

BIO1140 Introduction to Cell Biology

Professor: Dr. Caroline Petit-Turcotte

Midterm Exam 2 – Version C: Monday March 19th, 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 C**) 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: _____

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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 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 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 of these statements is false regarding the inner and outer membranes of mitochondria?

- a) The inner mitochondrial membrane is the main site of ATP generation.
- b) The inner membrane is mainly composed of proteins, which are involved in oxidative phosphorylation and transportation of pyruvate and fatty acids.
- c) Like the outer membrane, the inner mitochondrial membrane contains many porins to allow entry of pyruvate and fatty acids into the matrix.
- d) The outer membrane is more permeable to ions and small molecules than the inner membrane of mitochondria.
- e) None of the above

3) Which of the following is an example of potential rather than kinetic energy?

- a) the muscle contractions of a person mowing grass
- b) water rushing over Niagara Falls
- c) light flashes emitted by a firefly
- d) a molecule of glucose
- e) the flight of an insect foraging for food

4) When a molecule of NAD⁺ (nicotinamide adenine dinucleotide) gains a hydrogen atom (not a proton), the molecule becomes

- a) dehydrogenated.
- b) oxidized.
- c) reduced.
- d) redoxed.
- e) hydrolyzed.

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5) The ATP made during glycolysis is generated by:

- a) substrate-level phosphorylation.
- b) electron transport.
- c) photophosphorylation.
- d) chemiosmosis.
- e) oxidation of NADH to NAD⁺.

6) Assume a thylakoid is somehow punctured so that the interior of the thylakoid is no longer separated from the stroma. This damage will have the most direct effect on which of the following processes?

- a) the splitting of water
- b) the absorption of light energy by chlorophyll
- c) the flow of electrons from photosystem II to photosystem I
- d) the synthesis of ATP
- e) the reduction of NADP⁺

7) What does the chemiosmotic process in chloroplasts involve?

- a) establishment of a proton gradient across the thylakoid membrane
- b) diffusion of electrons through the thylakoid membrane
- c) reduction of water to produce ATP energy
- d) movement of water by osmosis into the thylakoid space from the stroma
- e) formation of glucose, using carbon dioxide, NADPH, and ATP

8) Protein kinases are enzymes that catalyze phosphorylation of target proteins at specific sites, whereas protein phosphatases catalyze removal of phosphate(s) from phosphorylated proteins. Phosphorylation and dephosphorylation can function as an on-off switch for a protein's activity, most likely through

- a) the change in a protein's charge leading to a conformational change.
- b) the change in a protein's charge leading to cleavage.
- c) a change in the optimal pH at which a reaction will occur.
- d) a change in the optimal temperature at which a reaction will occur.
- e) the excision of one or more peptides.

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

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

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10) 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.

zyp E	zyp regulatory region (promoter and operator)	zyp D	zyp C	mal z	mal y	mal a
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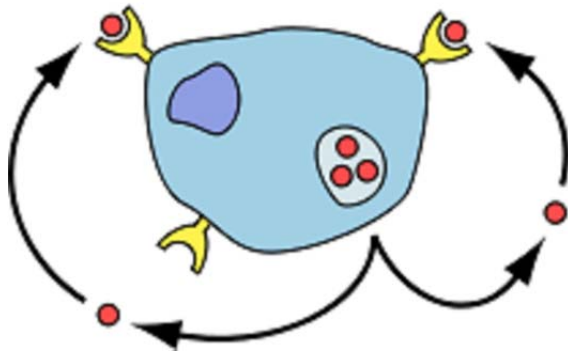
Under which of the following conditions do you expect your bacteria to be able to express the enzyme permease (whose gene is zypE)?

- a) zypE will not be transcribed
- b) Only when malactose is present
- c) Only when malactose and zryptophan are present
- d) Only when zryptophan is absent
- e) Only when zryptophan is present

11) You wish to design an experiment that will specifically prevent the G-protein-coupled receptor interaction with the α -subunit. Where would you direct your blocking agent?

- a) The extracellular domain of the receptor
- b) The transmembrane domain of the receptor
- c) The intracellular domain of the receptor
- d) The amino acid sequence in the binding site for the G protein
- e) All of the above

Use the following figure to answer questions 12 and 13 below.



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

- a) autocrine
- b) paracrine
- c) hormonal
- d) synaptic

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e) long-distance

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

- a) receptor molecules
- b) peptides (proteins)
- c) neurotransmitters
- d) eicosanoids
- e) pheromones

14) During splicing, which molecular component of the spliceosome catalyzes the excision (removal) reaction?

- a) protein
- b) DNA
- c) RNA
- d) lipid
- e) sugar

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

- a) A protein binds to a receptor dimer; phosphorylation of 6 tyrosine residues provides the kinase activity of the receptor
- b) A protein binds to an intracellular ligand binding domain; a membrane bound effector is recruited; the kinase activity of the receptor is functional
- c) Protein ligands bind to 2 monomeric subunits; dimerization leads to autophosphorylation of 6 tyrosine residues; the kinase activity of the receptor is functional
- d) Protein ligands bind 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

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

- a) A sigma factor binds to the promoter
- b) Elongation of the mRNA occurs at the 5' end
- c) DNA polymerase separates the DNA strands for RNA polymerase to begin transcription
- d) Transcription can begin as soon as translation has begun even a little.
- e) RNA polymerase requires a primer to elongate the molecule.

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- 17) Which of the following represents a function of the poly-A signal sequence?
- a) It adds the poly-A tail to the 5' end of the mRNA.
 - b) It is part of the mechanism to allow release of the mRNA through the nucleoporins**
 - c) It allows the 3' end of the mRNA to attach to the ribosome.
 - d) It is a sequence that codes for the hydrolysis of the RNA polymerase.
 - e) It adds a 7-methylguanosine cap to the 3' end of the mRNA.
- 18) In eukaryotic cells, transcription cannot begin until
- a) the two DNA strands have completely separated and exposed the promoter.
 - b) several transcription factors have bound to the promoter.**
 - c) the 5' caps are removed from the mRNA.
 - d) the DNA introns are removed from the template.
 - e) DNA nucleases have isolated the transcription unit.
- 19) In eukaryotes there are several different types of RNA polymerase. Which type is involved in transcription of mRNA for a ribosomal protein?
- a) ligase
 - b) RNA polymerase I**
 - c) RNA polymerase II
 - d) RNA polymerase III**
 - e) primase
- 20) Which components of the following transcript will be found in the mRNA in the cytosol?
- Transcript: 5' UTR Exon₁-Intron₁-Exon₂-Intron₂-Exon₃-Intron₃-Exon₄ UTR 3'
- a) 5' UTR Intron₁ Intron₂ Intron₃ UTR 3'
 - b) 5' Exon₁ Exon₂ Exon₃ Exon₄ 3'
 - c) 5' UTR Exon₁ Exon₂ Exon₃ Exon₄ UTR 3'**
 - d) 5' Intron₁ Intron₂ Intron₃ 3'
 - e) 5' Exon₁ Intron₁ Exon₂ Intron₂ Exon₃ Intron₃ Exon₄ 3'

Make sure you have transcribed all your answers to your Scantron

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

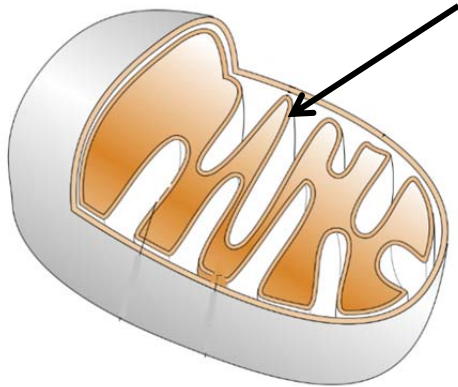
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Section B – Written answers ()

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: _____ **Cristae (0.5 mark for inner mitochondrial membrane)** _____



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

	Statement	Example
A	An amplifier enzyme	Adenylate cyclase, phospholipase C (produces second messenger)
B	Guanine exchange factor	Sos
C	Adaptor protein	Grb2
D	Second messenger	Ras, cAMP, IP3, DAG, Ca²⁺ etc.

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

in mitochondria; in the inner mitochondrial membrane (1 mark) OR
in chloroplast; in the thylakoid membrane (1 mark)
that carry electrons or perform redox reactions to a final electron acceptor molecule (1 mark)

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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

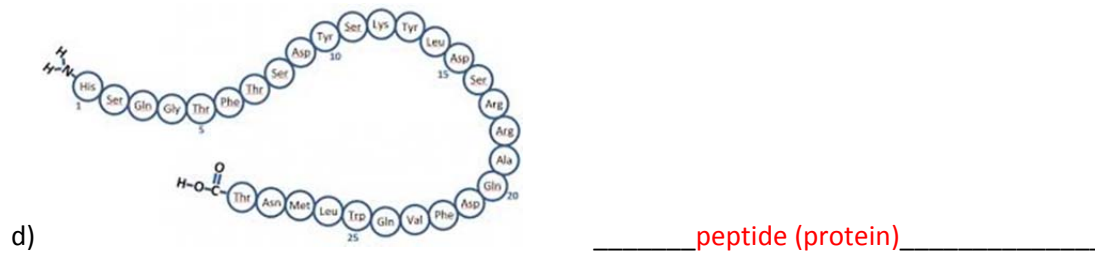
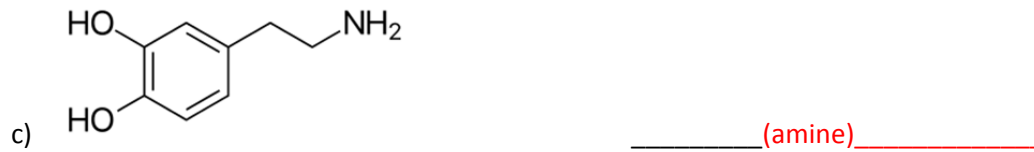
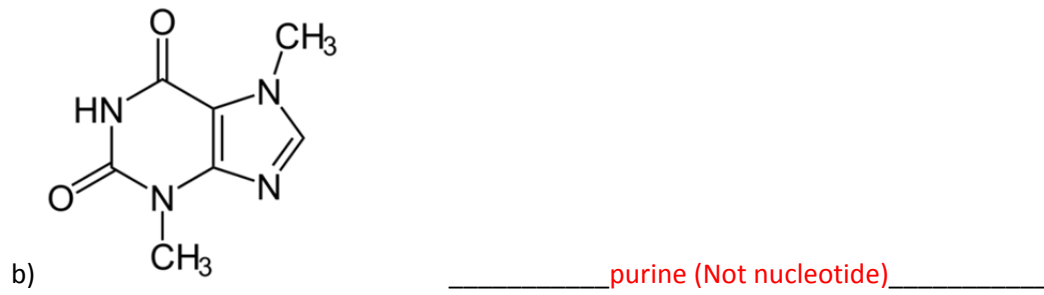
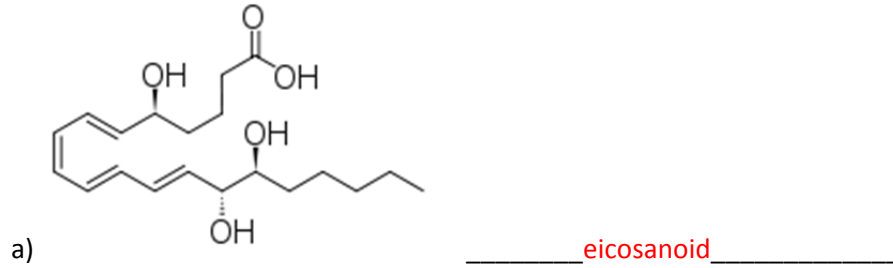
- Same number of cells in each organism (131 cells = 0.5 marks)
- Development of each cell and progeny is well known OR the same cells die through apoptosis
- Genes and associated proteins involved are identified
- Genes and associated proteins involved have conserved homologs in most species

5. Explain the role of activators and repressors. (2 marks)

Activators bind to enhancer regions and repressors bind to silencer regions of TIC (Transcription initiation complex).
They are proteins that can modulate transcription: activators increase and repressors decrease transcription

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



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7. A mouse's kidney 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 kidney? 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 GTP, how would you interpret what is depicted in the picture?

GTP acts as an intermediary to store energy for cellular work. OR
GTP provides the energy necessary to activate Rho.

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

Cells use readily available GTP/GDP to control the activity status of the molecular switch

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

Many possible answers;
Molecular switches are used as second messengers (for example Rho, Ras), intermediary proteins (for example Galpha subunit), involved in signal transduction

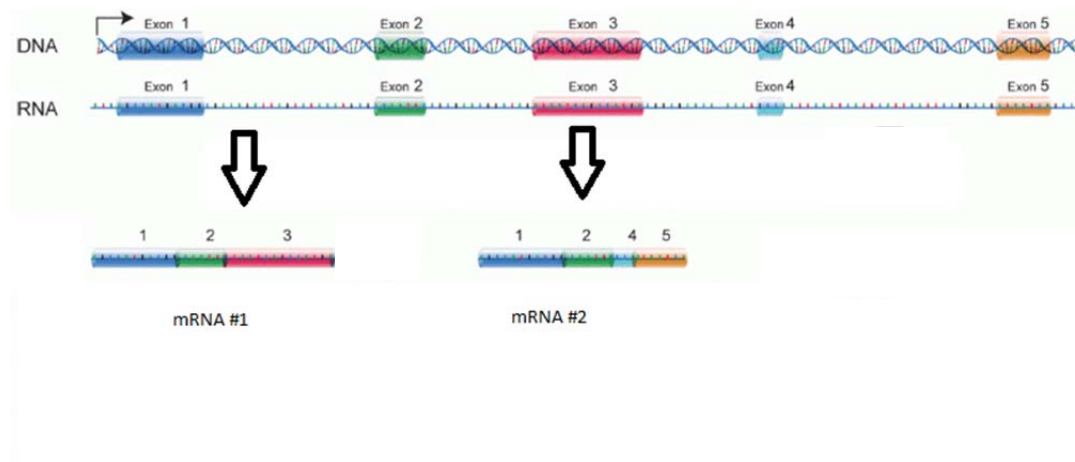
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9. Which of the following is a *correct* association? T or F Justify if F (4 marks)

	T (True) or F (False)	Justify if False (F)
SH2 domain and GPCR ligand binding	F	Tyrosine kinase receptors and adaptor proteins, not ligands
Phosphodiesterase activity and conversion of cAMP to AMP	T	
GTPase activity and phosphorylation of GDP to GTP	F	Hydrolysis of GTP to GDP or no phosphorylation but rather exchange of GTP for GDP
Adenylyl cyclase activity and conversion of ATP to ADP	F	Adenylyl cyclase responsible for ATP to cAMP

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10. The image below represents an important mechanism in gene expression. Name this mechanism **and** provide an explanation of all the steps that occurred to achieve these 2 mRNAs (mRNAs #1 and #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

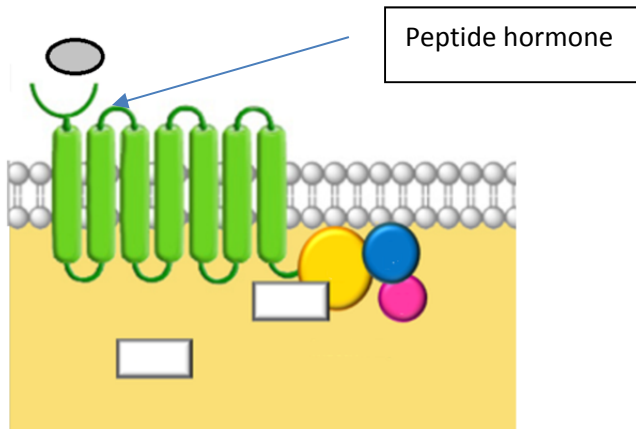
The difference between mRNA #1 and #2 is the sequences the snRNPs recognized:

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

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

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



1 mark for complete, labelled and accurate drawing

6 marks from elements below 1 mark each):

- Peptide hormone binds to GPCR
- Change in conformation recruits heterotrimeric G protein
- Alpha subunit exchanges GDP for GTP, changes conformation and dissociates from beta and gamma
- G α binds to PLC β and activates it,
- PLC β cleaves PIP₂ into DAG and IP₃
- IP₃ binds to IP₃ gated Ca²⁺ channel on ER and allows release of Ca²⁺
- DAG and Ca²⁺ together activate PKC, which in turn phosphorylates target proteins
- Ca²⁺ can bind to calmodulin and lead to various cellular responses

Examples of cellular response: (1 mark)

Activation of transcription factor to increase expression of protein

Production of eicosanoids in pain/inflammatory response

Calmodulin involved in learning, memory, smooth muscle contraction, etc.

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12. A cell's growth is maintained by binding growth factors that maintain production of specific proteins. In the absence of this information, the cell will die. Name the process and describe the steps leading to its demise. (6 marks)

Apoptosis (1 mark)

Name of the process: Apoptosis (1 mark)

5 elements out of the 8 below:

- 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 Ca²⁺
- Mitochondria takes up Ca²⁺ (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, activate scramblase and flip phosphatidylserine to outer layer of membrane, blebbing, formation of apoptotic bodies.

Congrats! You have completed the second midterm exam.