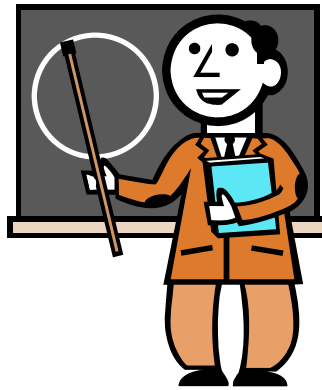


# A Manual for Teaching Assistants



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## INTRODUCTION

This manual is a collection of advice, tips, and miscellaneous useful information for teaching assistants. Most of the information was contributed by members of the Columbia Biological Sciences Department. Some of it is from graduate students who served as teaching assistants and some of it is from professors who depended on teaching assistants to help with their courses. Most of this advice was obtained in response to the questions, "What would you tell a new TA?" and "What should a TA know?" The material has been organized by topic so you can look up advice on whatever subject concerns you. Some ideas are repeated in slightly different form under different topics and some cross references are included. This manual was originally prepared for TAs in Biological Science at Columbia, but the advice should be useful to TAs in almost any field or educational institution. It has already been used at Columbia for training of TAs in other science departments, and in economics.

I want to thank all those who contributed ideas to this manual and I welcome additions, corrections and comments. Please contact me by email at [dbm2@columbia.edu](mailto:dbm2@columbia.edu).

An HTML version of this manual is available on the web at <http://www.columbia.edu/cu/biology/faculty-data/deborah-mowshowitz/faculty.html>

A similar manual, *Teaching Scientific Concepts & Problem Solving*, is available on the same web site. It overlaps this TA manual, but contains additional advice on explaining scientific concepts and problem solving. For the sections on explaining that are *not* included in this manual, go to <http://www.columbia.edu/cu/biology/faculty/mowshowitz/explain-more.html>

For the pdf version of either manual, and additional tips on teaching, go to the 'How To' Collection at [http://www.columbia.edu/cu/biology/faculty/mowshowitz/howto\\_guide/menu.html](http://www.columbia.edu/cu/biology/faculty/mowshowitz/howto_guide/menu.html)

A much more extensive manual and additional information on teaching for TA's is available from the Graduate School of CU at <http://www.columbia.edu/cu/tat/index.html>

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## **Topic 1 -- WHAT DOES A TA DO IN RECITATION OR LAB SECTION?**

**1. The TA discusses the material of the course** -- finds out what students are confused about and explains. The trick is to get the students to speak up and to tell you what they need to know so you can zero in on the trouble spots. (See the section on how to avoid passivity.) You don't want to repeat everything in the book or everything the lecturer said in class. It's too boring and slow if you repeat everything, so you have to be selective.

If there are assigned questions or problems, the TA goes over them. If there are no assigned questions, the TA uses the students' questions or covers whatever seems important and/or difficult from the lecture material or readings. The 2 major rules are (1) be selective and (2) be responsive to the students' needs -- find out from the students what they need help with.

**2. The TA tells students what's important** -- what's stressed on exams, what's worth reading, what to memorize, and so on. Teachers differ a lot in what they expect of the students, and the students get very anxious as a result. A well informed TA can reduce student anxiety and free the lecturer from endless questions about what's on exams and "what are we responsible for?" The TA can usually get the necessary information from the teacher or from last year's TAs in the course. Some very successful TAs have acted very much like coaches on a sports team, urging their students on to victory with tips on exam taking, studying etc. For many students the moral support and encouragement provided by a TA can be as important as the scientific information that the TA provides.

**3. Some TAs are expected to present material which is not covered in lecture** (or by the lab instructor). This means that some TAs give short lectures &/or lead discussions of articles.

**4. What about Lab TAs?** A laboratory TA does all of the above and guides the students through the actual experiments as well. The basic point for a lab TA is to be as helpful as possible without hanging over the students' shoulders. There is a big temptation for a lab TA to sit down in one spot and wait for the students to ask for assistance. It is much better to walk around and look for students in need of help. There are two reasons to seek out the students. First of all, students will often ask questions if you walk by, but won't bother to ask if they have to seek you out in your corner. Secondly, it is better to catch them before they mess up than afterwards. So it pays to walk around and look for students who look lost or as if they are about to mess up their experiment.

## Topic 2 -- WHAT WORKS AND WHAT DOESN'T

### What Works

A well prepared TA

A positive, helping attitude

Student participation

Prepared students who have gone over the material

Students who come with questions

An atmosphere that is  
Relaxed  
Co-operative  
Lively

### What Doesn't

A poorly prepared TA

The attitude that this is a chore to get through

Students who sit passively waiting for something to happen

Unprepared students who have not thought about the material

Students who don't have or won't ask questions

An atmosphere that is  
Tense  
Antagonistic  
Boring

### Topic 3 -- HOW TO AVOID PASSIVITY & INCREASE PARTICIPATION

Most students are used to listening, and most teachers are used to talking. So you have to be quite careful to keep the recitation from reverting to a lecture. Students would rather be passive, but the whole point of a recitation or lab is to get them actively involved. Try to emphasize questions – yours and theirs. In other words, “Ask, don’t tell.” It may be hard to get them to either ask questions or to answer yours at first, but if you stick with it, you should be able to establish a friendly, inquiring and non-intimidating atmosphere.

Try to establish the right participatory atmosphere at the very start – if you let the students act passively at the beginning, you will find it hard to change the pattern later. Here are some tips on how to maximize student participation and minimize passivity.

**1. Names.** Learn the students’ names, and use their names as much as possible -- when calling on them, when referring back to early points, summarizing, etc.

**2. Wait time.** When asking questions, give students more time to respond. Give the students enough time to collect their thoughts, look through their notes, & respond to your questions. It's ok if there is a pause of a few seconds now and then. If they don't answer a question after a reasonable pause, rephrase the question or ask a simpler one. Don't give in and give the answer yourself -- get it out of them if at all possible. (See #4 for another approach.) Long, dead silences are boring, but if you stand firm in the beginning and make it clear that you will not do all the talking yourself, the students will get in the habit of talking. (They probably won't talk at first because they are shy, afraid of looking stupid, &/or unprepared.)

If you feel foolish during pauses, do something so you feel busy -- look through your notes, sip your coffee (or glass of water), clean your glasses, etc.

**3. Be explicit.** Say "I don't want to do all the talking. That's the lecturer's job, not mine." (Then you have to stick to it.)

**4. Pre-discussion.** Let students write or discuss the issue at hand before you call on them. (This allows them to think without looking stupid.) When you pose a question, have the students write down their answers and/or discuss them with their neighbors for a few minutes. Then call on individuals or ask for volunteers. This increases both the amount of participation and the quality of the comments.

**5. Student Questions.** You can ask each student to bring a question to class. To make it concrete, insist that each student bring a 3 X 5 card with a question written on it. You can even stand at the door and refuse to let anyone in without a card. You may ask the students to write their names on the cards so you can get some sense of where they are (or take attendance). Alternatively, you may find you get better responses if the questions are anonymous. If the atmosphere in the class is sufficiently relaxed, it may not make any difference. (You can also ask students to submit questions by email before class.)

**6. Student Presenters.** Have the students take turns going to the board and explaining problems. This works well if the students have already worked through the problems for homework, or discussed them in small groups (as in 4 above).

**7. The Silent Majority.** What if the same few students tend to do most of the talking, and the others don't speak up. How do you deal with this?

A. Wait until a few hands are up before calling on anyone. This gives the students more time to think (see 2 on previous page) and increases the number of volunteers.

B. After a few questions, when the same students raise their hands again, say something like "I'd like to see 3 hands from people who have not talked yet." Wait until you get the 3 new volunteers, and then call on them.

C. Don't always rely on volunteers.

(1). You can go around the room and make the students speak in order. If you go around the room in an arbitrary order, it's hard on the shy ones, but at least it's fair, and you clearly aren't picking on anyone. You can have each student in turn ask *you* a question, or you can have each student answer *your* questions -- that is, have each student in turn try to explain a problem or principle. (But see (3) below.)

(2). You can randomize the order in which you call on the students. This way they don't know when their turn is coming, so they have to pay attention. One way to do this is to shuffle the question cards (or a set of cards with the students' names on them) and call on the students as their names come up.

(3). Don't be too heavy handed when calling on students. Try to distinguish between those quiet students who are comfortable talking (but reluctant to volunteer), and those who really do not like to speak. It is probably best to call on those who are willing (but need a little prodding), and leave the truly reluctant alone. (If you want to engage an unwilling participant, you might try speaking privately to the student or communicating by email.) One approach is to let the volunteers speak first, and then say "Do you have anything to add?" (or the equivalent) to a student who has not spoken up or volunteered. That allows the student to pass or to talk without being embarrassed.

**8. The Over-Participating Student.** What if *one* student talks too much? This is undesirable especially because it reinforces the passivity of the others -- why risk exposing your ignorance by asking questions if the class big mouth will do it for you? One way to defuse the situation is to say something like "Does anyone but Joe have a question?" Or you can ask a question, and when Joe raises his hand say "Let's give someone else a chance -- I know you know the answer." In other words, compliment Joe on his knowledge and/or willingness to participate (even if he always gives the wrong answer). If Joe doesn't take the hint, and continues to monopolize the discussion, speak to him privately.

**9. Humor.** A little humor helps a lot, but be careful not to embarrass anyone or make fun of ignorance. Never belittle a student, no matter how stupid the question is. It's okay to defer answering a question, but don't insult the student who asked it.

**10. Follow up an answer with a question.** (Another application of: "Ask, don't tell.") It doesn't matter if the answer is right or wrong (or if you can't tell) -- either way you have an opening to extend the discussion. (Wrong answers are often more useful, as they provide an opportunity for figuring out how the student -- and probably a good part of the class -- arrived at a misunderstanding.) If you just answer "yes" or "no," you stop the discussion dead. If you ask another question, the discussion keeps going, and the class usually arrives at a deeper understanding of the issue. So when a student answers a question, or explains a point, ask them to elaborate. Whether the answer is correct or not, throw the question back to the student or another member of the class. Ask a follow up question such as "Why do you think that is so?" or "What do you mean by 'it'?" or "Does anyone disagree?"

For this to be really effective, (a) you have to ask for clarification (at least sometimes) even when the student seems to be right. That way your request for more information doesn't give away the answer -- it doesn't signal whether the response is correct or not. (b) You have to ask for more information in an encouraging way, so that the student feels rewarded for speaking, and doesn't feel attacked.

## Topic 4 -- PREPARATION

**1. Be Prepared!** You need to know the subject you are discussing one layer deeper than you expect to talk about it. In other words you need to know the right answer and why the right answer is right and you should be able to explain why the right answer is right.\*\*

**2. You don't need to know everything!** Which is fortunate, since you can't know it all anyway. If you are confident, it is ok to say "I don't know" or "It doesn't matter" (if it really doesn't matter). It is much better to admit you don't know than to bluff. If you don't know, and it does matter, say you'll look it up and then do it promptly.

Some TAs find it helpful to bring the text to recitation so they can look up things on the spot. Others find they need a little peace and quiet (after class) to think things through before they can come up with an answer. Either way is fine, but once you figure out the answer, be sure to tell the students promptly (in an email, or at the start of the next session).

**3. Plan Ahead.** It is good to look in advance for trouble spots -- places where confusion, misunderstanding, etc. can arise. (See topic 5 -- famous misunderstandings). You might keep this in mind when listening to the lectures -- in addition to trying to follow the lecture, you might note any points that you think will need to be clarified in recitation. (See point 5 below.)

**4. How to Prepare a Problem.** When you go over a problem in preparation for class, you should understand:

(a) The general principles on which the specific problem is based, not just the answer to that particular problem, and

(b) How to get the answer. The process of getting there is just as important as the result. Remember you are trying to teach the students how to solve problems for themselves. (See topic 7 -- problem solving)

**5. Attend Lecture.** Going to lectures is well worth it. It seems very time consuming, but it is much faster than learning all the material on your own, and it is the best way to find out the lecturer's strengths, weaknesses and emphases.

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\*\* You do not need to **say** everything you know -- it's usually better not to say everything you know on the subject, but it is necessary to know more than you plan to say so that you will feel confident.

## Topic 5 -- FAMOUS DIFFICULTIES & MISUNDERSTANDINGS

### A. Problems of terminology

#### 1. Confusing technical meanings and ordinary meanings of words.

Some scientific terms have technical meanings that are very different from their commonsense meanings. For example "spontaneously" in chemistry does not mean "very quickly" or "all by itself" -- it means "without net input of energy." Unfortunately, in common English, spontaneously means "all by itself" and often also "very quickly." So students think spontaneous reactions occur rapidly &/or without an enzyme. This type of difference between technical and ordinary meanings often leads to a lot of confusion, because the TA, book or lecturer is using the term in the technical sense, while the student is using the same term in its nontechnical, commonsense meaning. Even when the student tries to use the term correctly, s/he is often confused by the connotations that the word has in common usage.

Another example: The teacher asks "Does burning destroy matter?" and the student says "Yes." The teacher groans and thinks the student is an idiot. But the student is not -- s/he is using the term "destroy" in its ordinary English sense, and the teacher is using it in its technical physics sense. If the teacher's house burns down, the house will certainly be destroyed (in the English sense), even though the atoms that were in the house have not been altered.

#### 2. Using words that have technical meanings and not even realizing it.

Some ordinary English words are used as technical terms, as explained above, but experienced scientists (such as graduate students and lecturers) are so used to using these words that they often forget that these words have special meanings. So the scientists don't define the terms and are surprised when the students don't know what they mean. For example, what is a "strain" of bacteria? Do all bacteria of the same strain have the same genes &/or alleles? Are the genes in the same order? Are all bacteria of one strain of the same sex? A graduate student who works with bacteria will consider these questions so obvious that s/he will not realize that the answers are not common knowledge.

#### 3. Getting confused between similar but not identical terms.

Certain terms seem to be difficult to get straight, for example, gene vs allele and chromosome vs chromatid. There are many such pairs of terms that are very similar in meaning and that are often used sloppily even in scientific writing (and speech). To make it worse, some of these terms are synonyms in common speech, such as "inhibition" and "repression." A good way to clear up confusion is to "compare and contrast" -- compare what is similar between the two terms and contrast what is different.

**Note:** If you are explaining a topic in your own field, you have to watch out especially for problem 2 above. If you are discussing an area outside your field, you have to beware of problem 3 – you are likely to find the terms confusing, just like the students. The good news is that you can understand the students' confusion; the bad news is that you have to go to extra effort to get the terminology sorted out before you can conduct recitation.

## Topic 5, cont.

### *B. Other types of common conceptual difficulties*

#### **1. Finding unlikely &/or complex solutions when ordinary, simple ones will do.**

There is a saying in medical school: "When you hear hoof beats in Central Park, you don't think of zebras." In other words, when you hear hoof beats in the park it is probably a horse, even though it could be a zebra. A person who thinks it is probably a zebra (or equally likely to be a horse or zebra) does not understand the situation. When solving problems, always look for the "horse" -- the simple, obvious solution, before you starting worrying about the "zebra" -- the possible, but unlikely solution. Students often come up with very improbable (but possible) answers, and don't understand why their answers are unlikely or why unlikely answers are not as good. Usually their problem is a lack of general background -- if you don't know much about New York, you might not realize that horses are relatively common here and zebras are rare. (Sometimes the answer IS a zebra -- maybe it escaped from the Central Park Zoo! But students should always rule out horses first.)

#### **2. Not seeing how the parts relate to each other or to the whole.**

Students often understand what certain items are, or what they do, but do not understand how the items relate to each other, or how the details relate to the big picture. For example, students may understand the structure of DNA, that genes are made of DNA and that chromosomes carry genes, but they may have trouble figuring out how the DNA fits in the chromosome. (How many copies per chromosome? How many strands? What's a strand?) As another example, students may understand how DNA is replicated, transcribed, and translated, but they still may not understand how a gene controls a trait. So you may need to explain "up" or "down" how the parts relate to the whole -- up, how the item under discussion fits into something bigger, and down, how the item is made of smaller things. For example, if you are discussing genes, you should be prepared to go "up" to chromosomes, genomes, traits, etc., and "down" to DNA, codons, nucleotides, and bases.

## Topic 6 -- HOW TO START A CLASS DISCUSSION

There is no one perfect way to start a discussion that works for every leader in every situation. Different methods work best for different people and for different occasions. Many discussion leaders swear by method 1, but others say it does not work for them at all. So look through the following bag of tricks, and select the ones that are best for you. Feel free to experiment until you find the method(s) that work for you.

### 1. Collect Questions

Ask the students for specific questions, topics, or terms that they want you to go over. Write the questions &/or topics on the board. Do not answer the questions as they are asked. Keep collecting questions until you have a reasonably long list. Once you have the list of questions/topics on the board, you can look at the list and decide what to do first. You can go over the questions in order of importance, or logical order, or the order they were covered in class. Do whatever seems sensible to you. As you cover each question, check it off the list.

The first few times you do this, it will be very difficult to get the students to speak up. So be patient and give them plenty of time to come up with questions. If they don't seem to have any questions, suggest that they look through their notes or text to find points that were unclear. Wait until you have a decent length list before you start answering the questions. (See topic 3 -- how to avoid passivity.)

This method works best if you can look at the list and see instantly what topics need to be discussed. So be sure your list is self explanatory. If the student says "Do problem 5," don't just write "#5" on the board - add a few words so you and the students can remember what problem 5 is about. For example, write "#5 -- crossing over" or "#5 -- protein synthesis" or whatever. If the student asks a long question, you don't have to write it out word for word -- just write enough on the board so everyone can remember what the question is about. For example, you don't have to write "Why is the maximum value for recombination frequency 50%?" You can just write "Max RF" or "why RF < 50%?"

### 2. The Old Card Trick

Ask each student to come to class with at least one question written on a 3 X 5 card. Collect the cards at the beginning of class and use the questions to organize the session. One way to proceed is to spend a few minutes reading the questions silently. Then you can write the good questions on the board, as above, or read them out loud. Another way to start is simply to shuffle the cards and read one out loud at random. Once you have picked the question(s) to go over, you can answer the questions yourself, or you can let the students answer each other's questions.

An electronic variation – ask the students to email you the questions the night before. This gives you more time to compose your thoughts, decide which questions to use, and look up the answers.

## **Topic 6 -- HOW TO START CLASS, CONT.**

### **3. Ask Them a Question**

Ask the students a question, preferably about an experimental situation. For example: Suppose you find a one foot black and white sphere in Riverside Park and you suspect it is a new organism. (a) If it really is alive and not an abandoned soccer ball, then is it more likely to be a prokaryote or a eukaryote? (b) How can you decide (experimentally) if your answer to (a) is correct?

After you pose the question, you can then ask the students:

- (1) What do you know that's relevant to this question/situation?
- (2) What do you need to measure or find out?

After you have discussed what information you need, you can then go over how to use the information to get the answer. This sort of exercise will reveal what level of knowledge the students have (what facts they know) and their level of insight (how good they are at applying the facts). It will also allow any confusions the students have to surface.

### **4. Pair them Up**

This method works well if the teacher has assigned questions, but the students have not had time to go over them. In other words, this works even if the students are not prepared. Divide the students up into pairs or small groups and have each group go over the assigned questions and prepare an answer sheet for the entire group. (You can also do this by making up your own questions and handing them out.) Allow about 1/2 hr. minimum for the students to go over the questions. While they are working, you should walk around the room and listen to what they are saying. Don't sit up front and wait for them to come to you. If they are stuck, help them. If they are fooling around, prod them into getting down to work. If they have made mistakes, ask them leading questions. At the end, collect the answer sheets and go over any points that are still unclear.

If you have a sheet of questions, this seems to work best if you give out one copy per group, not one per person. You can have extras so everyone gets a clean copy to take home at the end. However it seems to maximize interaction if the students in a group have to share one copy.

Variation: The "Interrupted method." Have the groups do the problems, case studies or scenarios in steps, and summarize or discuss after each step. Ask the students to discuss the first problem or part as a group for a few minutes. Then interrupt the groups and bring the class together to go over the answer to the first part. You can call on one group, take a vote, or ask for volunteers. If everyone agrees on the answer, have the groups proceed to part two. If there is any disagreement, or lack of understanding, clear it up. In other words, do what ever it takes to get everyone straight on the issues in part one before they go on to part two. Once the class has agreed on the solution to part one, have the individual groups discuss part two, then bring them together to go over part two as a class, and so on.

## Topic 7 -- PROBLEM SOLVING

**1. What's the Point?** Before you try to explain a problem, ask yourself "What is the point of this problem or experiment?" Is it to show how to use a formula? Get certain facts or relationships straight? Gain familiarity with a concept or procedure? Make certain distinctions clear? Once the answer is clear in your own mind, it will be much easier to explain the problem and much easier for you and the students to see what is important and what is trivial.

**2. How do I solve it?** A common response to a complicated problem is, "How the \*?#\*#! am I supposed to answer/solve this?" So go over (a) what information is needed to solve the problem and then (b) explain how you use the information. Students often know the right information but they know so much irrelevant information that they can't pick out the right pieces. So go over how you figure out the answer to "What do I know (or need to look up) that's relevant?" Once you have shown the students what information they need, go over how to use the information to get the solution. It is important to realize that explaining how you get the solution is different from explaining the solution itself. So be sure that how you got the answer is just as clear as the answer.

### 3. What is meant by "Explain your answer?"

On tests & problem sets students are often asked to explain the reasoning behind their answers. They are often frustrated and/or confused by "explain." What & why are they supposed to explain? Here is one answer:

It isn't enough to get the right answer -- you have to be able to explain how you got it. To be sure you get enough practice at explaining yourself, it pays to discuss the questions with your fellow students and/or to write out explanations of your reasoning. You need to both

(1) Include the right facts, principles, etc., AND

(2) Explain the logic that you used to solve the problem. How did you get from the facts to the answer?

It is not sufficient to pile up unselected facts (even if they are correct), OR just to state the facts (even if they are the right ones) without explaining how they relate to the problem at hand, OR to just explain the logical train of thought (even if it is correct) without any specifics.

That's what you shouldn't do. What should you aim for??

Try to explain as if you were talking to a fellow student in the class who is generally intelligent, prepared, etc., but can't figure out this particular question. In other words, explain your reasoning step by step. Don't just repeat all the related facts in the book or notes--try to pick out the important, relevant points, put them in logical order, and explain (or diagram) how one leads to the next. (In other words, pretend you are writing a simple answer key.)

### 4. Acting as a role model.

If you are asked an unexpected question, and you can see how to reason out the answer, it sometimes pays to think through the steps out loud so the students can see how you do it. It's a good way to model proper problem solving. This is not an excuse to be unprepared -- you shouldn't have to do this too often.

## 5. Problem solving tips to pass on – Useful if your class does “Classic Word Problems”

**Important:** These are things the student should learn to do. You may demonstrate them the first time, but the student should learn to do them for him/her self.

*A. Draw a picture or diagram whenever possible.* (You may draw the picture for the student the first time. But the goal is to get the student to learn how to draw his/her own picture.) The relationships between the various parts and pieces of information are often not readily apparent until you get the words translated into pictures. Once you understand the relationships between the terms, facts, steps, etc., you will find the individual pieces are much easier to remember and recall. If a picture isn't appropriate, try a chart or diagram.

*B. If at first you don't succeed, try, try again.* If you have a complex problem to solve, don't try and get it in one shot. Read it through, and make an intelligent guess at the answer. Then go back and see if your solution explains all the data given. If it does, fine. If it doesn't, refine/adjust your solution and try again.

*C. If one approach doesn't work, try another one.* The following list comes from a math class, and duplicates some of the suggestions above, but is a useful list of problem solving approaches to keep in mind:

- Guess & check
- Draw a picture
- Look for a pattern
- Make a model
- Act it out
- Use easier numbers
- Write a number sentence
- Make an organized list
- Make a table or chart
- Use logic
- Work backwards

## **Topic 8 -- PROBLEMS WITH NUMBERS**

### **1. The case of the over-mathematical student**

Some students are very at ease with numbers and greatly prefer numerical plug-in problems to thinking problems. These students tend to miss the biological point because they are so busy manipulating the numbers. They can solve anything that uses a formula, but tend to overlook the meaning of the formula. With these students you have to be careful that you don't lose the biology in the number crunching.

### **2. The case of the un-mathematical student**

Some students are just the opposite -- they prefer words and discussions to numbers and turn pale every time a formula appears. These students often get the general idea but have trouble doing specific numerical examples. These students are often unaware that biology is a quantitative science -- they think it is all descriptive and are shocked to find out they will have to do problems with numbers.

### **3. Most classes have both types of students**

Remember that you probably have both kinds of students described above in your class and that you will have to explain the biology to the mathematicians and the math to the biologists.

### **4. Estimate first and calculate later (if necessary)**

Encourage students to estimate and use their heads instead of relying solely on their calculators. Estimating makes the math seem less formal and intimidating to some of the nonmathematical, and it discourages the overly mathematical from plugging blindly into formulas. In other words, using estimates often helps keep the focus on the biology instead of the math. If students learn to estimate, they can often avoid gross errors that lead to absurd results.

## Topic 9 -- USING THE BLACKBOARD

### 1. How to write on the board

A. Both words and diagrams should be large and clear. (Biology students: There is lots of big soft chalk in room 500.)

B. Use colored chalk as much as possible. If you can't find any, buy some and get petty cash to repay you. (Biology students -- ask in room 600).

C. Use diagrams as well as words (see below).

D. Erase carefully.

(1). When you have filled up the board, erase a large area thoroughly before continuing. Don't keep writing in the corners and edges of your old, filled up board.

(2). When you need space, try to erase the oldest writing, not the most recent. You and the students may want to refer back to the most recent writing, so leave it up for a while.

### 2. Using Diagrams

Diagrams and pictures are very helpful, both to you and to the students. A diagram helps the students because it can convey relationships that are almost impossible to put into words. It helps you, because you can refer to it over and over. Once you have the picture on the board, you can point to it and avoid using the technical terms or you can point and use the terms at the same time as reinforcement. So draw as much as you can. Artistic talent is not required, but remember the colored chalk and draw big, clear pictures.

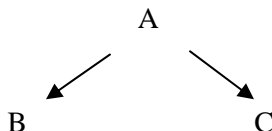
To put it another way, drawing allows you to show what you mean in pictures at the same time that you say what you mean in words. So drawing a diagram and explaining it as you go along makes the best use of the board. It is much better than just writing down the words that you say.

### 3. What to write

Don't write everything you say on the board. It is good to write all the important points and terms on the board, but it is not necessary to write down all the details. It usually works best to write a term or draw a picture and then explain verbally.

### 4. Showing relationships

When you write down the important points or terms, try to write them in a way that shows their relationships. Suppose you are explaining terms or concepts A, B, & C. Suppose B and C are subcategories of A. (Example: A is transport, and B and C are types of transport. Or A is a structure made of two parts, B & C.) Then a simple diagram like the one below shows the relationship between A, B & C, and is much more informative than just writing a list with A, B & C (or writing A, B & C in random order).



## **USING THE BLACKBOARD, cont.**

### **5. Timing**

Drawing carefully, writing clearly, and erasing properly all take time. Don't worry about wasting time. A pause is usually welcome if the general pace is lively. Remember that the students are writing things down, and that they usually are writing more than you are, since they are copying your lists and pictures and taking notes on your explanations. So they sometimes need a pause in order to catch up with you.

### **6. Avoiding "blackboard carpentry"**

Many problems in biology involve comparing two very similar situations -- normal vs mutant, before drug added vs after drug added, with oxygen vs without, etc., **or** explaining a sequence of events. In these situations it is very tempting to draw the picture for the first case or step, and then to alter the picture by erasing or adding a little here or there (that's the carpentry) to convert the picture into the next case or step. It is usually much better to draw each case or step separately. It does take time, but it's worth it. Why bother to draw each situation individually?

(1) If you have both pictures on the board at the same time it is much easier to compare and contrast the two stages. If you modify the first stage to get the second, the first one is gone! You can't go back and point to the critical differences or show how the two cases compare. You can say it, but you no longer have the two pictures in front of the students.

(2) It is much easier for the students to take notes if you redraw the pictures. If the students are trying to take notes so they can capture the essence of your explanation, they can't keep modifying the picture (using pen and paper) the way you can on the board (with chalk and eraser). They have to keep drawing it over again, and they can't get all the details straight or keep up with the speed of your changes. (See 5 above.)

If the picture you are drawing is complex, and you want to be sure the students can follow, you might consider providing a handout with the main steps or features. (It's hard to copy drawings – harder than getting down words.) It's best if the handout does not have all the details – that way the students are more likely to pay attention so they can label and/or annotate the picture as you explain.

### **7. Miscellaneous Advice on using the Blackboard**

A. When you are facing the blackboard, stop talking. In other words, don't talk into the blackboard.

B. When you write an important point or term, and then explain, don't stand in front of what you have just written.

C. If your English pronunciation is poor, draw and write more on the board.

## Topic 10 -- EXPLAINING

**1. Don't stick to Words.** Use a picture or diagram instead of (or in addition to) words.

**2. Improving Clarity: Avoid pronouns and use nouns instead.** Don't say "it" -- say "mRNA" or "gene" or whatever. You should be careful not to use too many pronouns yourself and you shouldn't let the students do it either. For example, suppose a student says "The gene is transcribed and then it goes to the cytoplasm and it is translated which uses tRNA and mRNA." Now the student may or may not understand how genes are expressed, but you can't tell whether s/he knows or not, because "it" could mean gene or mRNA and "which" could mean transcription or translation. In this example, the student may know the correct answer and just be using poor English by accident, or the student may not know and be using unclear language on purpose to hide his or her confusion. Alternatively, the student may not even realize that s/he is unclear in his or her own mind. So if you want to express yourself clearly, and you want to be sure that your students have everything straight, use as many nouns and as few pronouns as possible, even if it sounds a little repetitious. And make the students talk in nouns too.

**3. Probe First.** Before you start to explain a topic or problem, find out where the student is stuck. This will save you from wasting time and energy explaining things that are clear and allow you to zero in on the real problem.

### 4. Explain at the Right Level

*a. Don't Start too Far Back.* When a student asks a specific question, try to answer it without going over a lot of background material. If a student asks you to explain hydrophobic bonds, don't start with atomic structure. Assume s/he knows what electrons and covalent bonds are, and proceed from there. If there is any question about where to start explaining, ask the student. (See point #3 above.)

*b. Don't assume too much.* Remember that your students may not have as much background as you do, so you may have to explain things that seem obvious to you. (Of course this contradicts (a) – you don't want to overdo it in either direction.)

**5. Explain in Small Bites.** Explain a short piece of a problem at a time, and then don't go on until (a) you are sure that everyone understands what you explained and (b) you are sure that you need to explain the rest.

For part (a) asking "Does everyone understand?" doesn't usually get a satisfactory answer. You have to look at the students' faces or ask a specific question about what you have just said in order to find out if they understand.

For part (b) you may discover that you don't have to explain the whole thing because the part you just explained was the only hard part and the student has now come "unstuck." (See point #3 above.)

### 6. If you don't know the answer, what should you do?

A. Go look it up for next time, or look it up right on the spot if you have the right book and can figure it out right away. You aren't expected to know everything, but you are expected to be able to figure everything out eventually. (See section on preparation.)

B. If you start to explain, and realize half way through that you are stuck, it usually pays to stop and admit it. It doesn't pay to continue, unless you are one of the rare people who can think well enough in public to get untangled in front of the class. The best strategy is usually to stop before you get in even deeper, and to go home and figure it out. (But be sure to tell the students the answer when you finish.)

C. The fact that you have to look things up has its bright side. It's useful for students to see that learning is a continuous project that doesn't end when you finish the course or when you graduate. It can increase their interest and enthusiasm to see you "get hooked" and go running after the information.

For more tips on explaining, see <http://www.columbia.edu/cu/biology/faculty/mowshowitz/explain-more.html>