

SUGGESTIONS FOR STUDYING BIOLOGY¹

1. When trying to learn the material, **focus on the right stuff**. The things that your professor considers most important to the subject and which are most likely to appear on quizzes and exams are the things that have been emphasized in lecture and in specifically assigned readings. Learn these things first and learn them best. More general assignments (e.g., “Read all of Chapter X”) are important too, of course, and you are responsible for the broad general points that are made in them. But when setting your priorities, remember that most questions on an exam deal with what’s been clearly emphasized by the professor.

2. **Make sure your lecture notes are complete and accurate**. Since the lecture material is so important, it follows that your lecture notes are one of your most important resources. Often, notes are incomplete, disorganized, and filled with errors. Furthermore, they’re written in an impromptu shorthand that may still make some sense to you later on the same day that the notes were taken, but becomes increasingly unclear with every passing day. If left in their original form, the notes can become almost useless to you by the night before the exam. Therefore, here are some things to consider doing:
 - a. If your professor provides materials ahead of class (e.g., lecture outline, PowerPoint) get them and use them to guide your note-taking.

 - b. Rewrite your notes into clear and complete form after every lecture, while the scribbles still make sense. Do it regularly as a part of a formal schedule or you won't do it at all. Use complete sentences; add labels and notes to diagrams even if you think they're quite clear already; try to organize things into sections or categories to show relationships. Use your book and the PowerPoints to get definitions and help you fill in the gaps, etc.

 - c. It would be better if you did all of this after first talking over your notes with a friend, or better still with two of them. Rewriting your notes by yourself reduces the chance that you'll catch wrong or missing data, or that you'll correctly interpret a cryptic phrase or diagram. But if two of you are doing it cooperatively, the odds of doing it well are considerably improved.

Picture this: One of you is responsible for reading/explaining his or her version of the notes that day, while others check theirs against it. Differences will arise: one student says, "Wait, my notes say 'A leads to B in spite of C', while yours say 'A leads to B because of C'." Another says, "C? What C?" Clearly, when something like this happens, you're forced to discuss the material in order to arrive at the best possible set of notes. And if you can't agree on what's right, then at least you've identified something to check in the book or to ask about in the next class meeting.

¹ Adapted from Dr. Terry Hill’s “Suggestions for Studying”.

3. **Practice “active” studying.** Don’t just *read over* your notes and PowerPoints, however complete and helpful they may be. Someone who really knows the material can go well beyond just the good feeling that comes from not getting lost while reading complex material. If you really know the subject, you can call up large parts of it from memory – can recognize elements of what you know when you see them in new situations – can explain to others what you understand. You want to be able to *participate* in discussions of a topic, not just listen critically.
- a. Why should you have to practice explaining? Because you may have to do it on an exam. Depending on the course, some exams will pose questions that require responses of several well-chosen sentences. Even on multiple choice exams, you can't prepare yourself well for the exam without practicing explaining (in brief, clear, and accurate language) the things you "know". That last word is in quotes because until you can do this, you don't really know the material well enough. Think of it -- would you practice for a tennis tournament just by reading books and by watching others play? All of that may be important, but in the end you've got to be able to do the thing yourself. And of course the tournament is the wrong place to try out your backhand for the first time. Likewise exams in college are the worst possible place to get feedback for the first time on your knowledge.
 - b. When practicing for exams and testing your understanding, make yourself give clear, accurate, brief, but complete explanations, entirely from memory. If working in a group, start by agreeing upon representative questions, then take turns answering them, while others point out what parts of the attempts are especially good and what parts need improvement. If studying alone, write out what seem to be good answers, based upon your notes, and then put those answers aside or a while and see how well you can reproduce them from memory. Do the same thing with any diagrams or figures covered in class to make sure you can recreate them from memory with all the key parts and steps labeled, and their function and significance stated. Even you don't have to create a diagram or figure on a test, practicing it from scratch will help you to understand the material better. This is what's meant by “active” knowledge. It will stand you in good stead if the same topic comes up in some form on the exam, and the skills of reasoning and the discipline of explaining that you develop will help with wholly unexpected questions too.

It's hard to overemphasize your need to gain an active knowledge of the subjects. If all you do is read your notes, the chapter, and the PowerPoint, then you'll gain only a passive familiarity with the material. This will indeed help you on the test – the simplest forms of questions may require of you no more than to remember a certain term or to recognize a correct answer in a list. But college exams usually test your active knowledge, by asking you to provide something written, which someone else (the professor) will evaluate as right or wrong, complete or incomplete, elegant or clumsy.

Or questions sometimes pose entirely new situations, which you need to analyze – even though you've never seen that situation before. Suppose, for instance, you've learned a lot about a certain forest ecosystem in class. And then on the exam, the professor doesn't ask a thing about the forest, but instead puts you in the middle of the desert, acquaints you briefly with certain of its inhabitants, and asks you complicated questions about their

relationships to one another. If you *really* know your way around the ecosystem you were given (the forest) – know about its energy and nutrient flow, its inhabitants’ adaptive strategies, etc. – then you will be better prepared to see familiar patterns in this strange new situation (the desert). You know in advance that there’s a food network of some sort – that it will be like that in the forest in some ways, etc. You end up understanding a bit about the desert ecosystem not because you memorized it (indeed you’ve never encountered it before at all), but rather because you know the forest ecosystem so well that you now can think beyond just that. But the only way to be sure in advance that you really know the given system well (the forest) is to practice explaining what you know.

- c. While we’re at it – a note about multiple choice questions. You need your “active” knowledge and your ability to offer your own complete explanations even on multiple choice questions. Sure, *some* MC questions (particularly those you’re familiar with in high school) can be very simple: “Which of the following is the principal language spoken in Paris?” – the connection between such a question and its answer is a very short and simple one. You know it or you don’t – and even if you don’t really “know” it, maybe just seeing the word “French” in the list of options will remind you.

But MC questions in college often are more sophisticated than just that – they might pose entirely new situations for you, which require you think and analyze. “Suppose the forces of Charles Martel had been defeated at the Battle of Tours in AD 732. Which of the following languages might the citizens of Paris be speaking today *instead of* French?” Whoa! You need to remember who Charles Martel was, whose forces he led, who he fought against, and a whole lot more before you choose the best answer. Ideally you would have an idea of the correct answer in your head already, even before you read the list of options. (What *would* you choose for an answer, by the way?)

- d. One excellent approach to active studying is to go over each quiz and exam as soon as results are back. If your professor lets you keep the exams, use part of your group study time to go over them. You should discuss each question, critiquing every option in multiple choice questions (especially every group member’s wrong choices) and every member’s essay answers. Be sure to identify what understandings provide the keys to a correct answer in each case, and identify where in lecture or assigned readings these understandings come from. If someone did poorly on a question, help them identify (hopefully by your own successful example) where their notes or study practices have let them down. If you can identify what you did wrong in studying for a quiz or exam already taken, then you are in a better position to study well for evaluations yet to come. If your professor keeps the exams, then ask if you can bring your notes to review your exam in their office. You will not have your group members present, but you can still critique all the multiple choice options (can you explain why each incorrect answer is wrong?) and figure out where your notes or your study process may have helped you answer correctly, or where they led you to an incorrect or incomplete response.

Whether you’re dealing with an essay question or one of the more sophisticated versions of multiple choice, in college you very often have to reason your way through a situation that you’ve never seen before in quite that form. Active study, leading to active understanding, is the best way to prepare yourself to reason through the unexpected.

4. **Study in groups** in addition to studying on your own. The object of group study is more than merely to get the benefit of someone else's understanding of the subject. The far greater benefit is the practice you'll gain both in explaining what you think you know and in gaining the ability to evaluate explanations that others offer. If you've agreed with the suggestion that you should be studying "actively" and aiming for an "active" understanding, then where better than in a group of peers can you get real practice in explaining and critiquing? In addition, where better than amongst your friends can you get a "student-level" explanation of something you're having trouble understanding? Where better than from other students can you find proof that people just like you can get the hang of subjects that may seem at first intimidating?

Choose your group well, and establish a regular meeting schedule. Find people who seem responsible in their study habits. That's far more important than whether they got an A on the last exam or not. Your group should consist of 3 or 4 persons – if there's just two, you have too much chance of just reinforcing one another's errors. And meet regularly – ideally once per lecture. Use the time for anything that's class-oriented – correcting notes, finding answers for what you don't know, having others critique your explanations of a subject. It's all worthwhile, and it all leads to active involvement with the material.

Remember – "active involvement" in a group setting means **you have to open your mouth** – and often.

5. **Take advantage of the peer study partner or tutor** if your course has one assigned. Whether alone or with your group, have the peer study partner ask you questions and everyone in your group can take turns answering them and critiquing each other's explanations as you would when working with just your group.
6. Check to be sure that your answers **employ the proper "logic" of science**. Exam questions may be testing your understanding of proximate or ultimate mechanisms, or possibly both. Proximate answers are mechanistic and usually address causes, i.e., how things work in nature, even if the question contains the word "why." For example, if a question asks why a certain chemical accumulates at a certain time in a cell, a proximate answer might say something like, "because the enzyme that creates the chemical has become active." In contrast, ultimate answers usually address the adaptive significance of a phenomenon. In this case, if a question asks why a skunk produces a chemical with an unpleasant odor, an ultimate response might say, "because it will likely deter predators, which increases the skunk's chance of survival and its fitness." How does one determine which type of answer to provide or whether the answer should incorporate both proximate and ultimate reasons? You should know based on the subject of the course (e.g., Cell Biology vs. Animal Behavior) and what your professor has been emphasizing in class.

When explaining causal connections, it's important to build a logical and adequate **chain of connection** between the initial cause and the final effect. For instance, if you were asked to explain why carbon monoxide kills, you might answer, "Because it stops respiration." That might be adequate in casual conversation, but it isn't normally enough on an exam. There are too many questions left unanswered. "How does CO inhibit respiration?" "Why does the stopping of respiration lead to death?" Depending on the course and the level of detail

normally employed in it, you might well be expected to offer an answer more along the lines of the following: "CO binds to hemoglobin, inhibiting its ability to carry oxygen from the lungs to the tissues. Oxygen is required as the terminal acceptor of electrons in the respiratory electron transport system, which then ceases because oxygen is absent. Without respiration, no ATP is generated. And since ATP is the form of energy needed by numerous energy-requiring processes essential to life, these processes cease, and death ensues." Notice how many logical links between CO and death profitably can be employed. Some courses, depending on emphasis, may require fewer than these; some might require more. It's up to you, of course, to gauge what's appropriate for the course that you're in. To form the habits and instincts of offering "complete" answers, become more like the pestiferous child who replies to every statement with the question, "Why?" It will help your thinking immensely.

When answers include a relative statement, it is important to complete the comparison. For example, you may wish to argue that feature "z" is advantageous to a group of animals because it allows them to be faster, stronger, slimier, or whatever! However, if you use one of these descriptive terms, you should specify the alternative for comparison. For example, if someone told you that "Driving on interstate 40 gets you from Memphis to Nashville faster," you would naturally ask "Faster than what?" Driving on different roads? Walking? Flying? A good answer includes the alternative for comparison.

7. **Memorization is not a bad thing.** There's nothing undignified or "high school" about memorization. No matter what the subject and no matter what the level, there will always be things that simply must be committed to memory. Just remember that memorization, like everything else, has to be active, not passive. Don't just read the facts over and over - you'll doze off. Write things down, make flashcards, make mnemonics, create diagrams, and/go over them again and again. Leave plenty of time between trials so you're not just testing short-term memory and repeat until you know that you can always get them right.

This website, <https://www.butte.edu/cas/tipsheets/studystrategies/studybio.html>, provides some very helpful strategies for memorizing terms ("Strategies for memory-based tests") and complex processes ("Study strategies for concept-based tests"). One of several free online flashcard programs is Anki, at <http://ichi2.net/anki/index.html>. You may prefer another program – or you could just do them all by hand – your choice.

8. **Lab requires active learning** beyond doing the scheduled activity.
 - a. If your course has a lab component, read the exercise before coming to lab. Not only will this help you to understand the goals of the experiments, but operating equipment and performing procedures in lab for the first time will be easier if you know what to expect. This is especially important if you will be asked to perform lab tasks and understand the output data in a practical exam later on.
 - b. If you are working in a group, it is your job to make sure you know how to do each part of the project. Sometimes it is tempting to let someone else do all of a procedure because they are faster at it than you are, but this interferes with your learning and may have negative consequences if you are later tested on that procedure. Be sure to get your hands on the equipment - basic laboratory procedures such as pipetting or using a microscope are not activities you can practice later in your dorm room. Of course, one procedure you can do outside of lab is using computer programs such as Excel to run statistical

analyses or generate graphs. These are useful skills that you will likely need in the future, so once you are given directions for running these programs, it is worth practicing the steps until you feel comfortable doing them on your own.

- c. When lab includes materials (dissections, models, microscope slides etc.) that you need to know for a practical exam, **come back to the lab and study the materials directly**. Pictures and YouTube videos can be helpful, but they are not the same as the real thing. Ideally, do this with a study group so you can quiz one another. You may be able to point to and name all the parts you know, but it is a different challenge to identify something that someone else has tagged, which is how the practical will be conducted.
9. Finally, whatever you do, whether active or passive, whether alone, with the peer study partner, or in groups, **don't put it off until the night before the exam**. No one will be impressed with your conscientiousness and maturity for having devoted "the entire night" before the exam to just this one subject. No one will care - even if it was two entire nights. It won't work, and your grade will show it.