BIO1140 Introduction to Cell Biology

Professor: Dr. Caroline Petit-Turcotte

Midterm Exam 2 – Version FF: Saturday March 21st, 2015

PLEASE DO NOT OPEN EXAMS UNTIL YOU ARE INSTRUCTED TO DO SO.
MAKE SURE YOU HAVE A COMPLETE EXAM PACKAGE – 1 QUESTIONNAIRE (13 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 on the first page, and write your student number in the space provided on all subsequent pages.
4. You should only have writing material and this exam on your desk, nothing else.
5. When you have finished, raise your hand and a TA will come pick up your exam. Please remain in your seat during the last 15 minutes.

Part A Instructions (20 marks): Multiple Choice.

1. Use pencil. 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 Scantron sheet.
2. Follow instructions on the computer Scantron sheet. – Make sure you include your student name and number, and the exam version; BIO1140FF.
3. The answer on your Scantron is the answer that will be marked. Make sure you fill in your answers on the Scantron before the time for the exam is up. You will NOT be given extra time to do so. Answers not appearing on the Scantron will not be marked

Parts B-D Instructions (54 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.

Good luck!

Student Name: _____CORRECTION KEY_____

Student Number: _____

Version FF 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. Which of these is translocated to the outer leaflet of the plasma membrane to trigger phagocytosis?

a) Phosphatidylethanolamine

b) Sphingomyelin

c) Phosphatidylserine

d) Phosphatidylcholine

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

a) Paracrine

b) Endocrine

c) Exocrine

d) Autocrine

3. Which one of the following cellular consequences is not related to caspases?

a) Initiate DNA fragmentation

b) Cytoplasm and cell size shrinking

c) Loss of ATPase activity

d) Disrupt cell adhesion and initiate blebbing

4. If you were to look at cells undergoing cell death to compare necrosis and apoptosis, which of these observations would you expect to see in necrotic cells:

a) Decaying mitochondria

b) Rearrangement of the cristae

c) Loss of adhesion

d) Condensation of the nucleus

5. Cellular communication can be organized in three key steps. Which of these statements is NOT relevant to one of them?

a) The signal is relayed to effectors in the cell

b) A ligand is received by the target cell

c) The number of mitochondria must increase

d) The target cell initiates changes to address the signal

6. Which one of these chemical messengers is able to interact with transmembrane AND intracellular receptors?

a) Adrenalin

b) Nitric oxide (NO)

c) Insulin

d) Acetylcholine

7. 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

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

8. Which of these types of proteins would be the ideal candidate to act as a ligand-gated ion channel?

a) Monomeric integral protein

b) Prenyl-anchored protein subunits

c) Calcium binding protein

d) Multiple protein subunits within the membrane

9. Which of these is not an efficient mechanism to end cellular communication?

a) Activation of a gene transcription factor

b) Degradation of the ligand

c) Inactivation of the receptor by phosphorylation

d) Endocytosis of the receptor-ligand complex

10. When mitochondria become damaged, what proteins, **in order**, will they express on their surface to trigger their transfer to the lysosome?

a) Plik and Plak

b) Ubiquitin and Pink

c) Pink and Parkin

d) Parkin and Pink

11. What is the coordination of cellular pathways aimed at avoiding futile and contradictory cycles called?

a) Agonism

b) Inhibition

c) Synergism

d) Antagonism

12. How did Hershey and Chase demonstrate that DNA is responsible for heredity?

a) By tracking ^{35}S radiolabelled DNA in *E.coli* and in progeny phages

b) By using virulent strains of *Streptococcus pneumonia* in mice

c) By tracking ^{32}P radiolabelled DNA in *E.coli* and in progeny phages

d) By using non virulent strains of *Streptococcus pneumonia* in mice

e) None of the above

13. Within DNA, nucleotides arrange themselves in a specific pairing. What is the proper pairing and why is it the only possible arrangement?

a) Purine and Pyrimidine; because the diameter of the helix must be greater than 2 nm

b) Purine and Pyrimidine; because the diameter of the helix must be approximately 2 nm

c) Purine with Purine; because this is the only conformation that leads to a helix

d) Pyrimidine with Pyrimidine; because this is the only conformation that leads to a helix

e) None of the above

14. During elongation, each additional nucleotide is added to the strand….?

a) … by joining its phosphate group to the 3rd C of the deoxyribose

b) … by joining its phosphate group to the 5th C of the deoxyribose

c) … by joining the nitrogenous base to the 3rd C of the deoxyribose

d) … by joining the nitrogenous base to the 5th C of the deoxyribose

e) None of the above

15. The flow of genetic information can only occur in a single direction according to the Central dogma of molecular biology. Therefore, which of these statements is accurate?

a) Translation –> Replication –> Transcription

b) Transcription –> Replication –> Translation

c) Translation –> Transcription –> Replication

d) Replication –> Transcription –> Translation

16. Watson and Crick had a pretty good idea as to how DNA was able to replicate itself, but lacked the tools to prove it. A few years later, who was able to design an experiment to prove the replication model?

a) Hershey and Chase

b) Meselson and Stahl

c) Griffith and Frederick

d) Avery and Franklin

17. Which of these statements describes the role of the primase?

a) Assemble a short sequence of RNA 5’ to 3’ to recruit the DNA polymerase

b) Assemble a short sequence of RNA 3’ to 5’ to recruit the DNA polymerase

c) Assemble a short sequence of DNA 5’ to 3’ to recruit the DNA polymerase

d) Assemble a short sequence of DNA 3’ to 5’ to recruit the DNA polymerase

e) None of the above

18. G-proteins are actually three protein subunits. Which of the three is/are NOT directly involved in the cAMP pathway?

a) The beta (β) subunit

b) The gamma (γ) subunit

c) The alpha (α) subunit

d) Both a and b are correct

19. How can incorrectly mismatched nucleotides be corrected?

a) Nucleotide excision repair

b) Telomeric extension

c) Restriction enzymes

d) They cannot be corrected

20. What is the most powerful technique to produce a large number of copies of a target DNA sequence?

a) A Xerox machine

b) Cloning

c) Polymerase chain reaction

d) X-ray crystallography

You have completed section A; please continue to the next page for sections B to D.

Version FF Student number: _____

Section B – General knowledge (1 mark each – Total 7 marks)

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

1. Which type of cell death involves cellular lysis?

_____Necrosis_____

2. Define mitophagy:

Controlled regulation of the number of mitochondria AND removal of damaged mitochondria
Both elements necessary for full marks, if one present 0.5 marks

This is NOT programmed cell death, as mitochondria are not a cell

3. What are lipid rafts and why are they relevant for cellular signalling?

They are microdomains (accept small areas or regions) of the membrane that are rich in sphingolipids and cholesterol. (0.5 marks – both sphingolipids and cholesterol MUST be present for marks)

Accommodate long or large transmembrane domains/proteins/receptors (0.5 marks)

4. Define an Okazaki fragment?

Short complementary strand of DNA obtained by discontinuous replication – (1 mark)

OR

make up the lagging strand – due to the orientation of the parental strand (0.5 mark)

5. Once the RNA primers have been removed, which enzyme is responsible to seal the nicks left on the DNA strand?

____DNA ligase___ OR ligase (0.5 marks)_____

6. Name 2 of the 6 ways to end a signal transduction cascade: (2 marks)

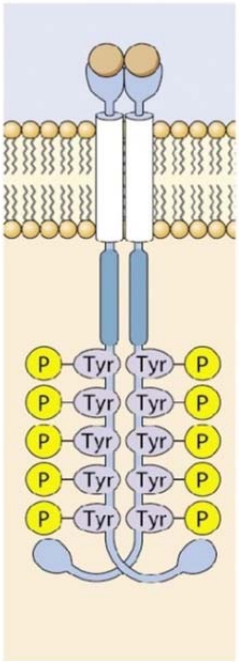
Name 2 of these 6 possible answers:

- Ligand removed by neighbouring/distant tissue
- Ligand/receptor removed by endocytosis
- Ligand degraded by extracellular enzymes
- Ligand taken up by adjacent cells
- Inactivation of signal transduction pathway
- Inactivation of the receptor

Section C – Fill in the blanks / Associate (1 mark each – total of 37 marks)

1. Complete the following sentences using the most appropriate term: (10 marks)

a. Using the following figure, fill in the blanks:



In order to become activated, this type of receptor, a member of the ____receptor-enzyme/receptor-enzyme [tyrosine kinase = 0.5 marks; as it is not a class of transmembrane receptors]_____ (2 words) class of transmembrane receptors will have bound its ligand. This leads to the __dimerisation/dimer formation_____ of the receptor monomers. This enables the receptor to __autophosphorylate (accept self-phosphorylate, DO NOT accept only phosphorylate)_____ specific amino acids in its catalytic domain to become fully active. It can now interact with proteins that have a specific structural conformation domain, named the ___SH2____ domain, such as for example this protein _____PLC or PI3K [PI3 = 0.5 marks]_____ that can bind directly without the use of adaptor proteins. The activation of this type of receptor is associated with cellular responses such as ___growth OR survival OR differentiation OR division OR increased metabolism [gene transcription or gene regulation = 0.5 marks]____.

b. A chemical substance that fits into a specific binding site on the surface of an integral protein is called a __ligand_____. This induces a change of _conformation___ for that protein.

c. DNA replication is accomplished by first unwinding the DNA. The enzyme _helicase_____ carries out this important task. The addition of nucleotides on the daughter strand is always done at the __3'_____ end.

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

a) ____The sugar ribose (and not deoxyribose)_____

b) _____Single strand helix (not double strand)_____

c) ____No Thymine only Uracil_____

Functional elements are not accepted

3. Compare the two following receptors by completing the table below. (3 marks)

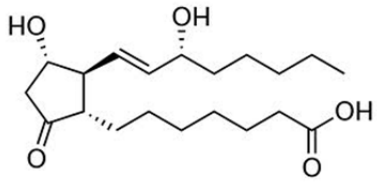
Criteria	**Intracellular receptor**	**Tyrosine kinase receptor**
Ligand properties	Hydrophobic or lipophilic Small able to diffuse across membrane	Hydrophilic Can't diffuse into membrane (terminology must be precise)
Main result of receptor activation (signal transduction mechanism)	Ligand and receptor act as a transcription factor and bind to regulatory elements to change gene transcription	Activation of effector protein Intracellular responses OR changes to gene transcription MAPK + gene transcription Regulation of IP3 ion gated channels on ER Maintain Bcl2 active Maintain Bad phosphorylated therefore inactive
Example of a cellular response obtained	Reduction of insulin transcription as a result of cortisol (any valid example is accepted; steroid response elements and sex hormonesl aldosterone, retinoids, etc.)	Calcium release Activation of gene transcription Survival via Bcl2 Inhibition of apoptosis Cell growth Production of eicosanoids

Version FF Student number: _____

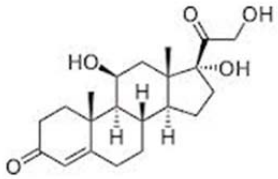
4. Associate the following molecular structures with the chemical messenger classes (3 marks) :

Chemical messenger classes	Choice of molecular structure
Purine	E
Gas	D
Eicosanoid	A
Amine	F
Peptide	C
Steroid	B

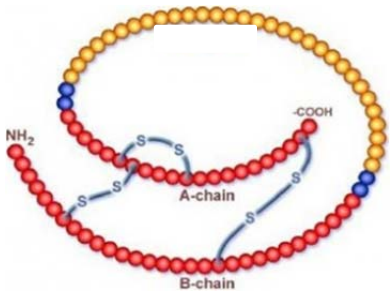
A)



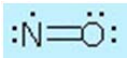
B)



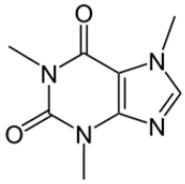
C)



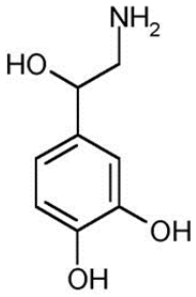
D)



E)



F)



Version FF Student number: _____

5. You must convince your colleagues that you have confirmed which of the three DNA replication models is correct. Name the three DNA replication models, name the correct model and explain your experimental approach to validate the correct model (6 marks)

1 mark total for naming models (if 3 correct give 1 mark, if a minimum of 1 is correct give .5 marks)

- Semi conservative
- Conservative
- Dispersive

Meselson Stahl experiment (1 mark for each element):

- Grow bacteria in 15N medium – nitrogenous bases have now incorporated 15N during DNA replication/cell division
- Transfer some bacteria to a 14N medium and allow bacteria to replicate (taking samples after time required for one and then 2 cell division cycles).
- Compare the N composition (or can be implied by looking at different bands) of DNA by using sediment centrifugation
- Compare the DNA of the parent generation and 2 subsequent generations; parent should be all heavy 15N; 1st gen will have 1 15N and 1 14N strand and then 2nd gen will have 2 identical to 1st gen. and 2 completely 14N.
- This can only occur following the semi-conservative model OR semi-conservative model is correct

Please note that students can use the terms heavy/light nitrogen to replace 15N and 14N respectively.

6. Here is a strand of DNA. You must identify on the strand where replication of the complementary strand would begin, list the steps and enzymes that will carry it out, and provide the sequence of the complementary strand obtained. (5 marks)

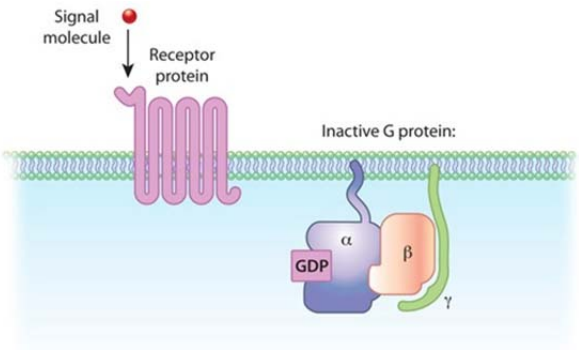
5’ TGCAGTCGATCGGTA 3’

0.5 marks for indicating replication start site (red arrow). We want a sense that replication starts at the 3’ end of the template strand or the 5’ end of the newly replicated strand.

1. Primase places an RNA primer (concept of RNA needs to be present)
2. DNA polymerase III (accept 3) and sliding clamp protein recognize double strand portion and begin completing the complementary strand (sliding clamp necessary for full marks)
3. Once complete, DNA polymerase I (accept 1) will replace each RNA nucleotide for a DNA nucleotide
4. DNA ligase (accept ligase) will seal the nick left behind by DNA pol I (if other bond than phosphodiester named, deduct 0.5 marks)

Obtained sequence: 3’ ACGTCAGCTAGCCAT 5’ (0.5 marks – all or nothing – orientation needs to be present for marks)

7. Completing the image below, describe the cellular signaling mechanism that will occur for a cell that receives a ligand bringing a pain message, such as glutamate. Be sure to describe all the steps of the signalling mechanism leading to the cell's response by producing local mediators of pain, eicosanoids. (7 marks)



1. Binding of ligand then changes conformation and recruits/activates the G-protein
2. The alpha subunit exchanges its GDP for GTP and in turn changes conformation (the exchange needs to occur prior to step 3, if mentioned after step 3 deduct 0.5 marks)
3. allowing it to dissociate from beta and gamma subunits
4. α-Gprotein moves to phospholipase C and activates it (this is the amplifier enzyme) OR alpha subunit amplifies phospholipase C
5. Phospholipase C cleaves PIP2 and releases/cleaves second messengers DAG and IP3 (concept of release/cleaving needs to be present for full marks)
6. DAG remains membrane bound and is further modified by phospholipase A2 into arachidonic acid
7. Arachidonic acid will be further processed in the cyclooxygenase pathway to produce pain mediators such as prostaglandins (if arachidonic acid makes prostaglandins, 0.5 marks)

- NOTE: If student used the lipoxygenase pathway to produce leukotrienes, give only 0.5 marks for last point
  - The lipoxygenase pathway is also a way to obtain eicosanoids from arachidonic acid, but this leads to leukotrienes, messengers involved in mediation of inflammation, not pain
  - There are no part marks for stating that arachidonic acid makes leukotrienes
  - If more than one pathway described **ONLY** mark the first pathway described

Version FF Student number: _____

Section D – Long answer questions (10 marks)

1. **Draw** a cell and the relevant organelles, receptors, etc. to explain the relationship between calcium regulation and the intrinsic pathway of apoptosis. Make sure your all the elements of your drawing are clearly labelled. You must include a written explanation to complement your drawing. (10 marks)

Drawing should have a the following elements clearly labelled: (2 marks total – each element 0.5 marks) Elements must be clearly labelled to receive marks.

- 1 point of entry for calcium at the plasma membrane (voltage-gated, ligand gated, etc),
- Calcium in ER and mitochondria
- Mitochondria
- Endoplasmic reticulum
- Channel on ER

Trigger of Apoptosis - (1.5 marks - .5 marks for each element)

- Trigger for apoptosis (stress, absence/inactivation of growth factor, toxin, hormone, cytokine, etc…)
- Dephosphorylation of Bad to activate intrinsic apoptotic cascade
- Bad activates Bax/Bak

Signalling cascade

- This leads to changes in affinity of IP3-gated calcium channel on ER (Bax/Bak facilitate IP3 binding to that channel and releasing calcium from ER – NOT necessary for full marks) (1 mark)
- Bcl2 was reducing that affinity and keeping calcium inside ER) (1 mark)
- Calcium released from ER will be taken up by mitochondria (1 mark)
- When concentration of calcium in mitochondria is too high, the cristae will rearrange (0.5 marks) and the PTP (permeability transition pore) will be formed (0.5 marks) allowing
- Cytochrome c released by mitochondria (1 mark)
- Cytochrome C will bind to Apaf-1 and caspase 9 to form apoptosomes (1 mark) – cytochrome c linked to apoptosome formation (0.5 marks)
- Apoptosomes will allow activation of the caspase cascade (1 mark)
- that leads to apoptosis (evidence: cytoskeletal and cytoplasmic shrinkage, nuclear fragmentation, blebbing, phagocytosis of apoptotic bodies) (1 example necessary - 0.5 marks)
- Caspases and calcium allow to activate Scramblase/flippase – the enzyme that allows to increase the expression of phosphatidylserine on the outer membrane and label for phagocytosis (0.5 marks)

You have completed the second midterm exam. Home stretch to the final begins!