

NAME (PRINT): _____ SIGNATURE: _____

MICROBIOLOGY 201

EXAMPLE EXAM-I 2013WT2 (MIDTERM)

62 x 1 point question blocks 110 responses) on 22 pages (including this cover)

Time allowed: 2 hours

READ THIS!

FAILURE TO FOLLOW INSTRUCTIONS CAN DELAY THE GRADING OF YOUR EXAM

A. MULTIPLE CHOICE QUESTIONS

On the computer answer sheet, in **PENCIL**, fill in the bubbles for your name (Last name **FIRST, First name LAST**) 8 digit student number. Other student information is **NOT** required.

Turn the computer answer sheet 90°. **IN INK**, sign the computer answer sheet in the spaces provided.

Record all **multiple choice responses IN PENCIL** on the computer answer sheet — **NOT** on the question paper.

All single **multiple choice responses** have **ONE BEST** answer. Point values vary with the response.

Students **MUST** record their multiple choice responses onto their computer sheet during the time allowed for the exam. **NO** writing will be permitted after the time allowed for the exam has expired. **NO** appeals will be considered.

B. RETURN OF THE QUESTION PAPER

The question paper **MUST** be returned with the answer sheets. Answer sheets without a question paper will **NOT** be graded. In this regard, students are **STRONGLY CAUTIONED** to guard against theft of their question paper by other students. **NO** appeal relating to loss of a question paper by theft will be considered.

C. FACULTY OF SCIENCE RULES GOVERNING FORMAL EXAMINATIONS

- (1) Each candidate must be prepared to produce, upon request, a Library/AMS card for identification.
- (2) Candidates are not permitted to ask questions of the invigilators, except in cases of supposed errors or ambiguities in examination questions.
- (3) No candidate shall be permitted to enter the examination room after the expiration of one-half hour from the scheduled starting time, or to leave during the first half hour of the examination.
- (4) Candidates suspected of any of the following, or similar, dishonest practices shall be immediately dismissed from the examination and shall be liable to disciplinary action:
 - Having at the place of writing any books, papers or memoranda, calculators, computers, cell phones, audio or video players or other memory aid devices, other than those authorized by the examiners.
 - Speaking or communicating with other candidates
 - Purposely exposing written papers to the view of other candidates. The plea of accident or forgetfulness shall not be received.
- (5) Candidates must not destroy or mutilate any examination material; must hand in all examination papers; and must not take any examination material from the examination room without permission of the invigilator.

D. EXAM DISRUPTION POLICY FOR EXAM-I

In the event of an exam disruption and students must leave the exam room, the following policies apply:

- (1) Procedure for exiting the exam room.
 - Pick up your question booklet and answer sheet. Slip your answer sheet inside the question booklet.
 - Exit the room in an orderly manner through the doors indicated by the invigilators.
 - As you exit the room, give your question booklet and answer sheet to an invigilator. Any student failing to produce a question booklet and answer sheet will be asked to wait until all students have exited. Students are **RESPONSIBLE** for return of their question booklet and answer sheet. Any student failing to do so will receive a grade of “0” for the exam. Students are **STRONGLY CAUTIONED** to guard against theft of their question booklet and answer sheet by other students. **NO** appeal relating to loss of a question booklet and answer sheet by theft will be considered.
- (2) Students **MUST** wait outside the exam room until the disruption has been resolved. During this time, students are **PROHIBITED** from discussing the exam outside the exam room or consulting course materials. Doing so is considered academic misconduct and will result in a grade of “0” for the exam.
- (3) Once the exam disruption has been resolved, the exam will be continued if at all possible.

Questions #1-4**(4 x 0.25 points)**

Bacteria and Archaea exhibit differences at the molecular level. These differences have been found in the structures of their

1. membrane phospholipids.
2. RNA polymerases.
3. flagella.
4. cell wall polysaccharides.

Mark **(a)** for **Yes** or **(b)** for **No** on the answer sheet.

Question #5**(1 point)**

Below sequences A-E have been aligned. Choose the **WORST** alignment of sequence F (20 nucleotides) with these aligned sequences.

Seq A 22 nucleotides:	CCCCAGCUUCGGCUGGGGGAGG
Seq B 21 nucleotides:	CCUAGCGAAAGCU-AAGGAGG
Seq C 21 nucleotides:	CCUCAGCGUGAGCU-GAGGAGG
Seq D 21 nucleotides:	CCAAGCUUU-GCUAUGGGAGG
Seq E 17 nucleotides:	CC--AGCUUUGGCU---GGAGG

Seq F 20 nucleotides: **CCAAGCGGAGAGCUUGGAGG**

- (a) **C-CAA-GCGGAGAGCUUGGAGG**
- (b) **CC-AAGCGGAGAGCUUG-GAGG**
- (c) **CC-AAGCGGAGAGCUUGG-AGG**
- (d) **CC-AAGCGGAGAGCUU-GGAGG**
- (e) **CCAAGCGGAGAGCU--UGGAGG**

Question #6**(1 point)**

You suspect a 5S rRNA gene has been transferred horizontally. Which of the following methods to detect HGT can **NOT** be used to investigate your suspicions?

- (a) GC/AT content analysis.
- (b) Codon bias analysis.
- (c) Incongruent phylogeny analysis.

Mark **(d)** if **ALL** of the above **CAN BE** used to detect horizontal transfer of the gene.

Question #7**(1 point)**

The table below shows nucleotide differences between the aligned, variable portions of SSU rRNA from 4 different prokaryotic organisms:

Organism	1	2	3	4
1		2	8	3
2	2		8	3
3	8	8		7
4	3	3	7	

Assuming these differences are due only to nucleotide substitutions and a branch length of 1 cm is assigned for every single nucleotide difference, the total length of the branches in a distance-based phylogenetic tree of the type used in MICB 201 will be:

- (a) 10 cm
- (b) 11 cm
- (c) 12 cm
- (d) 13 cm
- (e) 14 cm

Questions #8-11**(4 x 0.25 points)**

Horizontal gene transfer complicates the use of SSU rRNA for

- 8. tracing whole genome evolution.
- 9. tracing organismal evolution.
- 10. assigning taxonomic units (eg. genus, species)
- 11. classifying organisms.

Mark (a) for **Yes** or (b) for **No** on the answer sheet.

Questions #12-15**(4 x 0.25 points)**

Estimates of the extent to which prokaryotic genomes have been shaped by horizontal gene transfer vary between studies. Indicate which of the following are reasons for this by marking (a) for **Yes** or (b) for **No** on the Answer Sheet.

- 12. investigator bias.
- 13. different ways of analyzing for HGT and reporting the data.
- 14. methodological difficulties in identifying the remnants of a horizontal gene transfer events in an extant genome.
- 15. the incomplete and biased nature the prokaryotic genome nucleotide sequence database.

Questions #16-19**(4 x 0.25 points)**

Indicate which of following statements about prokaryotic abundance and diversity are correct by marking **(a)** for **Yes** or **(b)** for **No** on the answer sheet.

16. There are more individual prokaryotes on Earth than stars in the universe.
17. If all prokaryotic organisms were laid end to end, the distance covered would be about a trillion astronomical units (a.u.).
18. Most prokaryotes are found in the subsurface regions of the Earth.
19. Since prokaryotes were first discovered over 200 years ago, millions of different prokaryotic species have been cultured in the laboratory.

Question #20**(1 point)**

It has been estimated there are 10^{30} prokaryotic cells on Earth. What is the corresponding biomass? Assume the density of prokaryotic “tissue” is close to the density of water, i.e. 1 g/cm^3 and the average volume of a prokaryotic cell is $1 \text{ }\mu\text{m}^3$.

- (a) 10^{12} g
- (b) 10^{18} g
- (c) 10^{26} g
- (d) 10^{30} g

Question #21**(1 point)**

Indicate which one of the following SSU rRNA defined groups of Bacteria is **INC**orrectly matched to an important property of the group?

<u>Group</u>	<u>Property</u>
(a) Gram-positive	Includes members of major medical and industrial significance.
(b) Planctomyces	Many members possess a membrane around their chromosome.
(c) Purple	Includes the model organism <i>E. coli</i> , the most well-understood cell on Earth.
(d) Cyanobacteria	Perform oxygenic photosynthesis

Mark **(e)** if **ALL** of the above **ARE CORRECTLY** matched to an important property of the group.

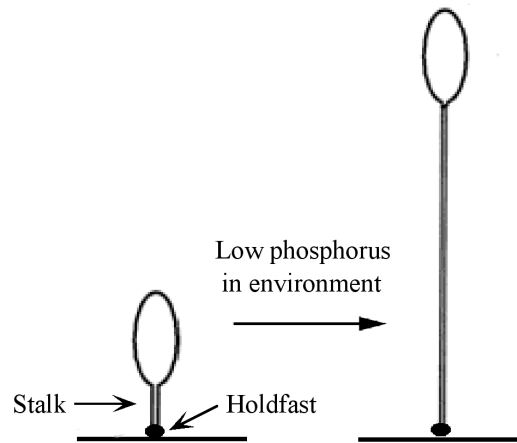
Question #22**(1 point)**

Pure cultures

- (a) are used to determine the characteristics of specific types of prokaryotes.
- (b) are important because they simulate the natural environment.
- (c) have been used successfully to study millions of different prokaryotic species.
- (d) contain all the prokaryotes purified from an environmental sample.

Mark (e) if the answer is **TWO** of the above.**Question #23****(1 point)**

Recall the dimorphic aquatic bacterium *Caulobacter crescentus* which sticks to surfaces using a polysaccharide “glue” at the end of its stalk. When starved for phosphorus, the bacterium forms very long stalks.



If the cell body has a SA = $7.36 \mu\text{m}^2$ and a V = $1.15 \mu\text{m}^3$ and the stalk has a SA = $13.23 \mu\text{m}^2$ and a V = $0.46 \mu\text{m}^3$ by how many times does the stalk increase the effective SA:V ratio of the cell body?

- (a) 2 times
- (b) 4 times
- (c) 8 times
- (d) 16 times
- (e) 32 times

Formulas: $?_{\text{cyl}} = \pi r^2 h$ $?_{\text{cyl}} = 2\pi r^2 + 2\pi r h$

Question #24**(1 point)**

The lipid bilayer of the prokaryotic cytoplasmic membrane is **LEAST** permeable to

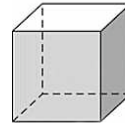
- (a) diatomic oxygen
- (b) protons
- (c) molecular nitrogen
- (d) water

Questions #25-28**(4 x 0.25 points)**

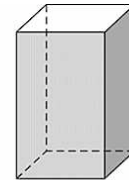
In 1980, a scientist named Tony Walsby discovered a thin, square prokaryotic microorganism in the Dead Sea. Initially, the microbe was called “Walsby’s square bacterium” but it has been subsequently named *Haloarcula*.

Haloarcula

Cube



Cuboid



Based on its cell shape, which of the following are expected to be additional characteristics of *Haloarcula* cells? Indicate your answers by marking (a) for **Yes** and (b) for **No** on the answer sheet.

25. The cytoplasmic membrane lipids of *Haloarcula* cells are expected to be similar in molecular shape to cubes or cuboids rather than cylinders.
26. *Haloarcula* cells are expected to retain their shape when placed in a hypertonic environment.
27. The cytoplasmic membranes of *Haloarcula* cells are expected to possess lipid bilayers which are less fluid than bacteria with a rod shape.
28. *Haloarcula* cells are expected to have a Gram-positive wall structure.

Question #29**(1 point)**

Which of the following mechanisms of DNA compaction is used by **ALL** Bacteria and **ALL** Archaea so far studied?

- (a) Histone-like proteins
- (b) Polyamines
- (c) DNA supercoiling
- (d) Histone proteins

Question #30**(1 point)**

A sample of a bacterial cell structure is subjected to partial chemical analysis and found to contain amino acids and sugars. The sample could be derived from

- (a) flagella.
- (b) outer membrane.
- (c) capsular material.
- (d) peptidoglycan.

Mark (e) if the answer is **TWO** of the above.

Questions #31-34**(4 x 0.25 points)**

When abruptly transferred from a hypertonic environment to a hypotonic environment, in general, Gram +ve bacteria are less likely to undergo osmotic lysis than Gram -ve bacteria.

Which of the following statements help to explain why this is so. Mark (a) for **Yes** or (b) for **No** on the answer sheet.

- 31. Gram +ve cell walls have more layers of peptidoglycan (PG) than Gram -ve cell walls.
- 32. Gram +ve PG has a higher degree (density) of cross-linking than Gram -ve PG.
- 33. The covalent bonds in Gram +ve PG are stronger than the covalent bonds in Gram -ve PG.
- 34. Gram +ve bacteria lack an outer membrane.

Question #35**(1 point)**

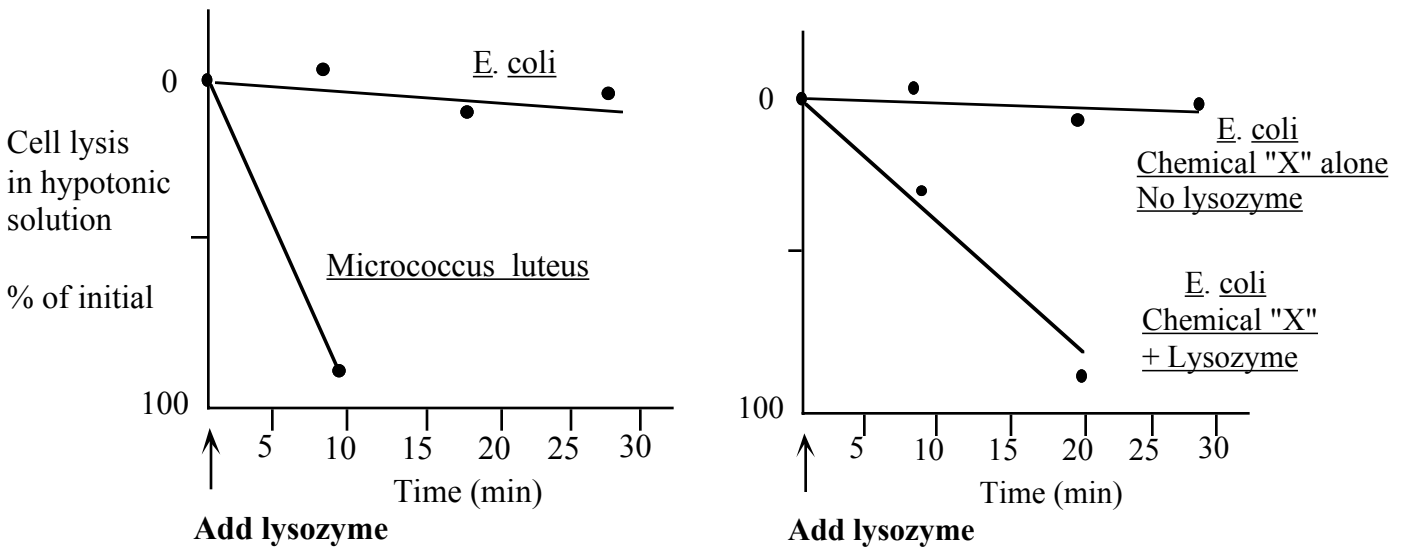
As MICB 201 students know, organisms classified as *E. coli* can exhibit important differences in their phenotypes. *E. coli* **K12** and *E. coli* **O157: H7** are both *E. coli* however one is docile while the other is deadly. Some of the differences between these two organisms show-up in their strain designations. Which of the following identifiers are correctly matched to the cellular structure they refer to?

<u>Identifier</u>	<u>Structure</u>
(a) K	flagella
(b) O	LPS
(c) H	pili

Mark (d) if the answer is **TWO** of the above.

Question #36**(1 point)**

Generally, Gram -ve bacteria are much more resistant to the effects of lysozyme than Gram +ve bacteria. For example consider the following data reproduced from the literature showing the effect of exposing the unicellular bacteria *E. coli* and *Micrococcus luteus* (Gram +ve) to lysozyme. In each case 10^6 bacterial cells were incubated in 1 mL of phosphate buffer + 50 μ g lysozyme @ 37°C . However when **Chemical "X"** (final concentration) is included in the phosphate buffer, *E. coli* is lysed by lysozyme.



What is the effect of **Chemical "X"** on bacterial cells?

Chemical "X" disrupts

- (a) the cytoplasmic membrane.
- (b) the outer membrane.
- (c) peptidoglycan.

Mark (d) if the answer is **TWO** of the above.

Question #37**(1 point)**

Because of a stronger hydrophobic effect and other factors, the outer membrane bilayer of Gram-negative bacteria is less fluid and less permeable to many chemicals than the cytoplasmic membrane phospholipid bilayer. Which regions of LPS are responsible for this difference between the cytoplasmic and outer membranes?

- (a) Lipid A
- (b) Core region
- (c) O polysaccharide

Mark (d) if the answer **TWO** of the above.

Question #38**(1 point)**

Porins transport

- (a) some nutrients into the periplasm.
- (b) extracellular proteins into the environment.
- (c) periplasmic proteins into the periplasm.
- (d) nutrients into the cytoplasm.

Mark (d) if the answer is **TWO** of the above.

Question #39**(1 point)**

Many bacteria have capsules. Which one of the following statements about capsule function in different bacteria is **NOT** correct?

Depending on the the bacterium, capsules help bacteria

- (a) stick to surfaces.
- (b) resist plasmolysis.
- (c) resist virus infection.
- (d) avoid phagocytosis.
- (e) avoid starvation.

Question #40**(1 point)**

Some lake-dwelling photosynthetic bacteria make internal sac-like structures called **gas vesicles** so they can float near the surface of a lake.



The gas vesicle sac is made from a single type of molecule which excludes water. Correctly predict the molecule that makes up the gas vesicle sac.

- (a) Peptidoglycan
- (b) Phospholipid
- (c) Protein
- (d) LPS
- (e) Nucleic acid (DNA or RNA)

Question #41**(1 point)**

The “tethered flagella experiments” described in class demonstrated

- (a) transport of H^+ down a $[H^+]$ gradient drives flagellar rotation.
- (b) the bacterial flagellum rotates.
- (c) in some bacteria the flagellum can rotate in two directions.
- (d) the bacterial flagellum is made of protein.

Mark (e) if the answer is **TWO** of the above.

Question #42**(1 point)**

Which of the following structures/molecules are **NOT** found in the Archaea?

- (a) Peptidoglycan
- (b) Rotary flagella
- (c) S-layers
- (d) Pili

Mark (e) if **TWO** of the above are **NOT** are found in the Archaea.

Question #43**(1 point)**

Like all organisms, the total physical DNA specifying the characteristics of a prokaryotic organism is referred to as its

- (a) genome.
- (b) genotype.
- (c) genes.
- (d) chromosome(s)

Question #44**(1 point)**

Prokaryotic chromosomes

- (a) constitute the majority of the genome in most organisms.
- (b) on the average have as many nucleotides making-up genes as between genes.
- (c) possess one strand that serves as a template for transcription for all genes.
- (d) are circular molecules in most organisms.

Mark (e) if the answer is **TWO** of the above.

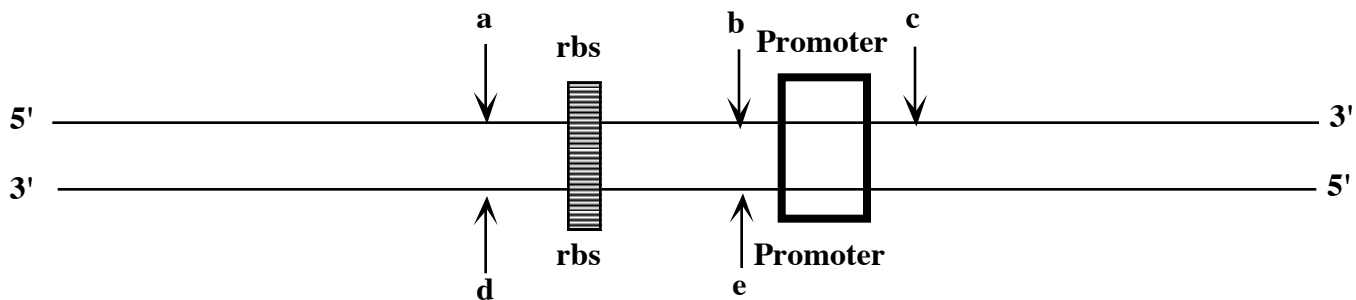
Questions #45-48**(4 x 0.25 points)**

Which of the following statements about transcription and translation in Bacteria are correct? Mark **(a)** for **Yes** or **(b)** for **No** on the answer sheet.

45. Transcription depends on the presence of a functional ribosome binding site.
46. The two strands of the mRNA are separated as a part of translation initiation.
47. The rho independent stem-loop hairpin structure in mRNA participates in the termination of translation.
48. Transcription takes place in the nucleus while translation takes place in the cytoplasm.

Questions #49-51**(3 x 1 points)**

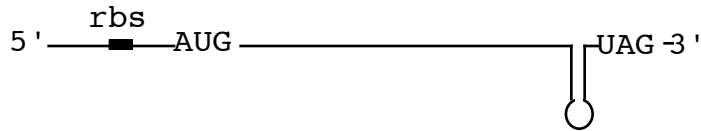
The following diagram represents a segment of double-stranded DNA specifying transcription and translation initiation information for a single gene. "rbs" indicates the nucleotide sequence in DNA that is either the same as, or complementary to, the nucleotide sequence of the ribosome binding site in mRNA. Transcription and translation termination information is **NOT** shown.



49. Identify the position of the first nucleotide used as a template for the synthesis of mRNA as either **a, b, c, d, e**.
50. Identify the position of the nucleotide sequence complementary to the initiation codon in mRNA as either **a, b, c, d, e**.
51. A gene transcribed divergently from the one shown above would use which strand as a template? Answer **(a)** for the top strand or **(d)** for the bottom strand.

Questions #52-55**(4 x 0.25 points)**

Consider the following **HYPOTHETICAL** bacterial mRNA molecule:



Indicate which of the following statements help to explain why this is a poor design for a mRNA by marking **(a)** for **Yes** or **(b)** for **No** on the answer sheet. Assume AUG (start codon) and UAG (stop codon) are separated by a number of nucleotides evenly divisible by 3.

52. It lacks a functional signal for termination of transcription.
53. It lacks a functional signal for termination of translation.
54. It lacks a functional signal for initiation of transcription.
55. It lacks a functional signal for initiation of translation.

Questions #56-59**(4 x 0.25 points)**

There are around 100,000 copies of the outer membrane protein OmpA in an *E. coli* cell and about 5 copies of the protein DNA polymerase III. Indicate which of the following statements could explain this by marking **(a)** for **Yes** or **(b)** for **No** on the answer sheet.

56. The gene encoding OmpA has a stronger promoter than the gene encoding DNA pol III.
57. Both strands of the OmpA gene are transcribed while only one strand of the DNA pol III gene is.
58. The OmpA mRNA has a longer half-life than the DNA pol III mRNA.
59. The 5' UTR of the DNA pol III mRNA has a different nucleotide sequence than the 5' UTR of the OmpA mRNA

Question #60**(1 point)**

Plasmids

- (a) carry genes for the DNA replication proteins required for replication in the host organism.
- (b) typically possess fewer genes than the host chromosome and are therefore typically smaller than the host chromosome.
- (c) usually carry extra copies of the same genes carried by the host chromosome.
- (d) exhibit little diversity, as a group these selfish genetic elements are quite similar in terms of size, copy number, host range and the kinds genes they carry.

Question #61**(1 point)**

In the process of non-replicative transposition, the transposase protein recognizes and binds to specific DNA nucleotide sequences. Transposase proteins bind to **ALL** of the following sequences **EXCEPT ONE**, which one?

- (a) The inverted repeat sequences of the transposon.
- (b) Target site sequences.
- (c) The single stranded regions created as a consequence of the transposition process.
- (d) Direct repeat sequences.

Question #62**(1 point)**

In genomic analysis, computer software is used to search for potential coding regions or “open reading frames” (ORFs). Consider the following dsDNA nucleotide sequence. The nucleotide sequence shown is only part of a gene but it includes all of the information present in the coding region of the mRNA. Do not make the dangerous assumption that the top strand is the non-template strand and the bottom strand is the template strand.

5' -ATGTAAAATCAAAGAAAACCAACATCACATGCCGCCATGTAA-3'
3' -TACATTTTAGTTTCTTTTGGTTGTAGTGTACGGCGGTACATT-5'

Find the longest **POTENTIAL** coding region. Using the Reference Material provided with this exam, the 3rd amino acid specified by this potential coding region is:

- (a) Gly
- (b) Ala
- (c) Arg
- (d) Asp
- (e) Ser

Question #63**(1 point)**

In **Question #62**, you were asked to identify a **POTENTIAL** coding region. Which of the following pieces of information would be the **MOST USEFUL** in deciding whether a **POTENTIAL** coding region is a **REAL** coding region?

- (a) The presence or absence of a sequence encoding a ribosome binding site close to the beginning of the coding region.
- (b) The presence or absence of a promoter sequence close to the beginning of the coding region.
- (c) The presence or absence of a sequence encoding a transcription terminator close to the end of the coding region.
- (d) The presence or absence of a palindromic (mirror image) sequence close to the beginning of the coding region.

Question #64**(1 point)**

A newly cultured bacterium is found to have a single circular chromosome with a molecular size of 2500 kb. Estimate the maximum number of average protein encoding genes in its genome. Assume that 10% of the genome does not code for anything (i.e. 10% of the chromosomal DNA constitutes the spaces between the genes), 1% of the chromosome codes for stable RNA molecules and the size of an average protein encoding gene is 1000 bp.

- (a) 1113
- (b) 1250
- (c) 2225
- (d) 2500

Question #65**(1 point)**

It is possible to roughly estimate the number of genes in a prokaryotic genome if the size of the genome is known. This is because studies have shown that

- (a) there is little non gene (coding) DNA in the genomes of prokaryotes.
- (b) the average size of a prokaryotic gene is about 1000 bp.
- (c) prokaryotes do not have overlapping genes.

Mark **(d)** if the answer is **TWO** of the above.

Mark **(e)** if the answer is **ALL** of the above.

Question #66-69**(4 x 0.25 points)**

When using a transposon to mutate genes in the lab following electric shock billions of organisms are spread on agar solidified nutrient medium containing an antibiotic yet only hundreds of colonies containing antibiotic-resistance organisms form. Below are some possible explanations. Indicate whether each is reasonable by marking **(a)** for **Yes** or **(b)** for **No** on the answer sheet.

- 66. A plasmid that cannot replicate in the recipient bacterium is used.
- 67. Transposition is a rare event.
- 68. The electric shock process is very inefficient at promoting plasmid uptake.
- 69. The antibiotic resistance gene is not expressed in the recipient bacteria.

Question #70**(1 point)**

Which of the following classes of antibiotics have received the most wide clinical use?

- (a) Peptidoglycan synthesis inhibitors
- (b) DNA replication inhibitors
- (c) Transcription inhibitors
- (d) Translation inhibitors

Question #71**(1 point)**

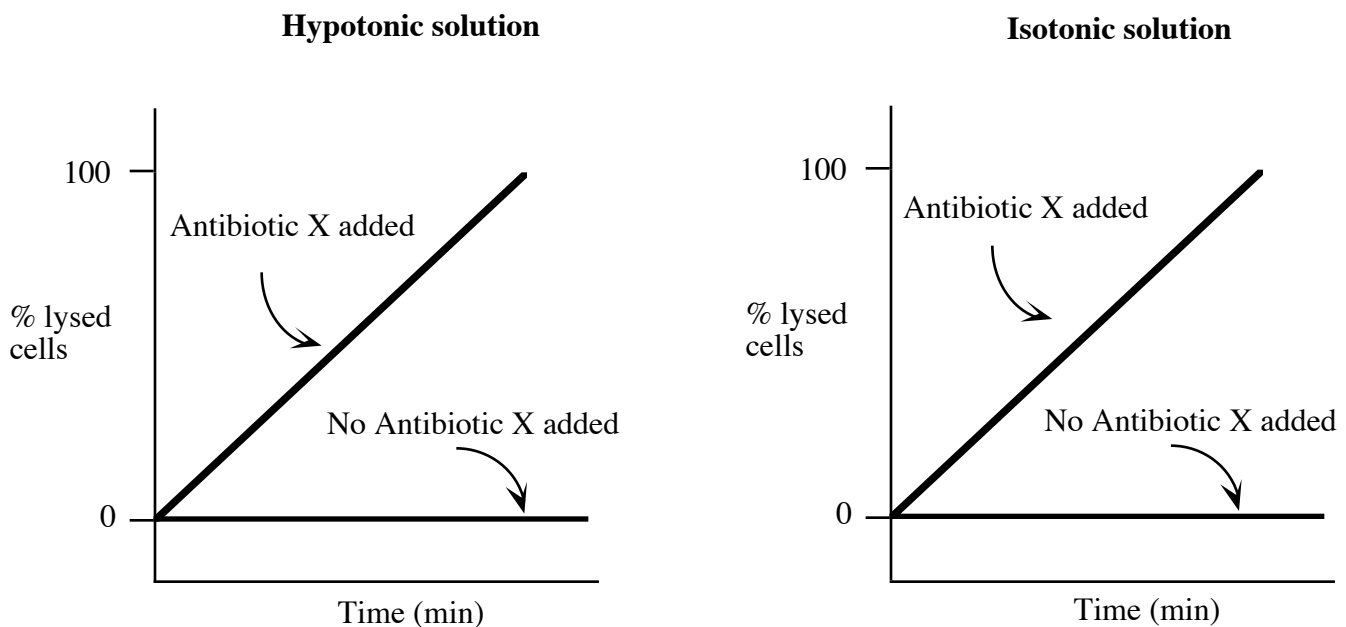
Consider the following new information. *Penicillium griseofulvum* produces the antibiotic griseofluvin that interferes with mitosis in Eukarya. *Streptomyces griseus* produces the antibiotic cycloheximide that interferes with protein synthesis in Eukarya.

Now the question. A new **antibiotic X** has just been discovered in extracts of soil. **Antibiotic X** kills bacterial microbes but not eukaryal microbes. Correctly predict the domain-affiliation of the organism that produces **Antibiotic X**.

- (a) Bacteria
- (b) Eukarya
- (c) Could be Bacteria or Eukarya

Question #72**(1 point)**

The graphs below represent what happens when **Antibiotic X** is added to Gram -ve bacteria suspended in either an **isotonic** solution or a **hypotonic** solution.



Antibiotic X has an effect similar to treating cells with:

- (a) polymyxin
- (b) ampicillin
- (c) lysozyme
- (d) vancomycin

Mark (e) if the answer is **TWO** of the above.

Questions #73-76**(4 x 0.25 points)**

Consider the following statements about peptidoglycan (PG) synthesis:

Indicate whether each statement is correct by marking **(a)** for **Yes** or **(b)** for **No** on the answer sheet.

- 73.** The individual amino acids of the X-linking peptide are transported across the cytoplasmic membrane and inserted into the expanding PG.
- 74.** Individual NAM and NAG sugars are taken from the environment and added to the growing glycan chains.
- 75.** Ribosomes in the periplasm mediate the formation of the final peptide bond which X-links the glycan chains.
- 76.** Partial degradation of peptidoglycan precedes new synthesis.

Question #77**(1 point)**

Antibiotic resistance through target site modification can arise through errors in DNA replication. Which of the following statements about DNA replication in Bacteria are **INC**orrect?

- (a)** DNA replication is initiated at several points on a chromosome or plasmid.
- (b)** DNA replication uses both strands of DNA as templates.
- (c)** Synthesis of new DNA requires a 3' to 5' template for both continuous and discontinuous synthesis.
- (d)** Errors in DNA replication occur during leading strand synthesis but not during lagging strand synthesis.

Mark **(e)** if the answer is **TWO** of the above.

Question #78**(1 point)**

Assume that DNA replication machinery makes uncorrected 1 error for every 5×10^8 base pairing events, how many base pairing errors would be made during DNA replication if a (hypothetical) chromosome consisting of 10^9 nucleotide pairs was replicated?

- (a)** < 1 **(b)** 1 **(c)** 2 **(d)** 4 **(e)** > 4

Question #79**(1 point)**

The target of **Antibiotic X** is a **Protein Y**. Which of the following mutational changes in the coding region of the gene for **Protein Y** is the most likely to lead to resistance?

- (a)** Deletion of 1 nucleotide pair
- (b)** Deletion of 2 nucleotide pairs
- (c)** Deletion of 3 nucleotide pairs
- (d)** Insertion of 2 nucleotide pairs
- (e)** Insertion of 1 nucleotide pair

Question #80**(1 point)**

A bacterium shows significant resistance to β -lactam antibiotics. Which of the following structures is the most important in this regard?

It's

- (a) cytoplasmic membrane.
- (b) S-layer.
- (c) capsule.
- (d) outer membrane.

Question #81**(1 point)**

Development of resistance to amino β -lactam antibiotics in a Gram-negative bacterium was found to be due to an alteration in the amino acid sequence of its transpeptidase enzyme. This is an example of

- (a) modification of the antibiotic's target site.
- (b) decreased antibiotic uptake (influx).
- (c) antibiotic efflux.
- (d) chemical modification of the antibiotic.

Question #82**(1 point)**

From the standpoint of the organism in which they occur, mutations that confer antibiotic resistance are

- (a) beneficial.
- (b) neutral.
- (c) harmful.

Mark (d) if the answer is **TWO** of the above.

Questions #83-86**(4 x 0.25 points)**

In an attempt to transfer streptomycin-resistance from *Erwinia amylovora* to *Mycobacterium tuberculosis*, a mad scientist mixes purified *Erwinia amylovora* DNA with *Mycobacterium tuberculosis* cells and plates the recipient bacterium on agar + streptomycin. Unfortunately no colonies of Str^R *Mycobacterium tuberculosis* are obtained on the streptomycin selection plates.

Which one of the following is a potential explanation for this result? Indicate your answers by marking (a) for **Yes** or (b) for **No** on the answer sheet.

- 83. *Erwinia amylovora* requires a species-specific DNA nucleotide binding/uptake sequence in order to transport DNA from the environment.
- 84. The *Mycobacterium tuberculosis* and *Erwinia amylovora rpsL* (Str^R) genes may have very different nucleotide sequences.
- 85. *Erwinia amylovora* may not have been competent when its DNA was prepared for the experiment.
- 86. The concentration of streptomycin in the selection plates may have been too low.

Question #87**(1 point)**

In the 1890s, Dimitri Ivanovsky, a Russian biologist, was studying a disease of tobacco crops that stunted the growth of plants and mottled their leaves. He found that the sap from a diseased plant was capable of transmitting the disease to another plant. He examined the sap in the best light microscope of the period and saw no microorganisms. He forced the sap through a filter whose pores were so small that they retarded the passage of the smallest known bacterium, yet the fluid that passed through the filter was still able to transmit the disease. Based on these experiments he concluded that the infectious agent was an unknown type of unusually small bacterium.

Today we would also consider the possibility that the microorganism in question was a virus. Which of the following tests available today would be **LEAST** useful to perform in order to distinguish between a bacterium and a virus?

- (a) Examine the sap using the electron microscope.
- (b) Try to grow the microbe in the absence of plant cells.
- (c) Using filters with different pore sizes, determine more precisely the size of the microbe.
- (d) Determine whether the microbe contains protein.
- (e) Determine whether the microbe contains rRNA.

Questions #88-91**(4 x 0.25 points)**

Antibiotic resistance can be spread by transduction and transformation.

Which of the following are similarities between the two processes? Indicate your answers by marking **(a)** for **Yes** or **(b)** for **No** on the answer sheet.

- 88.** Single stranded DNA is transferred into the recipient.
- 89.** Homologous recombination between the donor DNA and the recipient chromosome is required for the recipient to become antibiotic resistant.
- 90.** All or most of the proteins responsible for DNA transfer into the recipient are encoded by recipient genes.
- 91.** Donor DNA is derived from a dead organism.

Question #92**(1 point)**

In most “model” Gram-negative bacteria studied, in order for antibiotic resistance to be transferred from one bacterium to another without the donor losing its own resistance requires **ALL** of the following **EXCEPT ONE**, which one?

- (a) Cell to cell contact.
- (b) DNA replication in both the donor and recipient.
- (c) Recombinational mutation.
- (d) Tra proteins.

Question #93**(1 point)**

We watched the video “The Virus that Cures” in class. In this video, one of the arguments made for using phage to treat antibiotic-resistant bacterial infections was that if an antibiotic-resistant bacterium (a so-called “superbug”) evolved, a “superphage” would “always” evolve along side it to use the superbug as a host.

In fact, most antibiotic-resistant bacteria should be just as sensitive to phage as antibiotic-sensitive ones, so the evolution of a superphage is not necessary to kill antibiotic-resistant bacteria.

This being said, there are situations where the evolution of a superphage might be necessary to kill a superbug.

If resistance in the superbug arose from

- (a) a mutational alteration to the antibiotic’s target site.
- (b) a mutational alteration to a cell surface molecule resulting in decreased antibiotic uptake.
- (c) acquisition of a gene for an enzyme that catalyzes the chemical modification and inactivation of the antibiotic.
- (d) any mechanism resulting from the horizontal transfer of resistance genes by transduction.

Questions #94-97**(4 x 0.25 points)**

A fragment of bacterial plasmid DNA containing a transposon carrying a gene encoding an enzyme which chemically modifies chloramphenicol is mistakenly packaged into a phage capsid during a lytic infection. When this transducing phage infects another bacterium, however, the recipient bacterium does **NOT** become chloramphenicol-resistant.

Which of the following statements are potential explanations for this observation? Indicate your answers by marking (a) for **Yes** or (b) for **No** on the answer sheet.

- 94. The recipient did not contain the gene encoding transposase enzyme needed for transposition.
- 95. The recipient chromosome did not possess the inverted repeat sequences required for the transposition process.
- 96. The recipient chromosome did not possess the target site sequence required by the transposon.
- 97. The transposon was degraded by the recipient bacterium’s restriction enzyme.

Question #98**(1 point)**

A bacterium loses resistance to three antibiotics with very different modes of action simultaneously. This is **MOST LIKELY** the result of

- (a) Reversion
- (b) Conjugation
- (c) Plasmid curing
- (d) Plasmid mobilization

Question #99**(1 point)**

Which of the following are **NOT** selfish genetic elements (SGEs)?

- (a) Phage
- (b) Transposons
- (c) Conjugative plasmids
- (d) Mobilizable plasmids

Mark (e) if ALL of the above are SGEs.

Question #100**(1 point)**

Recall the experiment described in class that helped to prove how bacteria sense the environment in chemotaxis. In this experiment, *E. coli* was suddenly exposed to a high concentration of an attractant and its behaviour was observed. What would ultimately happen if *E. coli* continued to be exposed to this higher concentration of attractant for a longer period of time?

- (a) Increased transcription of genes for chemotaxis proteins induced by the higher attractant concentration.
- (b) Increased length of runs per unit time.
- (c) Increased frequency of tumbles per unit time.
- (d) Nothing until *E. coli* consumes enough of the attractant to change its concentration.
- (e) Depends on whether *E. coli* uses a spatial or temporal sensing mechanism.

Questions #101-104**(4 x 0.25 points)**

Consider the following statements about operons and the environmental regulation of gene expression.

Indicate whether each statement is correct by marking (a) for **Yes** or (b) for **No** on the answer sheet.

- 101.** If a gene is the middle gene of a 3 gene operon, it cannot be transcribed without transcribing the first gene in the operon.
- 102.** A gene for a regulatory protein is usually the first gene in the operon to whose operator the regulatory protein binds.
- 103.** Before binding to DNA, a regulatory protein must first bind a small molecule (the effector).
- 104.** Each gene of an operon possesses a nucleotide sequence encoding a translation termination codon.

Question #105**(1 point)**

In the Chapter 6 Self-Study materials, the regulation of **fepCDG** gene expression in *E. coli* is discussed. **FepC**, **FepD** and **FepG** are cytoplasmic and periplasmic proteins required to transport Fe-siderophore complexes across the the cytoplasmic membrane. In order to transport these complexes, another protein **FepA** is required. **FepA** is located in the outer membrane. Expression of the **fepA** gene is regulated in the same way as expression of the genes in the **fepCDG** operon which involves a regulatory protein **Fur** and a DNA nucleotide sequence called the **fur** box.

Given this information, which one of the following statements is correct?

- (a) In the presence of sufficient iron, **Fur** spends most of its time bound to the **fepA** promoter.
- (b) In the absence of sufficient iron, a **Fur-FepA** complex spends most of its time bound to the **fur** box.
- (c) In the presence of sufficient iron, an **Fur-Fe** complex spends most of its time bound to the **fur** box.
- (d) In the absence of sufficient iron, RNA polymerase is frequently blocked from accessing the **fepA** promoter.

Question #106**(1 point)**

In the quorum sensing system of the *Alivibrio fischeri*-Hawaiian squid (*Eupryma scolopes*) symbiosis, the autoinducer binds to

- (a) an initiator (activator) nucleotide sequence.
- (b) a repressor protein.
- (c) an activator protein.
- (d) an inducer.
- (e) light.

Questions #107-110**(4 x 0.25 points)**

To hunt and kill prey in packs, proteolytic myxobacteria use all of the following **EXCEPT ONE**, which one?

- 107. Flagella-based swimming motility
- 108. Quorum sensing
- 109. Pili-based twitching motility
- 110. A poorly understood mechanism of chemotaxis