
- Enzymatic degradation of ligand;
- receptor-ligand internalisation by endocytosis; (concept of receptor and ligand must be present)
- inactivation of receptor;
- inactivation of signal transduction pathway OR second messenger;

Section C –Associate (Total of 22 marks)

1. Place the following steps in the correct order to produce albumin, an endocrine transport protein: (1 mark – all answers must be correct, no partial marks)

Order	Steps
1	a. Splicing
2	b. Elongation
3	c. Release factor lines up with stop codon
4	d. mRNA bound to small ribosomal subunit
5	e. Binding of large ribosomal subunit
6	f. mRNA passes through nucleoporin

Correct order: _____A-F-D-E-B-C OR B-A-F-D-E-C _____

2. When considering RNA, what are three things that are different from DNA: (3 marks)

Each answer worth 1 mark

- Ribose (not deoxyribose)
- Uracil (not Thymidine)
- Single strand (not double strand) (single helix is acceptable)
- It can leave the nucleus
- It can act as an enzyme
- DNA more stable than RNA
- RNA does not have histones

Student number: _____

3. Using the codon table provided, indicate what the peptide sequence would be for the following mRNA sequence: (1 mark)

mRNA: 5' AUGUCAAGCGGAGAGGUACUCUAA 3'

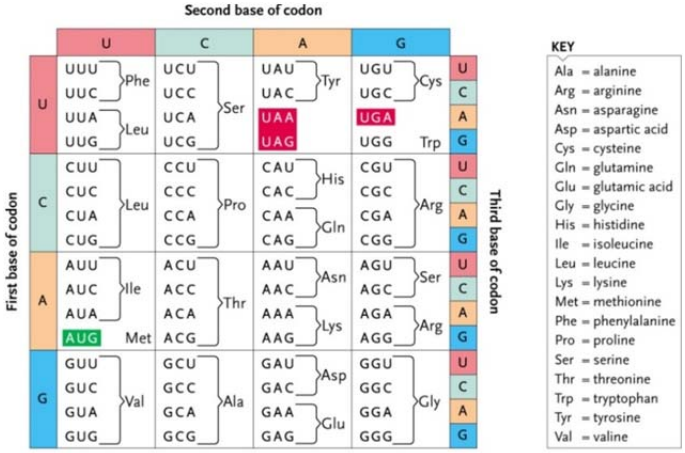
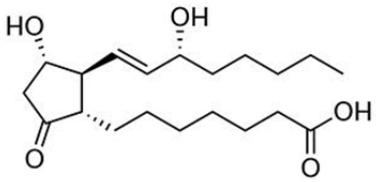


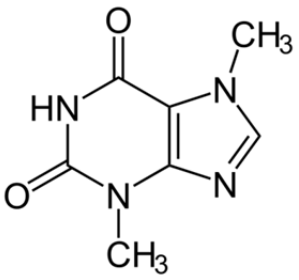
Figure 13.5
The genetic code, written as the codons appear in mRNA being read 5′ to 3′. The AUG initiator codon, which codes for methionine, is shown in green; the three terminator codons are boxed in red.

Answer: Met – Ser –Ser –Gly –Glu –Val –Leu

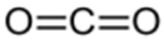
4. Identify the chemical messenger class the following molecular structures belong to (3 marks):

a) 

eicosanoid (accept prostaglandin, not leukotriene)_____

b) 

__purine_____

c) 

____gas_____

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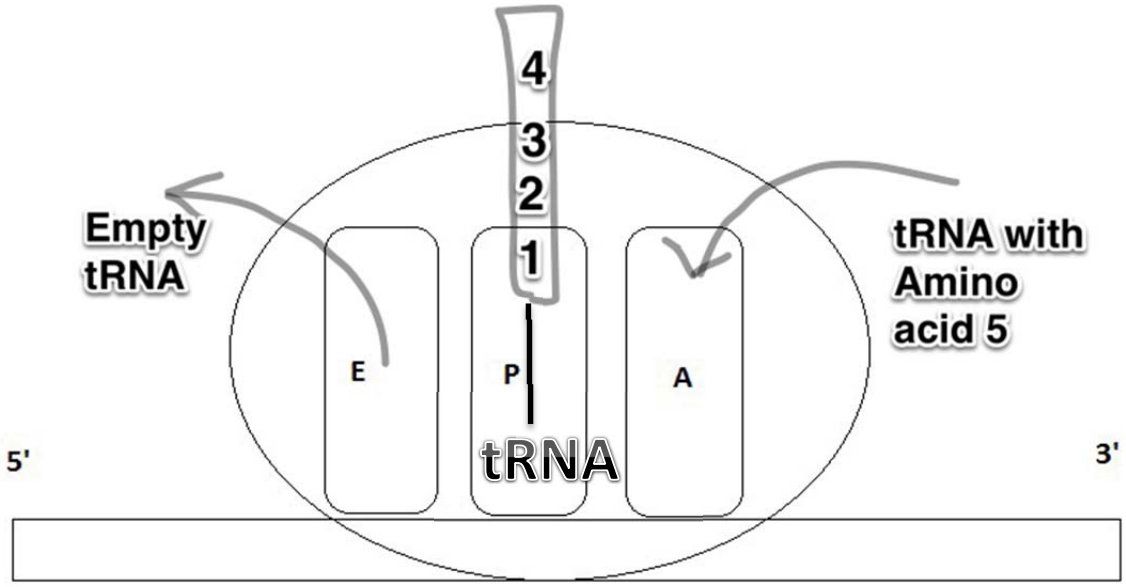
5. Complete the drawing below to represent **elongation**. Include and **label** all the necessary elements in this step. (4 marks)

- Must clearly identify on drawing:
  - Empty tRNA leaving E site, (1 mark)
  - tRNA (1 mark) linked with growing polypeptide in P site (1 mark)
  - Loaded tRNA with next amino acid arriving at A site (1 mark)



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6. What would be the consequence if the IP_3-gated channel of the endoplasmic reticulum became insensitive to IP_3 which is produced following activation of the GPCR by an amine such as norepinephrine? Use the key steps of the transduction pathway to support your answer. (4 marks)

1 mark each

- Activated PLC cleaves PIP2 into DAG and IP3
- IP3 is directed to the IP3-gated Ca2+ channel on ER
- If that channel is insensitive to IP3 then Ca2+ is not released
- Therefore unable to activate PKC along with DAG, DAG will be the main second messenger

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)

Maximum 6 marks

- The damaged mitochondria will undergo mitophagy. (1 mark)
- Specific proteins will promote fission of the healthy and damaged portions of the mitochondria. (1 mark)
- The healthy portions will fuse together to form functional mitochondria. (1 mark)
- The damaged portions will induce the expression of PINK on the outer mitochondrial membrane. (1 mark)
- This will recruit a ubiquitin ligase/Parkin (1 mark)
- which will promote the addition of ubiquitin groups (ubiquitination) of the membrane.(1 mark)
- This will label the damaged portion of mitochondria and signal the lysosome to conduct autophagy. (1 mark)

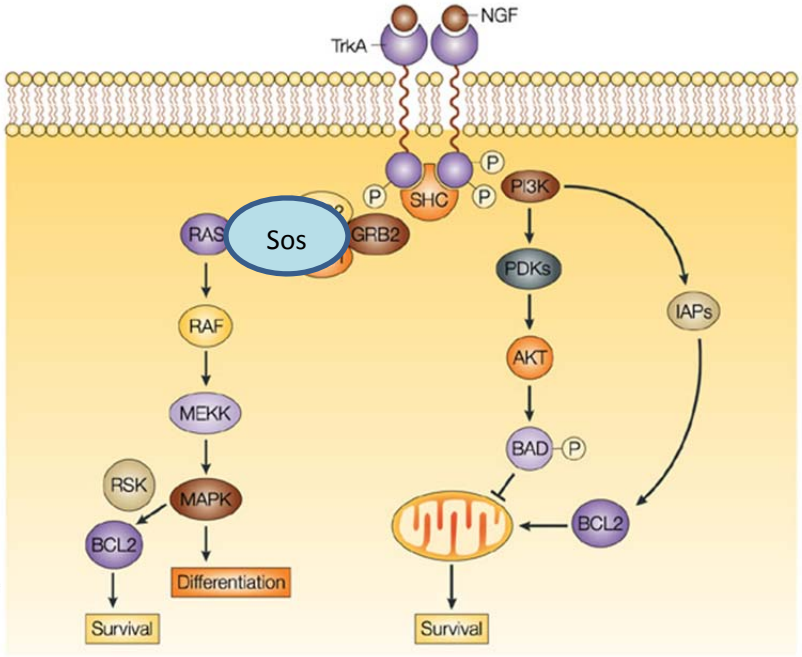
Student number: _____

Section D – Long answer question (10 marks)

1. Growth factors contribute to a cell's growth, survival and in some cases, its differentiation. Using a **drawing** of a cell, explain how NGF's signal is transduced by the cell and how it relates to ensuring survival and preventing the initiation of apoptosis. (10 marks)

Context for marker:
Tyrosine kinase receptor activation leads to transduction of 2 possible pathways – the Ras-MAPK pathway and the PI3 kinase pathway. The Ras pathway promotes the translation of Bcl2 – an ant apoptotic protein while the PI3K pathway maintains Bad in a phosphorylated and inactive state (Bad is a pro-apoptotic), as well as maintain Bcl2 active.
In the absence of NGF, Bad would no longer be phosphorylated and would inactive Bcl2 leading to the initiation of the apoptotic cascade.
Maximum 10 marks

- Ligand (NGF) binds to TRK receptor (1 mark)
- TRK receptor dimerize (1 mark)
- TRK receptor dimer autophosphorylate (1 mark)
- Activated TRK dimer recruits effectors RAS-SOS-GRB2 & PI3K (1 mark)
- PI3K pathway – end of cascade results in inactive BAD because it is phosphorylated (0.5mark) & active form of BCL2 (0.5mark)
- Consequence on apoptosis: In absence of NGF, then BAD becomes dephosphorylated and active (1 mark), then it inactivates BCL2 (1 mark), resulting in triggering apoptotic cascade (or description that mitochondria releases cytochrome C, Apaf1 and caspase 9 form apoptosome) (1 mark) (Note exact opposite of these three ideas are acceptable)
- RAS pathway - MAPK stimulates the transcription factors that promote survival (0.5 mark) including activating BCL2 (0.5 mark)
- Consequence on apoptosis: MAPK kinase will not promote the production of BCL2 (1 mark), which stunts apoptotic activity (1 mark)
- Note: No drawing deduct 1 mark



PI3K = Phosphatidyl inositol 3 kinase

IAP = Inhibitors of apoptosis

erm exam!