

General Microbiology BIO 3124

Midterm 1

October 7<sup>th</sup> 2020 – October 8<sup>th</sup> 2020

Introduction:

Please read all instructions below carefully before beginning the midterm.

General instructions:

Please read all questions carefully and answer all questions.

Mechanisms should be described using proper terminology where feasible and please include concise definitions of any key terms.

Please write in full sentences and in your own words.

The midterm itself is comprised of 3 sections and all 3 sections must be completed. There are 14 questions, worth a total of 30 points.

Section I – Multiple choice questions (/8).

Section II – Short answers. (/12).

Section III – Long answer. (/10).

Time:

You have 120 mins to complete this midterm during the 24 hours that it is available on Brightspace.

You must answer all questions and submit your answers within the 120 min time frame.




If you have any accommodations for time with SASS, those accommodations have been added for the exam by SASS directly, provided you confirmed your participation for this midterm on VENTUS.

You only get one attempt to do this midterm, no pauses or stops are allowed, so please make sure that you can devote the required time to the midterm before starting.

The due date for this midterm is Oct 8, 2020 by 10:00 am. It will be considered late if it is submitted after the due date and will not be counted.

Resources allowed and academic integrity:

Please refer to the guidelines below:

 <p><b>Individual</b></p> <p>Work individually, without consulting others.</p>	 <p><b>No posting or asking for answers</b></p> <p>At no time may answers be broadly posted.</p>	 <p><b>Open book</b></p> <p>You may only consult your course or lecture notes.</p>
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This is a non-proctored, open book exam.

You may only use your course or lecture notes to answer questions.

My expectation is that you are working independently and without consulting others.

Your work has to be your own and you must answer questions in your own words.

There are serious consequences to committing academic fraud and we will be checking for plagiarism.

Please don't post questions or answers on Brightspace discussion forums during the exam period.

This form can be used to anonymously report an academic integrity issue that has arisen in the course.

Questions:

No questions will be answered during the duration of the exam.

I consider the examination questions to be sufficiently clear. If you do need to make some assumptions in order to respond to the questions, please specify what these assumptions are in your response.

## Technical Issues:

If you are disconnected from your quiz or exam, try to reconnect immediately. Then, to keep track of the problem for us and technicians, please fill out the [Brightspace support form](#) as soon as possible with the following details:

The approximate time of your disconnection

The browser you are using

The type of computer (PC, Mac, Linux)

The name of your Internet provider

You can also call the following number: 1-866-811-3201

NOTE: You may experience longer than usual call wait times.

Thank you for your patience.

Support form link: <https://tlss.uottawa.ca/site/support-form>

Good luck :)

**Section I – Multiple choice automatically marked by the system. Answers are highlighted in yellow. Students will have answered one question from each block, for a total of 8 questions.**

Section I, Question 1

Which one of the following organisms is NOT considered a microbe:

- A) yeast
- B) protozoan
- C) bacterium
- D) mushroom**
- E) virus

The classification of organisms into three domains of life is based on:

- A) the presence of a cell wall
- B) the number of cells in the organism
- C) cellular organization**
- D) nutritional requirements
- E) cellular proteins

A student has obtained a sample of pond water for study. Using a high-powered microscope, she/he/they observe several cells with nuclei. It can be concluded that the cells are NOT bacteria.

- A) True.**
- B) False.

Section I, Question 2

If you were setting up an experiment to disprove spontaneous generation in a liquid medium, which of the following would be essential to the experiment?

- A) Supplying the liquid with nutrients
- B) Starting with a liquid that contains microorganisms

- C) Adding antibiotics to the liquid
- D) Using a sterile liquid and eliminating exposure to microorganisms
- E) Adding carbon dioxide to the liquid

Regarding Louis Pasteur's experiments with the S-neck flask, which of the following statements is TRUE?

- A) Air exchange was involved.
- B) A food source was provided.
- C) The possibility of contamination was removed.
- D) All preexisting microorganisms were killed.
- E) All of the answers are correct.

### Section I, Question 3

In which of the following situations would Koch's postulates be utilized?

- A) Determination of the cause of a patient's illness in a hospital microbiology lab
- B) Development of a new antibiotic in a pharmaceutical lab
- C) Determination of the cause of cancer in a patient
- D) Formulation of a vaccine against a new pathogen in a genetic engineering lab
- E) Whenever the scientific method is used to investigate a microbiological problem

Which of the following findings was essential for Edward Jenner's vaccination process?

- A) Exposure to a milder disease form may produce immunity.
- B) A weakened microorganism will not cause disease.
- C) Someone who recovers from a disease will not acquire that disease again.
- D) Disease is caused by viruses.
- E) Pathogenic microorganisms infect all humans and animals in the same manner.

Section I, Question 4

What structure does light pass through after leaving the condenser in a compound light microscope?

- A) ocular lens
- B) objective lens
- C) specimen
- D) illuminator

Which of the following correctly traces the path of light through the compound microscope?

- A) light source; condenser; specimen; objective lens; ocular lens
- B) condenser; light source; specimen; ocular lens; objective lens
- C) light source; specimen; condenser; objective lens; ocular lens
- D) condenser; light source; specimen; objective lens; ocular lens
- E) light source; condenser; objective lens; specimen; ocular lens

Section I, Question 5

You are performing a Gram stain on **gram-positive bacteria** and you stop after the addition of the first dye. What is the appearance of the bacteria at this point?

- A) purple
- B) red
- C) colorless
- D) brown

You are performing a Gram stain on **gram-negative bacteria** and you stop after the addition of the mordant. What is the appearance of the bacteria at this point?

- A) purple
- B) red
- C) colorless

D) brown

You are performing a Gram stain on **gram-positive bacteria** and you stop after the addition of the counterstain. What is the appearance of the bacteria at this point?

A) purple

B) red

C) colorless

D) brown

Which type of stain is most useful in helping clinicians to decide which antibiotic to prescribe for a bacterial infection?

A) negative stain

B) simple stain

C) Gram stain

D) endospore stain

E) flagella stain

Section I, Question 6

By which of the following mechanisms can a cell transport a substance from a lower to a higher concentration across a cell membrane?

A) simple diffusion

B) facilitated diffusion

C) active transport

D) extracellular enzymes

E) aquaporins

Which of the following is NOT a typical characteristic of most bacterial plasma membranes?

A) Site of energy production

B) Composed of a phospholipid bilayer

C) Contains proteins

D) Contains cholesterol

E) Is selectively permeable

The antimicrobial drug imidazole inhibits sterol synthesis. This would most likely interfere with:

A) Bacterial cell walls.

B) Fungal cell walls.

C) Eukaryotic plasma membranes.

D) Prokaryotic plasma membranes.

E) Genes.

Section I, Question 7

Functions of the glycocalyx include all of the following EXCEPT:

A) biofilm formation.

B) increased virulence.

C) source of nutrition.

D) protection against dehydration.

E) binary fission.

Which structure acts like an "invisibility cloak" and protects bacteria from being phagocytized?

A) Slime layer

B) Fimbriae

C) Capsule

D) Cell membrane

E) Cell wall

Section I, Question 8

Endospores are a reproductive structure.

A) True.

B) False.

The number/quantity of organelles such as chloroplasts, mitochondria, and rough endoplasmic reticulum is the same in all eukaryotic cells.

A) True.

B) False.

**Section II – Short answers. Answers in purple. Students will have answered one question from each block, for a total of 5 questions.**

Section II, Question 1

What evolutionary advantage, if any, do smaller cell sizes provide? (/2).

Smaller cells have more surface area relative to cell volume than larger cells (0.5 pts) which allows for faster rates of nutrient and waste exchange (0.5 pts). This enables them to grow (0.5 pts) and thus, adapt faster than larger cells (0.5 pts).

How can visualizing cell morphology aid in our understanding of microbial cells? (/2).

Visualizing cell morphology, such as cell shape, cell size, or cell arrangement, can help in identifying or classifying or characterizing the microbe as each species typically has its characteristic morphology (1 pt). While cell morphology cannot predict anything about the physiology/ecology/phylogeny/any other properties of prokaryotic cells (0.5 pts), it may help to indicate if particular structures such as flagella or endospores etc. are present (0.5 pts).

- Anything else along the lines of why knowing what a microbe may be can be helpful is also fine here for the last 0.5 pts.
- Cell morphology is not associated with or informative of mechanisms of disease so 0 pts for that

You have discovered a new kind of microbe, never observed before. What kind of questions about this microbe might be answered by light

microscopy? What questions would be better addressed by electron microscopy? (/2).

Light microscopy can be used to answer questions about overall cell structure, morphology, cell number and shape for this new microbe (1 pt).

- Students may give specific examples here such as whether a cell is alive or dead, whether it has motility structures etc. and that is also acceptable for what kind of questions can be answered using light microscopy.

Electron microscopy can be used to answer detailed questions about the intracellular/subcellular structures and compartments of the cell (1 pt).

- Students may give specific examples here such as the number and types of organelles present, the individual proteins and nucleic acids etc. and that is fine for what kind of questions can be answered using electron microscopy. Key point is it can be used to visualize smaller physical structures at greater resolution
- If the answers demonstrate that students understand this distinction between light and electron microscopy, then they get the mark.

Also, please check answers for this question for similarity to answers posted on Chegg/other websites

## Section II, Question 2

If microbial life had not evolved, would more complex organisms such as yourself be here today? Give one good reason why or why not. By contrast, if all higher organisms suddenly disappeared, would microorganisms also disappear? (/2).

No complex organisms would not be here (0.5 pts) as microbial evolution and metabolic diversity was key for other more complex organisms to develop (1 pt). And no, most microorganisms would not disappear/most microorganisms would be able to survive without higher, more complex organisms as they did for billions of years (0.5 pts).

- Acceptable answers for the 1 pt part are those that are along this line of thinking, that microbial metabolism was key for higher organisms to form or that some complex organisms required endosymbiosis to occur and microorganisms were necessary for that endosymbiosis to occur etc.

Also, please check answers for this question for similarity to answers posted on Chegg/other websites

Imagine that all microorganisms suddenly disappeared from Earth. From what you have learned in this class so far, why do you think animals and more complex organisms would eventually disappear from Earth? By contrast, if all higher organisms suddenly disappeared, would all microorganisms also disappear? (/2).

Complex organisms would eventually disappear as microbial metabolic activities are essential for life on Earth such as the cycling of elements in biogeochemical systems or the digestion of food (1.5 pts). Also no, most microorganisms would not disappear/most microorganisms would be able to survive without higher, more complex organisms as they did for billions of years (0.5 pts).

- Acceptable answers for the 1.5 pt part are those that are along this line of thinking, that microbial metabolism is key for sustainable life of higher organisms/food chains. Students may just give one specific example in the form of carbon, oxygen, nitrogen and sulfur which is acceptable. Students may also answer that if some microbial symbionts would disappear, some complex organisms could go extinct and that is all also acceptable.

Also, please check answers for this question for similarity to answers posted on Chegg/other websites

Explain why photoautotrophic organisms are essential for life on Earth as we know it?

Photoautotrophs are organisms that carry out photosynthesis/use light as their source of energy and inorganic carbon to carry out cellular processes and build biomass (1.0 pt). Photoautotrophs thus provide nutrition for almost all other forms of life (1.0 pt), particularly heterotrophs, and so are essential for life on Earth.

- For this exam, it doesn't matter if the inorganic carbon part is not specified.
- Answer needs to state that building blocks of life/chemical compounds that other organisms can then use.
- 0 pts for stating that photoautotrophs are essential because they produce oxygen. Not all photoautotrophs do that and the main thing is

they produce chemical compounds that can then support different metabolic processes.

- 0.5 pts for saying they are essential for the carbon cycle as it is not the whole answer, what are they doing/producing within that cycle?

### Section II, Question 3

How could you use Koch's postulates to demonstrate the causative agent of influenza? (/4).

Koch's formulated postulates to establish a link between a microorganism and a given disease. We know that influenza is a virus and so a modified set of postulates would need to be used/satisfied (0.75 pts).

To demonstrate the causative agent of influenza, the virus must be isolated from individuals with the disease but not from healthy individuals (0.5 pts).

- To definitely state that something is a causative agent it must be absent in healthy individuals so only 0.25 pts here if the distinction of virus being absent from healthy individuals is not made.

Then it must be able to be grown in host cells or in cells similar to the host as it would not be able to grow in pure culture without the host (0.75 pts).

Then, the pathogenicity of the virus should be demonstrated. Basically, if the virus is removed from the system, by filtration for example, then influenza should not be able to occur (0.5 pts).

The virus must also be able to cause influenza when inoculated in a compatible or similar healthy host (0.5 pts) and an immune response must also be induced in that once healthy host (0.5 pts).

Finally, the virus that is isolated in the once healthy host needs to be the same as the one that was initially isolated from individuals with the disease (0.5 pts).

In this way, the causative agent of influenza could be identified using Koch's postulates.

- Part marks for this question are okay, but need all points above for full marks.

Also, please check answers for this question for similarity to answers posted on Chegg/other websites

Pasteur's experiments on spontaneous generation contributed to the methodology of microbiology, understanding of the origin of life and techniques for the preservation of food. Explain briefly how Pasteur's experiments affected each of these topics. (/4).

Pasteur's experiments on spontaneous generation contributed to the methodology of microbiology by showing that microorganisms were present in the air or water (0.25), thus highlighting the need of sterility when conducting experiments and introducing the concept of sterile techniques (1.0 pt).

- 0.5 pts only for saying boiling was shown to make things sterile as that is only half the answer, need to say why knowing that or why sterility was relevant or important to the field of microbiology.

Pasteur's experiments on spontaneous generation contributed to the understanding of the origin of life by showing that microorganisms in the air caused contamination of nutrient broth in flasks with curved necks (0.5 pts), thus conclusively disproving the theory of spontaneous generation (0.75 pts.)

Pasteur's experiments on spontaneous generation contributed to the understanding of food preservation by showing that microbes were directly associated with food spoilage (0.75 pts) and that heat could be used to treat perishable food to prevent microbial growth, thus introducing the concept of what is now known as Pasteurization (0.75 pts)

- Part marks for this question are okay, but need all points above for full marks.

Also, please check answers for this question for similarity to answers posted on Chegg/other websites

## Section II, Question 4

In your opinion, would it be easier for a prokaryotic cell to survive without a cell membrane or cell wall? Explain why you think so. (/1).

In lectures, the functions of the cell membrane were given as follows:

- Nutrient transport
- Environmental sensing
- Serving as a permeability barrier

- Polar and charged molecules must be transported across the membrane
- Transport proteins accumulate solutes against the concentration gradient and so transport of substances can be tightly controlled
- Keeps valuable molecules inside cell
- For example salts, sugars and amino acids
- Protein Anchor
- Holds transport proteins in place
- Energy conservation and consumption
- Maintains a proton gradient and thus generates proton motive force via ATP synthesis.

In lectures, the functions of the cell wall were given as follows:

- Cell wall confers shape and rigidity to the cell
- The bacterial cell wall also serves to resist the very high internal osmotic pressure that would burst (lyse) the cell unless the wall was present.
- The cell wall (depending on structure) can also help protect the cell from antibiotics etc.

Thus, any answer is acceptable and awarded the full marks as long as 1) a clear answer is given and 2) the justification is based on a demonstrated understanding of the role of the cellular components as based on the lecture notes.

- Part marks for this question are okay, but need both parts above for full marks.

Also, please check answers for this question for similarity to answers posted on Chegg/other websites

A sample answer thanks to Noah:

e.g. Losing either would have clear disadvantages, but it would be easier to survive with only a cell membrane because without a cellular membrane there would be free passage of a variety of molecules from the extracellular space into the cell that are normally blocked or have regulated passage through the membrane. This would disrupt a number of cellular functions including energy production through the proton motor force.

Most laboratory strains of *E.coli* and *Salmonella* commonly used for research lack flagella – why do you think this is the case? (/1).

In lectures, the functions of the flagella were given as follows:

- Helical structure that assists in swimming

In lectures, some reasons for locomotion were given as follows:

- Directed movement in response to chemical or physical gradients such as chemicals, light, oxygen, water, ions, nutrients etc.

Thus, any answer is acceptable and awarded full marks as long as 1) a clear answer is given and 2) the justification is based on a demonstrated understanding of the role of the cellular component as based on the lecture notes.

- Part marks for this question are okay, but need both parts above for full marks.

Also, please check answers for this question for similarity to answers posted on Chegg/other websites

A sample answer thanks to Noah:

e.g. I believe these lab strains of bacteria lack flagella because the function of this cellular component would not be useful in lab settings. Flagella serve to increase the locomotion of bacteria as they search for permissive environments and food. This function would not be useful in the lab, as bacteria are cultured in permissive environments for growth.

Why do you think it took so long for humans to connect microbes with infectious disease? (/1).

In lectures, the history of microbiology was described and particular focus was given to the advent of the microscope and how being able to actually visualize the microbial cells was a game changer. And even then, Van Leeuwen was not respected or believed and it took for other people like Pasteur and Koch amongst others to specifically establish a link between microbes and disease.

- That the miasma theory of disease was a dominant theory does not matter for this question, as microbial existence wasn't known for most of that time period and that is the answer that we are after, that microscopy was an essential discovery.

Thus, any answer is acceptable and awarded full marks as long as 1) a clear answer is given and 2) the justification is based on a demonstrated understanding of the role of the microscope as based on the lecture notes.

- Part marks for this question are okay, but need both parts above for full marks.

Also, please check answers for this question for similarity to answers posted on Chegg/other websites

A sample answer thanks to Noah:

e.g. Microbes were not known to exist for most of human history because they were too small to see prior to the development of microscopes.

Section II, Question 5

Consider the phylogenetic tree of some bacterial species shown below in Figure 1.

What species (#A-F/#1-6) is the ancestor? (/0.5).

F/6 (0.5 pts)

Name two species that are closely related to each other. (/0.5)

A and B or C and D/1 and 2 or 3 and 4 (0.5 pts)

Why is the biological species concept not meaningful for bacteria, and how are species alternately defined? (/0.5).

Biological definition of species requires sexual reproduction while bacteria undergo asexual reproduction (0.25 pts). Thus, we use the phylogenetic species definition which is based on DNA sequence similarities/nucleotide similarity (0.25 pts).

Of the three phylogenetic trees shown in Figure 2, which tree do you have the most confidence in and why? (/1.5)

Tree 3 (0.75 pts) as it is based on more than one gene/involves the use of multiple genes (0.75 pts).

- If it's mentioned that it's because they can now do bootstrapping etc. that is incorrect, it's because there are multiple genes.

Unfortunately, due to widespread usage of Chegg for this question, please give everyone 3 pts for this question.

**Section III – Long answer. Answer in purple. All students will have answered one question.**

Section III, Question I

Assume you are given four cultures; one of a species of gram-negative bacteria, one of a species of gram-positive bacteria, one of a species of archaea and one of a species of eukarya. Describe, in detail, at least four different ways in which you could tell which culture was which and what you expect to see for each culture in each method. (/10).

In lectures, we have looked at:

- different kinds of microscopy
- discussed 16S and 18S sequencing
- looked at different cellular structures
- the different staining methods, specifically the Gram stain
- also discussed the different ways how microbes can be identified and classified

In lectures, we talked about the following being used for identification and classification:

- Colony morphology
- Cell shape and grouping
- Structure of the cell wall
- Specific cell structures
- Serological testing
- Biochemical/metabolic characteristics
- Molecular properties
- G + C content

- Nucleic acid hybridization
- Nucleic acid sequencing

In lectures, we also talked briefly about:

- DNA structures, histones, flagella, archaella, pili, fimbriae, cilia, endospores, antibiotic action, lysozymes, motility, cell walls, cell membranes
- the difference between prokaryotes and eukaryotes

So, there are a lot of options possible and some methods have more distinguishing power than others. Answers are acceptable as long as 1) a clear method/technique/way for distinguishing is listed or described AND 2) there is a demonstrated understanding of how the different cultures would differ for that particular method. If the above two conditions are met, then for each method, students get 2.5 pts; with 1.25 pts being awarded for each condition.

- Please provide feedback for marking where you can 😊
- 0 pts for just listing differences in structures, methods or techniques must be stated as well as what each culture would depict (that is what the question is asking for)
- Gram staining/differences in cell wall thickness must be mentioned to distinguish between gram negative and positive so cannot get full marks for this question without that
- Cannot do chemical analyses of cell walls or tests for modes of reproduction so 0 pts for that – however can test for cholesterol or the presence of nuclear membranes
- Testing growth temperatures is not a diagnostic tool as the temperatures of various organisms differ greatly and it wasn't even discussed in class at this time so 0 pts for that.
- Testing for methane production is acceptable as an answer though not really useful as a diagnostic tool as only a certain group of archaea can do that but it was discussed as a unique ability of archaea so do give 2.5 pts for that if conditions 1 and 2 are met.
- Adding an enzyme that hydrolyses ether linkage only in cell membranes is not something that can be done or something discussed in class, so 0 pts for that.

Also, please check answers for this question for similarity to answers posted on Chegg/other websites.

Example answers include:

A phylogenetic analysis of all four cultures could be done, using both 18S and 16S primers (1.25). The 16S primers would only work for bacterial and archaeal cultures while the 18S primers would only work for the eukaryotic culture. We can then also identify what the cultures actually are based on the results of the phylogenetic analysis/the placement of the cultures in a phylogenetic tree and see what species they are closely related too (1.25).

Electron microscopy could be used to distinguish internal cellular structures for each of the four cultures (1.25). Bacteria and archaea would not have a nucleus or intracellular organelles like chloroplasts and mitochondria while the eukaryotic culture would have a nucleus and organelles like chloroplasts and mitochondria. The bacterial cultures could also have endospores while the eukaryotic and archaeal cultures would not/the bacterial cultures would be the ones lacking histones (1.25).

Electron microscopy could be used to distinguish cell wall structures for each of the four cultures (1.25). The gram-positive bacteria will have a thick peptidoglycan layer and the gram-negative bacteria would have a thin peptidoglycan layer. The eukaryotic culture may or may not have a cell wall but it would not be composed of peptidoglycan. The archaeal culture would also not have a peptidoglycan-based cell wall but instead the cell wall could be composed of pseudomurein or an S-layer or something else (1.25).

Students can also talk about using electron microscopy to observe the LPS/outer membrane as a separate thing:

Gram positive cells, archaeal and eukaryotic cells would not have an LPS while Gram negative cells would.

Gram staining and light microscopy could be used to distinguish cell wall structures for each of the four cultures (1.25). The gram-positive bacteria would stain purple while the gram-negative cells would stain pink/red. The stain would not work on the archaeal or eukaryotic cultures as their cell walls lack peptidoglycan (1.25).

Antibiotic resistance to an antibiotic that destroys peptidoglycan could be used to distinguish between cell wall structures for each of the four cultures (1.25). The gram-positive bacteria will likely be sensitive to the antibiotic while and the gram-negative bacteria may not as it has added protection in the form of the LPS layer. The antibiotic resistance method would not work

on the archaeal or eukaryotic cultures as their cell walls lack peptidoglycan (1.25).

Electron microscopy could be used to distinguish cell membrane structures for each of the four cultures (1.25). The bacterial and eukaryotic cultures will have ester linkages and fatty acids in their cell membrane while the archaeal cultures would have ether linkages and isoprene chains in their cell membranes (1.25).

Light/electron microscopy could be used to distinguish external cellular structures for each of the four cultures. Bacteria, archaea and eukarya have different structures for motility and if those are present, the sizes and structures of the flagella and archaella could be studied (1.25). The archaella is typically thinner than the bacterial flagella while the eukaryotic flagella move differently than the bacterial flagella and are not external to the cell (1.25).