

Bloom's Taxonomy of Learning

A Hierarchy of Microbiology Cognitive Abilities

1. Remembering – You will demonstrate the ability to recall memorized information. Although these items may involve remembering a wide range of material, from specific facts to complete theories, all that is required is the recollection of the appropriate information in the same form that it was presented.

- **Importance** – Learning and using appropriate scientific terminology and concepts are foundational to everything else in this course. Although these questions will not be the most common or difficult this semester, the material that they cover will spill over into just about every part of our class.

- **Example** – “Remembering” questions typically require you to recall or recognize a specific term or concept from the course in an unaltered form. One example is...

- ___ 1. Which of the following scientists is generally recognized as the first to observe and report single-celled microorganisms?
- A. Pasteur
 - B. Leeuwenhoek (✓) *you should directly recall this fact from your lecture notes*
 - C. Koch
 - D. Lister

- **Study suggestions** – Since rote memorization and simple recall are paramount at this cognitive level, repetitive review with flashcards is one of the best strategies available. You should consider developing and using electronic flashcards and recall questions using our StudyMate resource online. If you have an Android, iPad, or iPod Touch, there are free apps that will allow you to download the class question database and practice remotely at your leisure.

2. Understanding – You will demonstrate an ability to grasp the meaning of material to answer these questions. The items may require you to identify examples of a category, classify specific items into groups, summarize concepts, or compare and contrast material. This level goes one step beyond the simply remembering facts because you will need to recognize the information in a different context from the one in which it was presented.

- **Importance** – Appreciating the principles and concepts underlying the material in class is probably the most important goal for a lower-division college course. As a consequence, questions dealing with your understanding of the course materials will be frequently found in quizzes and exams.

- **Example** – “Understanding” questions typically require you classify an object or to recognize an example of a type of object. This means you must understand the underlying concept, not just remember a specific fact. One example is...

- ___ 2. Which of the following cannot translate their own proteins?
- A. Archaea
 - B. Bacteria
 - C. Fungi
 - D. Bacteriophage (✓) *you would need to know that viruses do not have ribosomes*

- **Study suggestions** – As these questions require you to compare and contrast different things, rote memorization is a poor strategy here. Instead, consider making comparison tables (like the one on the next page) to identify similarities and differences between objects. Another possibility is to put the name of each type of object on a separate index card or post-it note. You can then practice sorting the cards into categories. Alternatively, you can put three or four cards together and try to find the one that is most dissimilar to the others.

Type of microbe	Acellular	Cellular	Prokaryotic	Eukaryotic	Cell membrane	Nucleus	Ribosome	LPS	Teichoic acid	Mycolic acid	Cell wall	Human pathogen
T4 bacteriophage	X											
Influenza virus	X				*							X
Gram-negative bacteria		X	X		X		70	X			X	X
Gram-positive bacteria		X	X		X		70		X		X	X
Acid-fast bacteria		X	X		X		70			X	X	X
Protozoa		X		X	X	X	80					X
Fungi		X		X	X	X	80				X	X
Algae		X		X	X	X	80				X	*

A sample comparison table for a few features found in some common microbes

3. Applying – You will demonstrate an ability to use the learned material in new and concrete situations material to answer these questions. These items may require you to sequence or arrange concepts or procedures into a logical order or to solve problems using simple calculations. Questions written at this level require a higher level of cognitive ability than those under understanding and constitute the most basic level of critical reasoning.

Importance – These questions probe your practical knowledge of the course materials. Essentially, they help me to determine if you can actually use the information that you have learned in class. If you are not able to apply what you “know” to new and novel situations, then I begin to wonder exactly how well you really know it.

Example – “Application” questions typically require a concrete understanding of a process or object. They might involve creating a logical sequence (either spatial or temporal) of items. Alternatively, you might need to perform some sort of calculation to solve the question. One example is...

- ___ 3. Assume that you have a flask of nutrient broth that contains 1,000,000 bacterial cells. If the generation time of these cells is 20 minutes, how many cells will there be in the flask after one hour (assume optimal growth conditions prevail)?
- 2,000,000
 - 4,000,000
 - 8,000,000 (✓) *you would need to know how to calculate microbial growth*
 - 16,000,000

Study suggestions – You can practice ordering questions by putting the names of parts or sequence steps on separate index cards or post-it notes. After scrambling them up, practice putting them back into the correct spatial (inside to outside and vice versa), dimensional (smallest to largest and vice versa), or temporal (first to last and vice versa) orders. You should also practice performing the calculations covered in our textbook, lectures, and homework assignments.

4. Analyzing – You will demonstrate an ability to use critical thinking skills in order to break down a problem into its component parts. These items may require you to recognize unstated assumptions and logical fallacies in reasoning, distinguish between facts and inferences, evaluate the relevancy of data, and analyze the organizational structure of the problem. Questions written at this level require you to apprehend both the content and the structural form of the material presented in the problem.

Importance – The ability to use knowledge to solve complex problems is an essential skill in the sciences. This type of exam question requires a bit more thought and time to complete. Therefore, they are a little less common in our exams. I will, however, assess your analytical abilities in other ways as well (homework and lab projects for example) this semester.

Example – “Analyzing” questions usually occur as story problems with one or more associated prompts. You will need to read through the information, decide what is important and what is not, and then draw some sort of conclusion from what you have read. One example is...

- ___ 4. One of your classmates has just isolated a unique microbe from a pond on her property. A biochemical analysis of it revealed the following macromolecular composition: phospholipid, protein, RNA, DNA, lipopolysaccharide, and peptidoglycan. Based upon this information, this microbe is most likely a _____.
- A. Gram-negative bacterium (✓) *you would need analyze the composition list*
 - B. Gram-positive bacterium
 - C. Protozoan
 - D. Fungus

Study suggestions – Since these questions will be associated with story problems that you have not yet seen, direct preparation is not possible. Instead, my best advice is practice, practice, and more practice. Use the analysis problems from you homework and textbook and solve them. Concentrate on the process of solving the questions and less upon the correct answer.

5. Evaluating – You will demonstrate the ability to judge the appropriateness of a particular action or potential solution for a given purpose. Their conclusions would be based on definite criteria, which may be internal (organization) or external (relevance to the purpose). You might be required to determine these criteria or they might be provided in the prompt.

Importance – Getting the “correct” answer is not everything! Recognizing what is important and *why* something is correct is just as essential.

Example – “Evaluating” questions will require you to make an informed judgment about a fact or inference. These questions are usually associated with “Analyzing” questions and a story problem. One example is...

- ___ 5. Which component from the organism described in question four (above) was **most** useful in classifying it?
- A. DNA
 - B. Protein
 - C. Peptidoglycan
 - D. Lipopolysaccharide (✓) *LPS is only found in Gram-negative bacteria*

Study suggestions – Like “Analyzing” questions, this can only be practiced. When solving practice problems involving analysis, try to identify (circle them or highlight them) the most important facts. Try to identify the logic involved in solving problems and think about what might happen if some of the variables were changed. For instance, what compositional changes to the organism in this question would cause you to think that it might be a fungus?

6. Creating – You will demonstrate the ability to put several independent parts together to form a new whole. This may involve the production of a unique paper or talk, a research proposal, or a set of abstract relations (like a concept map).

Importance – This is a capstone type of activity. You must not only know the information and be able to use it, but you have to apply it to make something new on your own. This type of knowledge cannot be captured by an objective exam.

Example – Your ability to create will be assessed with laboratory projects.

Study suggestions – Read and follow all provide instructions and directions. Come to my office hours for clarification on these projects if you need more help.