FF

BIO1140 Introduction to Cell Biology

Professor: Dr. Caroline Petit-Turcotte

Midterm Exam 2 – Version FF: Saturday March 18th, 2017

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 15% 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 (BIO1140FF) 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 (37 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: _____

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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 a chloroplast, where does ATP synthesis (using the F-pump ATP synthase) take place?

a) The matrix

b) The outer membrane

c) The internal membrane

d) The stroma

4. Unlike mitochondria, chloroplasts do not have a transporter to export ATP to the cytosol. How does the plant cell obtain the ATP it needs to survive?

a) The ATP produced in chloroplast is mostly used for carbon fixation

b) The ATP produced in chloroplast can diffuse across the thylakoid membrane

c) The orientation of the ATP-synthase produces ATP in the cytosol

d) There is no ATP production by chloroplast

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5. Which of these cellular events is associated with necrosis?

a) Available energy increase

b) Loss of electrochemical gradients

c) Increased cell adhesion

d) Dissolution of nuclear membrane

e) None of the above

6. Which of the following choices corresponds to a post-translational modification that occurs in the endoplasmic reticulum?

a) Lipidation

b) Acetylation

c) Disulfide bond formation

d) Methylation

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

3’ GCTATAGCGCTCG 5’

5’ CGATATCGCGAGC 3’

a) 5’ CGATATCGCGAGC 3’

b) 3’ CGACGCGUAUACG 5’

c) 5’ CGAUAUCGCGAGC 3’

d) 3’ GCUAUACGCGUGC 5’

8. Executioner 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.

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; autophosphorylation of 6 tyrosine residues provides the kinase activity to 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 recruits a kinase that will phosphorylate 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 leads to autophosphorylation of 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) pinocytosis

b) the constitutive secretory pathway

c) the regulated secretory pathway

d) ubiquitination

e) both b and c

11. Which of the following statements about intracellular receptors is incorrect?

a) They mainly act by affecting gene expression

b) They preferably bind to lipophilic ligands

c) They are present in the cytosol or the nucleus

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

e) None, they are all correct

12. If a missense 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 be of little consequence as the intron will be spliced

c) It will depend on the polarity of the new amino acid

d) It depends on what impact that intron corresponds to during translation

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13. Your experiments on cells in culture reveal that their DNA has become fragmented and a specific protein was released. Which of the following choices corresponds to the chronology of events for these cells?

a) IP3 releases Bak/Bax from the ER → Ca2+ rises in cytosol → PTP pore is opened → cytochrome C is secreted by mitochondria

b) Ca2+ enters the cell → mitochondria and ER increase their uptake of Ca2+ → Bad is released from mitochondria → cytochrome C is activated

c) Bad is dephosphorylated → BCl2 is inactivated → IP3-gated Ca2+ channel is opened → cytochrome C is released from mitochondria

d) Bad is activated → Ca2+ is released from the mitochondria → cytochrome C increases in cytoplasm → loss of cellular adhesion is observed

14. Which of the following statements best describes how transmembrane receptors depend on membrane structure for stability and efficiency:

a) The membrane does not influence transmembrane receptors

b) The receptors are located in areas with less fluidity to offer more structural support

c) The receptors are located in areas with similar fluidity but increased thickness

d) The receptors are located in areas with more fluidity to facilitate conformational changes

15. Because of the Wobble effect (oscillation), there is more than one possible _____ for lysine.

a) DNA

b) tRNA

c) mRNA

d) rRNA

e) ribosome

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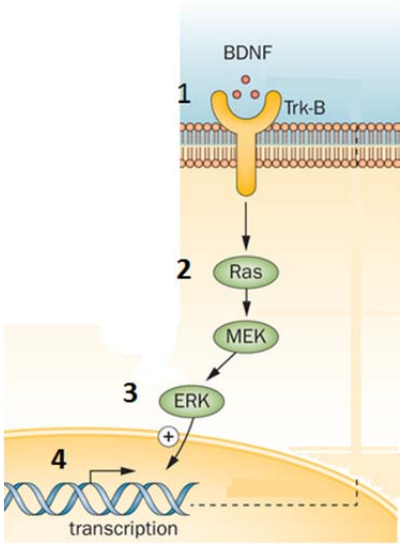
16. Using the diagram below, identify where amplification occurs:



a) At all 4 steps

b) At all steps except step 1

c) At all steps except step 4

d) None of the steps

17. Which of the following statements correctly describes how a steroid-derived messenger would act on its target cell:

a) Binding to a Trk monomer – dimerization and autophosphorylation – activation of MAPK and AP1

b) Binding to a GPCR – activation of $G\alpha_s$ and adenylate cyclase – activation of PKA – binding to CRE in promoter

c) Binding to an intracellular receptor – ligand-receptor complex goes to nucleus – binding to RE in promoter

d) Binding to transmembrane receptor – change in conformation – flow of ions and change in membrane potential

18. 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

19. You have recently designed a technique that allows you to create a fusion between two operons, namely the tryptophan and lactose operons (shown in the figure below) and express it in a strain of bacteria.

Trp regulatory region (promoter and operator)	trp E	trp D	trp C	lac z	lac y	lac a

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

a) None of the genes will be transcribed

b) Only when lactose is present

c) Only when lactose and glucose are present

d) Only when tryptophan is absent

e) Only when tryptophan is present

20. Which of the following choices does not correspond to a similarity between prokaryotes and eukaryotes regarding initiation of transcription?

a) It depends on protein recognizing consensus sequences in the promoter

b) Chromatin must be modified for the promoter to be accessible

c) Transcription is carried out by an RNA polymerase

d) The 3' to 5' DNA strand is the template strand

YOU HAVE COMPLETED SECTION A

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

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Section B – General knowledge (Total 12 marks)

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

1. Define *proton motive force* and provide an example of how the cell benefits from it. (2 marks)

- The potential energy from a gradient of ions built up across a membrane (0.5 marks)
- is used to drive an energy-dependant process. (0.5 marks) – Note: Does not necessarily have to make ATP

For example: The H+ ion gradient in the mitochondrial intermembrane space powers the F1 ATPase to phosphorylate ADP to ATP in matrix (1)
Or
Same in thylakoid lumen of chloroplast to produce ATP in stroma (1)

2. Explain how the α_s (alpha) subunit of a G-protein is activated. (2 marks)

- The GPCR binds a ligand and changes conformation which recruits the heterotrimeric protein (α, β, and γ) (0.5 marks – need all three for marks)
- When the α subunit interacts with GPCR it changes conformation and exchanges its GDP for GTP (0.5 marks)
- Once bound to GTP the α subunit detaches from the β and γ subunits (0.5 marks)
- the α subunit is now active and able to activate the amplifier enzyme (0.5 marks)

3. What is an amplifier enzyme? Give a description and provide a specific example. (2 marks)

An amplifier enzyme is responsible for producing the signalling cascade's second messenger. (1 mark)

Examples include adenylate cyclase (or AC), GRB2-SOS and phospholipase C (1 mark)

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
- Through development, the same cells die through apoptosis
- Genes and associated proteins identified
- Homologous gene sequences
- Observation of apoptotic events (ex. Blebbing)

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5. Name two reasons why cells use mitophagy: (2 marks)

1 mark each

a) _____To reduce the number of mitochondria_____

b) _____To eliminate damaged or dysfunctional mitochondria_____

6. Briefly describe two different ways cells can terminate a signal transduction cascade: (2 marks)

1 mark each

- Ligand removed /endocytosed by neighbouring tissues or cells
- Ligand digested by extracellular enzymes
- Endocytosis of ligand-receptor complex
- Inactivation of receptor (for example by changing phosphorylation state)
- Inactivation of amplifier enzyme

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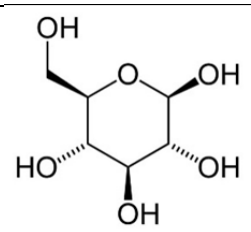
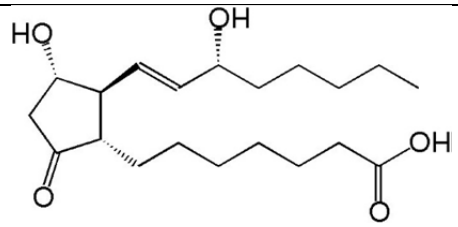
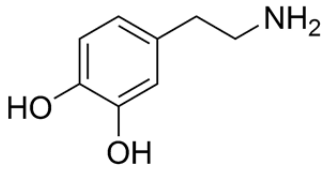
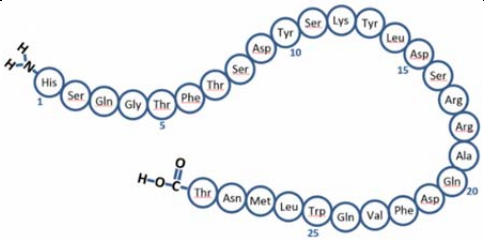
Section C –Associate (Total of 15 marks)

1. Associate the following messenger classes with their most likely communication path: (2 marks)

Messengers	Communication paths
A: 	1. Endocrine
B: 	2. Direct
C: 	3. Paracrine
D: 	4. Neuronal

<u>Indicate the number of the corresponding communication path for each messenger:</u>

A: 2
B: 3
C: 1 OR 3 OR 4
D: 1

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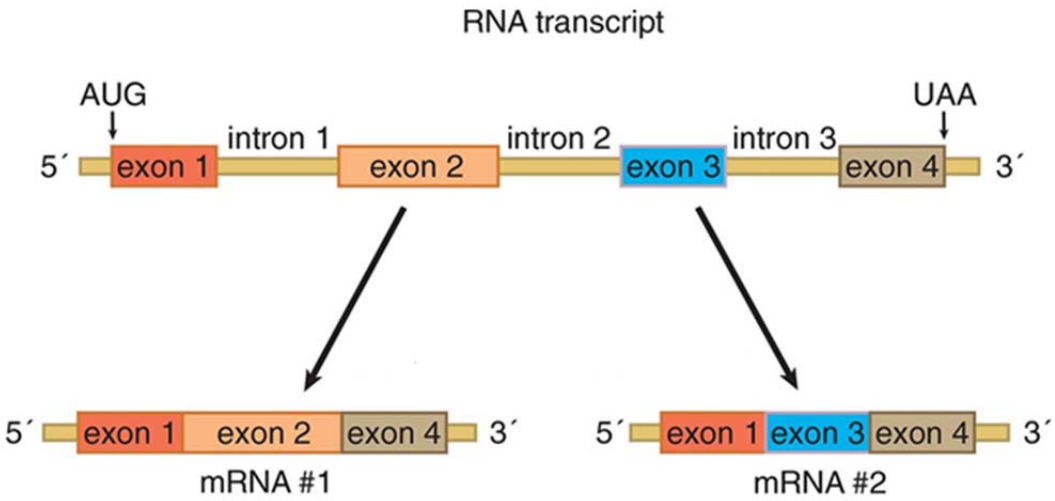
2. The image below represents an important mechanism in genetic expression. Name this mechanism **and** provide an explanation of all the steps that occurred to achieve mRNA#1 and mRNA#2 depicted in the diagram. (5 marks)



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

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3. There are at least 4 post-transcriptional gene regulation mechanisms in eukaryotes. One of them involves the cell interfering with its mRNA. Name this process and explain the steps involved in this process **and** provide an example of a consequence for the cell. (5 marks)

- RNA interference (1 mark)

Maximum 4 marks from elements listed below:

- A miRNA gene is transcribed and due to high base-pairing produces a pre-miRNA that is a hairpin loop (1 mark)
- In the cytoplasm, DICER will bind this pre-miRNA, cleave the stem-loop, recruit a protein complex which contains an enzyme that degrades one of the 2 miRNA strands (1 mark)
- This forms the miRNA Induced Silencing Complex (RISC or miRISC) (1 mark)
- This miRNA has the ability to base pair with mRNA:
    - If the pairing is perfect, the mRNA will be directed to degradation – the consequence for the cell is the absence of translation of that mRNA into its protein (1 mark)
    - If the pairing is imperfect, then the mRNA will remain bound to the RISC miRNA and will eventually be released and able to convert to translation – the consequence to the cell is a delay in obtaining that protein (1 mark)

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4. You have grown epithelial cells in culture, and some of them appear to be dying. Describe 2 manipulations that you could do experimentally and what observations each result should provide for you to be able to conclude the mechanism by which those cells are dying. (3 marks)

Mark the first 2 manipulations described.

- Microscopy (any type of phase contrast – Nomarsky, dark field) to observe structural changes to the cell membrane and / or organelles (0.5 marks)
  - condensation and blebbing would indicate apoptosis (0.5 marks)
  - swelling and membrane degradation or loss of integrity would indicate necrosis (0.5 marks)
- Fluorescent labelling of cytoplasmic proteins such as caspases or calpain and cathepsin, or complexes such as apaf-1, combined with fluorescence microscopy to quantify their presence (0.5 marks)
  - high activated caspases and apaf-1, presence of cytochrome C in cytosol would indicate apoptosis (0.5 marks)
  - calpain or cathepsin would indicate necrosis (0.5 marks)
- Measuring membrane potential (0.5 marks)
  - normal values expected for apoptosis (0.5 marks)
  - significant changes to membrane potential (higher in mitochondria, lower for cell) indicative of necrosis (0.5 marks)
- Quantification of phosphatidylserine in outer leaflet of membrane
  - Some quantity would be indicative of apoptosis (0.5 marks)
  - None would be indicative of necrosis (0.5 marks)
- Flippase activity (phospholipid translocating proteins)
  - would be indicative of apoptosis (0.5 marks)
  - no activity indicative of necrosis
- Addition of growth factor to cells or BCL2 to cytoplasm (0.5 mark)
  - Apoptosis would downregulated or eliminated therefore no cell death (infer the effect of necrosis if necrosis is mentioned) (1 mark)
- Quantification of cytosolic levels of calcium
  - Apoptosis: extremely high level in cytosol
  - Necrosis: low levels/normal of calcium

Any other feasible and plausible manipulation with predicted result is acceptable.

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Section D – Long answer question (10 marks)

1. Anesthesiologists often use a compound similar to acetylcholine, in order to **relax** the skeletal muscles. Using your knowledge of the ACh signalling cascade, propose a detailed explanation of the signal transduction cascade responsible for the observed muscular response with the alternate compound. (10 marks)

Maximum of 10 marks

Similar compound:

- The alternate compound is an antagonist of ACh (1 mark)
- It binds to the same ligand gated ion channel, and depolarizes the membrane (1 mark)
- but is not degraded by acetylcholinesterase, preventing further ACh from binding to receptor and depolarizing the membrane (1 mark)
- and obtaining subsequent muscle contractions keeping the muscle in a relaxed state. (1 mark)

ACh pathway:

- When ACh binds to the nicotinic receptor (1 mark)
- it depolarizes the membrane due the flow of Na+ into the cell. (1 mark)
- This depolarization leads to opening of voltage gated Na+ sodium channels further depolarizing the membrane and initiates an action potential. (1 mark)
- This leads to opening of voltage-gated calcium channels on ER. (1 mark)
- Ca2+ binds to troponin, change of conformation leads to displacement of tropomyosin, (1 mark)
- marking the myosin binding sites on actin available and muscle contraction can occur. (1 mark)
- Ca2+ reuptake in ER via SERCA allows muscle to relax. (1 mark)

You have completed the second midterm exam!

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Remarking procedure: For a complete description of the remarking process, visit the BBLearn course website (Course syllabus, registrations and policies -> Asking for an exam to be remarked). All midterm/final exam remarking appeals must be handed in prior to the deadline specified to Marc Charette (GNN 281), without exception, and will be remarked by Marc Charette. Remarking can increase, decrease or result in no change to the mark originally awarded. Tips and tricks for enabling a quick and easy remark: 1. Please note that it is key to clearly identify your issue in your written statement and clearly identify the question that is to be remarked. 2. It is best achieved by referencing the statements you made on the exam with the contents of the marking scheme (e.g. I said this and the marking scheme says that). This clearly identifies your issue with the marking and generally leads to better results when remarking. Things to avoid when asking for a remark: 1. Please avoid making written statement that employs reasoning that is something to the effect of: "I feel I deserve/would like more marks", as these requests will be ignored.2. Not providing a rational for the remarking of a question or simply asking to have the question remarked. Again, these requests will be ignored. When the remarking process is complete, you will be notified via an announcement on the course website. Therefore, please do not contact us regarding the progress of the remarking process.

REMARKING REQUESTS: