Laboratory Investigations of Topical Issues in Microbiology

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Abstract

Students become excited about experimentation in microbiology when they can investigate matters that are relevant to their own lives. The examples of laboratory exercises on everyday issues in microbiology included here are appropriate for student-designed investigations. They can also be used as laboratory exercises with instructor-provided protocols. Either way, students work individually or in small groups to develop hypotheses and/or experimental approaches to answer questions about everyday issues. These labs help students attain and improve skills in the following areas: scientific reasoning, microbiological techniques, critical thinking, analytical reasoning, communication, interpersonal relations, and citizenry.

Activity

Invitation for User Feedback. If you have used the activity and would like to provide feedback, please send an e-mail to MicrobeLibrary@asmusa.org. Feedback can include ideas which complement the activity and new approaches for implementing the activity. Your comments will be added to the activity under a separate section labeled "Feedback." Comments may be edited.

Editor's Note (2008): This Curriculum Resource was published prior to establishment of current criteria of submission, and as such, does not contain all criteria required of current publications. However, the Editorial Committee felt that the activity itself remained worthwhile and relevant, and encourages potential users to contact the authors for clarification as needed. If you do update this activity for use with your students, and are interested in updating the resource for distribution in the library, please contact ASM at MicrobeLibrary@asmusa.org.

PROCEDURE.

Materials.
Materials will vary with each investigation but most will be readily available in the laboratory and at home, or through commercial vendors. Instructors may help narrow the scope of the research by providing a list of available media and supplies. Students should be required to research their topic sufficiently to identify those microbes they are most likely to recover. By doing so, they can also narrow the media required for the experiment. Specific examples of materials needed for

this activity are provided in Sample Applications.

Instructor Version.
This activity is recommended for use as introductory microbiology labs, after students have been exposed to basic skills. The time needed for this activity depends on the nature of the investigation and how the activity is used. For student-designed investigations, up to a month may be required. To help students organize their time, the following timeline might be provided:

- Week One: Determine a topic of interest; find background information and do a literature review; and submit a proposal, outlining the experimental design and materials needed.
- Weeks Two and Three: Carry out the experiment(s); collect and analyze data.
- Week Four: Prepare and present a poster, oral presentation, or paper.

If the exercise is done as a class exercise with control for the exercise resting primarily in the hands of the instructor, then in many cases the activity can be completed within a 2 to 3 hour laboratory period. The former use of this activity is strongly encouraged because students are much more interested in an experiment that is their own.

Because of the wide range of investigations possible, the procedure described is generic. Specific examples of how this activity can be used are provided in much greater detail in Sample Applications.

1. Assign or have students choose a topic of interest based in common everyday experiences.

   Possible Topics for Research

2. The instructor leads an exercise to model the processes by which an

   hypothesis is developed and an experiment is designed. The instructor's role is to facilitate a discussion by the class members by asking appropriate questions. One student in the class can be asked to record the outcomes of the discussion in the form of a written protocol. Recording is facilitated if a computer and an overhead projector are used. In this way, all class members can see what is being written, modifications can be easily made, and the final version can be printed. For two examples of materials used to introduce this activity see Sample Applications.

3. Students submit a proposal stating the question of interest, their hypothesis

   regarding the question, an experiment designed to test that hypothesis, and a list of materials needed to complete the experiment.

4. The instructor and/or the students' peers review and critique the proposals.

   Although this activity can be done as a completely descriptive exercise, students should be encouraged to quantify their results. A good way to do titrations without using large amounts of media is to subdivide an agar plate into up to six equal sections (as described in Hudson and Sherwood, *Explorations in Microbiology*, Exercise 44). In each section spot duplicate 10 microliter samples of one of the dilutions. This way one plate can be used for undiluted through 10^{-5} dilutions. Spots having between 3 and 30 isolated colonies are used to calculate the titer.

5. Students conduct the experiments and collect, analyze, and interpret the

   data generated. Depending on the lab setup and the size of the class, students can be responsible for making the media and sterilizing the glassware they need.

6. The outcome(s) of the research project can be presented to the class in an

   oral presentation. If possible, students can be encouraged to use PowerPoint or similar software to prepare their presentations. The class participates by asking questions and making comments. In addition to, or instead of the oral presentation, students can present their research in a class poster session. To coach students in the construction of good posters, share an example of a good poster, illustrating the desired format, font size, and other important features. Several resources that provide helpful information about making posters can be found on the WWW.

   Oral and Poster Presentation Guidelines
   Guidelines for the Preparation of Effective Presentations (PDF)
   Effective Presentations
   Guidelines for ACS Speakers and Poster Presenters

   "Journal articles" may also be required; the Instructions to Authors for ASM Journals can provide guidelines for these articles.

   Instructions to Authors for ASM Journals

   The articles can be written either by the group or by each individual in the group. No matter which reporting mechanism is used, students will require information about the construction of tables and graphs, preferably from exercises devoted to this. For instance, students can be given a set of raw data, including anomalous numbers, and asked to create a labeled graph that accurately and clearly represents the data. Similarly, students can practice creating tables using simply the description of an experiment, without actually being given data. Students can also be provided graphs and figures to interpret.

7. Students and the instructor critique each presentation. If students work in groups, they should each have the opportunity to evaluate the contribution of group members to the joint effort, as part of the process for determining grades.

Safety Issues.

Safety issues will vary with the experiments proposed. Instructors should consider potential hazards, including recovery of pathogens associated with the region (e.g., *Coccidiodes immitis* spores in the Southwest). Students should be warned of all potential hazards, and reminded to use appropriate safety measures. If the potential hazard is deemed too large, students should be guided towards a safer project.

ML Safety Statement regarding Environmental Isolates

The Curriculum Resources Committee recognizes that isolated organisms can be a powerful learning tool as well as a potential biological hazard. We strongly recommend that:

- Environmental enrichment laboratories should only be performed in classes in which students have been trained to work at a BSL2.
- Direct environmental samples (eg. soil, water) which are known to contain infectious organisms should be handled according to the biosafety level of that infectious agent.
- Cultures of enriched microorganisms, derived from environmental samples, should be handled using Biosafety Level 2 precautions.
- Mixed, enriched or pure cultures of microorganisms from environmental samples with a significant probability of containing infectious agents should be manipulated in a biosafety cabinet if available.
- Where possible, media used for the enrichment of environmental isolates should contain an appropriate anti-fungal agent.
- Instructors should be aware if they are teaching in regions with endemic fungi capable of causing systemic infections, and should avoid environmental isolations.

SUPPLEMENTARY MATERIALS

Sample Applications.
Links are provided to the following sample applications. All of these applications can be used either as in-class exercises under the direction of the instructor or as student-directed activities. If the former, the experimental protocols can be provided to the students. If the latter, the experimental protocols can serve as suggestions for guiding students as they design their own experiments.

A. Application 1: Introducing this activity (shared by Janet Fulks)
B. Application 2: Introducing this activity (shared by Judy Kandel)
C. Application 3: Survival of microbes on surfaces: Implications for choosing and using a cutting board. (shared by Linda Fisher)
D. Application 4: Do condoms control the spread of diseases? (shared by Judy Kandel)
E. Application 5: Grading sheet (shared by Janet Fulks)
F. Application 6: Assessing individual contributions to group projects

Curriculum Resources

Possible Topics for Research

a. Survival of microbes on surfaces: Implications for choosing and using a cutting board.
b. Do condoms control the spread of diseases?
c. Do sponges become reservoirs for microbes?
d. Are sponges microbiocidal?
e. Is there a difference in bacterial load between antibacterial and regular sponges?
f. How much *Escherichia coli* is in hamburger?
g. How effective is the disinfectant ?
h. How effective is the mouthwash ?
i. What happens when milk sours?
j. Do spices and garlic have antimicrobial activity?
k. Do sponges, mops and other cleaning tools harbor and spread bacteria?
l. Do the new soapless hand cleansers work effectively?
m. What is the long-term effect of antibacterial lotions on normal flora?
n. How does the "All In One" contact lens solution compare to a traditional lens disinfectant?
o. How effective are "herbal" or "natural" antibacterial substances?

Giving a Good Scientific Presentation

Prepared for the American Society of Primatologists by members of the ASP Education Committee:
Edited by: Corinna Ross, Sara Hankerson, Mitchell Irwin, Anita Stone, and Dee Higley (2007)
Original Credit: Lynne Miller, Ann Weaver, Christine Johnson

This document has been compiled in hopes of providing some helpful guidelines on effective ways to present scientific information. It is aimed at improving the quality of presentation and is designed primarily for students who might be approaching their first professional conference, but other colleagues might also find the information useful for improving their own presentations. These guidelines assume that the audience will be composed primarily of other primatologists, rather than nonprofessionals. The tips we provide come mostly from our own experiences, our own likes and dislikes, and therefore should be taken as suggestions rather than ASP rules.

There are various reasons for attending a professional conference. One is to meet scientists whose research you are interested in and for those who have attended previously; it functions as a method to keep in touch with old friends and colleagues. Annual meetings give scientists the chance to share ideas on an informal basis (i.e., apart from published materials). We also make contact with new colleagues who might share our research interests, and this often leads us in new and fruitful directions. But one of the most important goals of a conference is to present your research. In the course of the conference, literally hundreds of papers and posters will be presented, and thus you must work hard to make your material stand out in the crowd.

Part 1: When to do an oral vs. a poster presentation

Oral presentations are challenging to design and execute effectively. One of the greatest obstacles is the strict time limit. For many sessions, each speaker is allowed just 15 minutes, which must include time for introduction and questions, leaving the speaker no more than 12 minutes to present the work. Therefore, oral presentations are appropriate when the research has a limited scope with clear and concise points to make. If the work is conceptually or methodologically complex, then a poster is probably a better way to go.

Many professors encourage students to offer a poster presentation, rather than an oral presentation, for their first time out. This is reasonable advice. If you suspect that you will be really nervous at your first meeting, and that there is some significant chance of your becoming catatonic, then presenting a poster might engender less trepidation.

The best reason for offering a poster has to do with the content of your presentation. If your materials (e.g., your methods or the results) are especially complicated, it may be a better idea to present them in a poster, where your colleagues will be able to take their time with the information and ask you questions at greater length. Likewise, if you are presenting something a bit esoteric (that is, more esoteric than primatology normally is), a poster might enable you to spend more time with the colleagues who are most interested in your field of research, rather than leaving you to speak to a room full of folks who don't follow your work. Give these issues some thought before you submit your abstract to the program committee. In many cases, posters and papers are interchangeable, but there are also some good reasons for choosing to do a poster.

Part 2: Developing the content of your presentation

The best presentations make one or two limited points, loudly and clearly. You might have tested two or three closely related hypotheses, but they should all revolve around the same single point. If you find that your research has two or three broad research subjects, then plan to give separate presentations that allow time to develop and discuss the issues surrounding each subject.

We can't help you in defining your central message, but we encourage you to spend some time thinking about it and putting it into words. Do your best to develop a summary of your work that you can state in 25 words or less, preferably words that real people use. For example, imagine you are on a plane on your way to the meeting, and you tell the person sitting next to you that you are a grad student at Primate U. He responds, "Oh, how interesting. What, exactly, do you study?" If you can answer that question in a short and simple statement, in a language that the guy sardined in next to you will really understand, you are half-way there.

Once you know your central message, you need to decide on supporting information. The best presentations generally follow the guidelines of a published paper, with sections like Introduction, Methods, Results, and Discussion/Conclusions/Significance. However, you will have only a couple of minutes per section, or a few sentences on a poster, so you might have to run through that 25-words- or-less exercise for each part of your presentation. For each section, ask yourself, "What is my central message?" Here are some guidelines:

Introduction This section should start with your general research objectives and a few words about the context of your work. You should make a clear statement of the hypotheses or predictions that you tested. Think ahead and ask yourself, how is this connected to the Discussion? Does it tell your audience why you did this experiment or research?

Methods Unless your material relates directly to methodology (e.g., a new way of collecting urine samples from uncooperative subjects), you should strive to keep your methods section brief. Don't be so brief that we can't figure out what you did, but do give some thought to what is really relevant to this particular presentation

Results What did you find? Did your tests come out the way you expected? This section will be supported by graphics of your data and statistics. This section may be shorter than you first expect, and this is ok! The more concise and clear your results are, the more time you have to talk about their importance. And it is better to have quick results that are really important than lots of results that aren't.

Discussion and Conclusions This is a section that is often overlooked in oral presentations. Speakers run short of time and rush through this, the most crucial part of the talk. Don't let this happen to you. Consider the major point that you want your audience to remember about your talk. Discuss not only what your results show but also why they are **SIGNIFICANT** *(significant meaning important, not statistically significant)*. Demonstrate how your research relates to the larger picture or issues. Indicate why anyone should care about your findings. This will summarize your study and send the audience off on a high note. In a poster presentation be prepared to address this issue, briefly in the poster and in greater depth when talking with your colleagues.

Acknowledgements and References References are rarely provided in an oral presentation, unless the speaker cites direct quotes or seminal works. However, it is becoming increasingly common to acknowledge sources of support and research assistance at some point in the talk. In a poster these sections often appear in the lower right corner. We recommend citing just a few sources, focusing on those papers that are seminal in your field or particularly relevant to your research.

We strongly recommend that you look to your friends and colleagues for assistance. When you think you have got the content outlined, even in a rough form, try it out on your professor, your office mate, and your mother. If they get what you are trying to say, then you're on the right track.

Part 3: Preparing visual aids for an oral presentation
The first question that many students ask is how many slides to show. Some experts recommend one slide per minute, but this is probably a little slow. Speakers should certainly allow at least one minute for some slides -especially the graphs of data, which need to be talked about at length – but other slides might go much faster (e.g., a photo of a baboon while you simply tell the audience the subjects' species name). You might plan on about 25 slides for a 12-minute talk. You must bear in mind each presentation is different and so the best approach will depend upon the material you are presenting.

There are many ways to make your visual aids. You can make slides, use overheads (aka, transparencies), or do a PowerPoint display. This section will focus primarily on producing a PowerPoint display, as these are the most commonly used visual aids at our meetings.

Preparing a PowerPoint presentation can be very intimidating the first time, but with the knowledge of a few of the programs little tricks it can be the most versatile form of presenting a talk. First, we recommend you find a friend to show you the program if you've never used it before. However, if your entire lab is computer phobic you'll find the program is not hard to use especially if you have used other Microsoft programs before. When you open the program select New presentation, choose a blank presentation rather than a premade one, because these are made for the business world and aren't great for scientific presentations. Then choose the first slide that you want (all text, text and a graphic, completely blank…). You can format the slides by choosing the Format option and choosing font, or background, etc.

Part 3A - Text slides:

Text slides can be used effectively in a variety of ways. For example, you might start your talk with a title slide, which includes your name, your affiliation (e.g., your graduate program) and of course the title of your talk. A text slide is also a good way to list those people and institutions you wish to acknowledge. Some colleagues suggest combining these two, so that your opening slide shows your title and name, and gets the acknowledgements out of the way, but be careful because you do not want too much text, even on the title slide.

Text slides can also provide visual support as you present your introductory material. For example, one slide might show "bullet statements" of your central research objectives. Another might list your specific hypotheses or test predictions. If you are going to review some of the general research context, you could provide an outline of the highlights. Some speakers feel the need to cite specific seminal works, or even a direct quote or two, and text slides are the best way to do this.

Text slides can be a good way to outline your research protocol. If you have specific methods of data collection that your audience needs to know, like behavioral categories or hormonal assays, try a text slide to summarize. You might return to text slides when you are recapping your research findings and stating their significance. Or you might want to close your presentation with that list of acknowledgments.

The key to doing text slides right is to remember "less is more" and "bigger is better." You have to design your slides keeping in mind the folks sitting in the back of the auditorium. If your slides aren't visible and legible, then you might as well leave them at home.

(1) Use very few words. We recommend no more than six lines of type per slide, with at most seven words per line. Try translating statements into bullet statements or an outline. Keep the wording tight; use simple language, minimal jargon terminology, and short, uncomplicated sentences. Even removing small words can make a big difference (e.g., say "assay results" rather than "results of assays"). Remember that you will also be speaking to your audience. These slides are visual support of what you are saying, not a substitute for your oral presentation.

(2) Choose the right font. Use a typeface that is easy to read, such as Times New Roman, Arial or Courier. If you are a Macintosh user avoid fonts that do not go across platforms, such as Helvetica. Studies show that text written in all capital letters is hard to follow; it is better to use bold print than all caps. Use the same typeface throughout your presentation. We recommend using 1.5 spacing so that the lines are easier to follow. Then use a font that is about as large as the slide will accommodate, for example title lines size 44, major text 32, and minor text 24.

(3) Choose the right color(s). We recommend using contrasting colors, light type on a dark background or vice versa, like white on cobalt blue, or dark green on a pale yellow. Avoid red type - it looks good on your computer but is virtually impossible to read off of the slide screen. And at all costs avoid bright yellow as a background, it is blinding for everyone.

(4) Different colors can be used effectively to guide your audience through your text. For example, you might write the section headings ("Introduction," "Methods," "Conclusions") at the top of your text slides in yellow, and then have your bullet statements in white below these headers. However, please don't get too carried away with color. Also bear in mind that a significant proportion of your audience may be red-green colorblind, so avoid this color combination.

Part 3B - Graphic images:
Graphic images can be helpful in your Introduction in the form of flow charts. If you are trying to summarize how several variables interact, then a good flow chart might be just the thing. The same might be true for your Methods section. Schematic diagrams might help to show a piece of equipment or the physiognomy of a forest.
Tables are really tricky. So many talks include a table full of tiny words and numbers that are impossible to read. This situation is hardly helped by the speaker's noting, "I know this is hard to read..." or "I don't expect you to read all of this..." Then why show it? If you must provide a table, keep it to no more than four columns and three lines - that is about as much as your audience is likely to digest. Another way of dealing with this is to highlight the column or row you are discussing at the time in each slide. Then the next slide would circle or highlight the next data point of interest.

Graphics are most important in the Results section. Effective graphs will clarify your findings at a glance. Poor graphs will leave your audience irretrievably confused. Our first recommendation is that you limit the amount of information that you put into each graph. You might be tempted to compile all of your data into one megahistogram, with ten different variables for each of your sixteen individual subjects across three months of testing, all stacked up in various colors and elaborate shadings and splashed across three dimensions, but please take pity on your audience. Try to keep it simple. Let each graph make one specific point, and plan to put just one graph on each slide. Be sure to clearly state your axes when discussing each graph. Start to plan this part of your talk by thinking about what type of graph is best for the type of data you are presenting.

<u>Bar graphs</u>:
If you are comparing two or three subjects (or groups) for two or three variables (e.g., large groups vs. small groups for rest time, play time and feeding time), then a bar graph is great. A "stacked" bar graph is good if you have to express proportions of the whole (e.g., out of 10 trials, what proportion ended in success vs. failure, with "success" at the bottom of the bar and "failure" stacked on top, and a separate bar for each subject). If the total for each subject (or group) doesn't add up to 100%, then it is better to put the variables side-by-side, with a cluster of bars for each subject. Think creatively about how to summarize your data so that you have just a few bars up on the screen at any one time.

<u>Line graphs</u>:
Line-graphs are good for displaying change over time (e.g., how weight increased over the 12 months of testing). One line-graph can accommodate several sets of data (e.g., how weight, time with mother, and time with peers changed over time), but too many lines can get confusing. Again, keep it simple. Three lines is probably the upper limit for any one graph.

<u>Pie charts</u>:
Pie charts are good for presenting proportions of the whole (e.g., a daily activity budget: the proportion of the day your subjects devoted to playing, foraging, resting, grooming, traveling, etc.). Two pie charts next to one another allow you to make a comparison (e.g., the daily activity budgets of two or more groups). In this way, they are like stacked bar graphs.

<u>Scatter charts</u>:
Scatter charts are often good for presenting data that does not follow an overall trend, but for which the comparisons of points is interesting. If you are going to draw the listeners attention to certain points (e.g. the chemical makeup of a certain food source), then it is vitally important that you highlight that point in

the chart for that moment of the talk and then add additional slides that draw the reader to each comparison that you are making verbally; rather than just having a splash of dots that the reader can't differentiate and you waving at them with the laser pointer.

Use of color:
Color is very helpful in presenting your results. For example, three lines of color representing different measures will be far easier to follow than three lines that are all black and differentiated only by little squares or circles. So color is good, but use some restraint. Your computer might encourage you to assemble a graph with 13 different data sets, each in a different color, with colored titles and subtitles, colored axis titles, a very colorful legend, and a faint map of the world in the background. This might seem like a great way to capture your audience's attention, but the final product will look like Walt Disney just hurled on the screen. Better to keep it simple.

Hopefully your data will be accommodated by two or three colors. Choose colors that are bold and clear, and use them consistently throughout. Thus, if one graph presents "success vs. failure" for one trial, and another graph "success vs. failure" for another trial, then keep using that same red vs. blue for all of these graphs. Skip to a different pair of colors if you move on to "male vs. female." Follow the same rules for graphics as for text: be sure to use contrasting colors for the graphic and the background, and for titles, use a large font that is easy to read.

A few other considerations:
Many programs will put in statistical markers, such as standard error bars. These are helpful, but make sure they are easy to see (i.e., use a good color). You might also find it helpful to mark "statistically significant" findings with asterisks, or even to write your "p-values" right on your graphs.

Be sure to have all of your axes clearly labeled and a good legend in place, with a font that is large enough to read. Titles and subtitles should be brief but descriptive so that your reader knows immediately what this graph presents. Also be sure that the axes don't fall too close to the boundaries of the slide. Too many talks have met with failure when the projected slide is smaller than the slide on the computer screen and all of the axes are chopped off.

Be sure to make as many images as you need. If your presentation demands that you show a certain graph, then move on to another point, but then come back to that graph, make two copies of that slide. Presentations that demand flipping back and forth through slides are distracting at best.

Part 3C --Other images:
Photos can be used effectively throughout your presentation, not only to make your points, but also to break up the monotony of text and graphics, and to keep your audience's attention. Who doesn't like to see dazzling images of primates? You might use a great picture of your subjects in the Introduction of your talk, just as eye candy while you discuss your general research objectives.

Photos are also important in the Methods section; they inform your audience immediately about your subject species. You might also use photos to depict some new apparatus or to show your subjects in action with their joysticks. If you work in the field, photos of your site at different times of year might clarify a point about seasonal changes. Photos of your field assistants are also appreciated.

Photos enhance your presentation only if they are of high quality. Choose images that are clear (rather than out-of-focus), of good color and contrast (rather than too light or dark), and easy to make out (rather than where's-the-monkey-in-this-picture?).

Part 4: Building an oral presentation
Some tricks to PowerPoint:
* Be creative and try new things, however, always remember to save your file before you push a new button to see what it does.

* If you insert a duplicate slide you can get an exact copy of your slide. This option is nice if you have a list you are trying to present. You can change the font of the point you are trying to highlight on each individual slide to draw the reader to your point, without overwhelming them with a list.
* You can duplicate graphs and add data points or lines of interest.
* You can animate the slide to bring up one bullet at a time, however, be sure to turn all noise making animations off. There is nothing worse than giving your audience a heart attack as your point appears on the screen accompanied by the sound of an explosion.
* You can import movies and vocals into the PowerPoint. We would caution you on this because there is no guarantee that the software you choose to make the film is on the computer at the meeting site.
* If possible, try projecting your talk on a data projector while you practice. This is good for two reasons. First, it gets you used to standing in front of the "big screen", and resisting the temptation to talk to the screen rather than the audience. Second, some colors look great on the computer screen but not so great when projected. This will give you a heads-up if you want to adjust the colors.
* Always be careful when changing platforms (i.e. preparing your PowerPoint file on a Mac and presenting it on a PC). It is common for movies and even pictures to completely disappear. Be ready for problems - have backed up files and separately saved graphics files.

We encourage you to explore the options the computer gives you but also to remember that less is more. Be aware that if you have a duplicated slide you may feel rushed during the presentation and breeze right past this slide without giving the listeners a chance to adjust.

We suggest you save your presentation on a CD, or USB flash drive; most presentation sites have the ability to use these storage units.

Also it is VERY important that you avoid the greatest temptation that PowerPoint gives: the potential for procrastination. More than one primatologist has been caught putting the "finishing touches" on their presentation on their laptop in the plane, or worse in the session prior to theirs. Make sure you have everything ready before you go to the meeting. Although PowerPoint is flexible and can travel with you, there is no excuse for doing things last minute. Plus, less time finishing your presentation equals more time free to socialize and meet other primatologists!

Part 5: Preparing the verbal part of your talk

We have various recommendations about the content of your spoken presentation. First, be sure to leave the title slide up long enough for your audience to read it. Remember that the title slide puts your name in front of the audience, and that is very important. Think about a few words that you can say while that slide is up, like acknowledging support, or introducing your research objectives.

There is a split decision on what to say during text slides. Some colleagues might recommend reading along, word for word, with your text slides. However, many others prefer an outline format on the screen while you provide a more complete verbal accompaniment. Do what feels natural for you. If you are planning to read the slide, try to read it verbatim rather than changing the wording, making it different from what is on the screen - that can throw off your audience.

Next, and really important, you MUST walk your audience through the graphs in your Results section. Even if you think that it's the most straightforward bar graph in the world, remember that your audience is seeing it for the first time and is trying to digest it in about 15 seconds. Don't make them work that hard. As you put that image up, tell your audience what they are seeing ("This graph shows the food intake for monkeys in large and small groups."). Clearly state your axes. Then walk them through the bars and lines ("The yellow bar is for the large groups ....""The white line is for juveniles). And finally, make it clear how this fit into your presentation ("Thus, the data support the prediction that juveniles play more than adults, and indicate that play provides important experience for adult activities.").

As you develop your presentation, keep reminding yourself that your audience will be listening to dozens of talks. Make yours as clear and dynamic as possible. Most people would agree that reading a paper is less dynamic than just speaking your way through your talk. However, many students are too nervous to wing it this way and therefore prefer to read the complete text. If you choose to read your presentation, try to make it as natural as possible. Write your text in short, uncomplicated sentences, using simple language and a minimum of jargon terminology. Address your audience as if they are intelligent laypersons, rather than experts in your subfield. Modulate your voice, striking a midpoint between a monotonic voice and a singsong voice. Try to look up and make eye contact frequently. Work hard to eliminate nervous sounds like uh or um.

Almost as important as the language you use is the speed at which you use it. Talking too quickly (either because you're nervous or because you have too many slides) makes your talk hard to follow, and if the audience can't understand the point of a slide before it's gone it will lose interest quickly. Talking too slowly will make the audience's mind wander and again, lose interest. The key is to practice, and get used to a certain speed. For your first talks you can also write down "milestones" for yourself on your notes – e.g., Introduction 0:00, Methods 3:30, Results 5:00, … That way, if you are way ahead or behind, you can attempt to recover.

When you print out your text, be sure to use a very large font that you can follow even in a dim room. Go through and mark clearly where you should change slides. You might even consider using one page per slide rather than having a lot of text on each page, which increases your chances of losing your place as, for example, you glance between the slide screen and your text. PowerPoint allows you to print handouts or notes pages to go with your slides; this can be a great way of writing out what you want to say and having it directly attached to your slides. However, if you have the cute joke that you want to sound spontaneous, if you have it written in the notes of the program it is likely your audience will see it while you are setting up or turning off your presentation.

Eventually, you might try going completely note-free, letting the slides themselves cue your speech. Thus, when the picture of the lemur feeding appears, then you know to say a few words about your subjects' diet. This approach is often more engaging for the audience, and might even allow you to judge their response to the material, expanding (briefly) on topics that catch their attention and minimizing topics that are of less interest. However, to make this work, you must know your material really well, and have practically memorized the order of your slides. You must also be very careful about exceeding your time frame. This type of presentation has its risks but can make a very good impression if done well.

Most people would say that prepping for your talk is like getting to Carnegie Hall: practice, practice, practice. You might start by practicing in front of the mirror. If you are planning to read your talk, read it straight through, out loud, in a slow, clear voice. Try to set up your practice sessions like the real thing. If you plan to use a laser pointer, practice with this, too. If you will be using a microphone, try to rehearse with some similar equipment so that you don't feel awkward when you are giving your presentation. Time your talk so that you are sure that it fits into the allotted time frame. If it is too long, do not just try to talk faster – cut something out.

If you plan to use a laser pointer, practice with it – but use it minimally. Laser pointers can be great for picking out one or two important outliers in a scatterplot. But too many presenters use laser pointers unnecessarily, for example circling the four bullet points on a slide as you read them. At best, this is distracting, at worst annoying! Ask yourself: will using the laser pointer on this slide improve the audience's understanding of it? If the answer is no, leave it on the podium!

After you have become comfortable with your talk - after you have timed it properly and worked out the rough spots in wording and such - then try it out on some other folks. You might start with your roommate, friends or family. If possible, get together a group of students and professors from your department. If your graduate program doesn't already have a tradition of older grad students listening to younger grad students' practice talks, start one! They can comment on all aspects of your presentation, including the content and the delivery. And again, try to do this early enough in the game that you will have time for the major revisions they might suggest.

Part 6: Putting together a Poster

This section makes more specific suggestions about the content of your poster. You must bear in mind, however, that each presentation is different and so the best approach will depend upon the material you are presenting. You will also be limited by the allotted space, which will vary from meeting to meeting. Be prepared to take these guidelines and modify them to meet your own unique needs.

There are many ways to construct a poster. We will discuss briefly one option, printing one large poster using a graphics program like PowerPoint. Be aware that the majority of posters being presented today are done using a graphics program, so a handmade “old” style poster (with lots of individual pages) may appear sloppy. Although everyone is supposed to be interested in the science presented rather than the appearance, no one will even look at the science if the poster doesn’t look like you put time and effort into it. Most Universities now have the ability to print large posters on a single piece of photo quality paper. Before you begin making your poster it is important to verify the size they are able to print. Most printers can handle a 40” width and a length of any size. Bear in mind the cost for printing and laminating may change the size capabilities. Places like Kinko’s also have the ability to print these posters, but the cost is much higher. Many companies also have the option of printing the poster in the city where the meeting is located or shipping the finished poster to that location. This alleviates the struggle of flying with a poster, however be aware that you are taking the risk of not seeing the product until you arrive at the meeting.

To start choose a New file, when it asks which type of slide you would like the easiest to work with for a poster is a blank page. In order to build a poster of the correct size you can go to the File menu, under page setup, reformat the size of the poster according the size allotment of the meeting site and your printer. We suggest a landscape layout rather than a vertical one. You can format the background for the poster by choosing the Format menu. We suggest a lightly colored background. Although PowerPoint allows you to place a photograph behind the poster these tend to be EXTREMELY distracting, and often appear very pixilated. We suggest you insert pictures elsewhere and keep the background a nice monochromatic color.

Your title can be inserted by choosing the text box option; we suggest at least an 80 font, centered on the poster. Most posters read best in three vertical columns reading from top to bottom. Typically Intro and Methods are on the left, the center holds the results and the right side contains Discussion/Conclusions and Acknowledgements and References. Everything should appear balanced. The nice thing about PowerPoint is you can move things around and change font sizes in order to balance the poster. You can insert graphs made using other graphing programs, pictures and additional text all by clicking various options buttons. The best way to learn is to play. We suggest you save your file before you try a new button to prevent the frustrations of losing your poster or changing the entire format. The “undo” button may be the best option on PowerPoint.

Remember to focus on the science you are presenting and keep the wording short and SIMPLE!! An effective poster provides minimal text. We will make this point over and over again as we go along. You must be complete, so that a person can understand the project based solely on what is written, but you must be tremendously concise, for no one wants to read ten pages of text while there are still 100 other posters waiting to be seen.

Part 6A - Text:

The most effective posters provide minimal text. (Didn't we warn you that we'd be saying that a lot?) Few of your colleagues will have the patience to read through a lot of verbiage. Furthermore, most of your colleagues will be standing at a great distance from your poster, as they jockey for position to get a look at your work. Thus, the rules on text are "less is more" and "bigger is better”. A certain amount of text will be necessary, especially in the Introduction and Discussion sections. Here are some thoughts:

Use clear and simple language. Cut out the jargon as much as possible. Consider using "bullet statements" to make your points short and clear. For example, your Introduction section might consist of three "bullet statements" of your research objectives, as follows:

Research Objectives
This study sought to explore:
* The effects of climate on food dispersion,
* The influence of food dispersion on exposure to predators,
* The relationship between group size and food intake.

You might then provide a more conventional paragraph on previous studies of this nature, but keep that sort of thing short. You've mainly included it to remind your reader that you are familiar with the related literature. Then this section might end with some bullet statements of your hypotheses:

Test Predictions:
* Monkeys in larger groups will forage on the ground more than those in smaller groups.
* Monkeys in larger groups will eat more than those in smaller groups.

Your Methods will also work well this way, as you bullet through subjects and protocol. Finally, do the same sort of thing for your Discussion sections, like this:

Findings:
* Monkeys in larger groups spent more time on the ground than did monkeys in smaller groups.
* Monkeys in larger groups ate more than did monkeys in smaller groups.

Significance:
* Larger groups are willing to forage in "risky" areas that smaller groups avoid and thereby gain a foraging advantage.
* These findings elucidate the causes of increased reproductive success for females in larger groups.

If these bullet statements are in big, bold letters, your audience will know within 60 seconds what you set out to do, how you did it, what you found, and how it fits in to the larger picture. That's the kind of poster we like to see. You can use additional text to fill in a little detail, but remember that you will also be there to answer questions, so you might find that this outline format is all you need.

<u>Font:</u>
Choose a typeface that is easy to read, such as Times New Roman, Aerial or Courier. Use the same typeface throughout your poster. You will probably use a variety of font sizes. Your title and authors' names, running along the top of your poster, should be huge, no less than 80 point. The title of each section of your paper should also be large, perhaps 60 point. Your bullet statements should really stand out, try 50 point or larger. Additional text should be no smaller than 24, but around 40-44 makes it very easy to read from a distance. You can get away with 18 for sections like Acknowledgements and References Cited, but don't go any smaller than that.

<u>Color:</u>
In general, black type on white paper is best, though studies show that a cream colored background is a bit easier on the eyes. Avoid using brightly colored background; we will be working color into your poster in other, more effective ways below. Using color in your text can be helpful when done right. For example, you might use red ink for your very most important points, like your research objectives, findings, and their significance. However, don't go berserk with this. Too many colors get distracting.

Part 6B: Graphics
Graphics are most important in the Results section. A picture really can replace a lot of words (you know we're in favor of that), and a good graph will be understood far more readily than a description of that

same information. On the other hand, be careful about how much you pack into that graph. See notes in section 3B for developing graphs.

You might consider putting a photo of yourself next to your name and the poster's title, so that interested colleagues can easily locate you, this is especially useful at meetings where the posters are up prior to the actual poster session.

Part 6C: Another Approach

A great way to present a lot of your material in a relatively small amount of space is to exhibit the predictions and results together. This is in striking contrast to how we do things in a printed paper. There, you offer predictions in one area and the results sometime later. This leads to some redundancy that is ok in a published paper but undesirable in a poster.

For example: Prediction #1

* Members of the large Group will maintain consistent food intake throughout the year, while members of the small Group will experience seasonal fluctuations in food intake.

Results:

1. During the dry season, food intake was higher in the large Group than the small Group: 1800 cc/day> 1100 cc/day, $t=24.33$, $p<0.001$.

2. During the rainy season, food intake was lower in the large Group than the small Group: 1800 cc/day <2700cc/day, $t=1\ 8.33$, $p<0.001$.

Figure 1: A two-color bar-graph showing food intake for the large group and small group, wet season vs. dry season.

This format gives your reader all of the important stuff, from the prediction to the stats to the graphic display, all located together on your poster where it is easy to understand. You can use this routine for two or three predictions and thus exhibit graphically, with minimal text, the big points of your presentation.

Part 6D: A handout

We strongly recommend that you write up a brief hand-out to accompany your poster. This will allow you to provide a little more detail about your work and will also achieve the important goal of sending your audience away with your work and your name in hand. The ideal handout is just one to two pages long, with all of the important points of your presentation in both text and graphics. An envelope of these can be attached to your poster display area so that your colleagues can easily collect them. PowerPoint allows you to print your poster fit to a normal page size and this is easily used as a handout. Attaching a business card with your contact info to the handout allows colleagues to walk away with all the information they need to contact you.

Part 6E: Presenting your poster

A poster session really serves multiple purposes. Your colleagues will come to see your work, of course, but these sessions also provide opportunities for social interaction that paper sessions don't allow. Thus, you will be presenting your material in the midst of pandemonium as people elbow past one another toward friends or the hors-d'oeuvre table, voices rise in vain efforts to be heard over the crowd, and someone spills wine on your new suit. Think of it as a test, a trial by fermented grape.

You will be expected to stand next to your poster for approximately two hours, answering questions from those who stop to read your poster. You will literally be standing, so wear comfortable shoes. Your attire should be professional, but the ASP is also a fairly casual bunch so a full suit (men's or women's) isn't really necessary. You aren't being asked to testify before the Senate but neither are you attending a frat party. Aim for something in between.

At the session itself, it is important to remember that YOU are on display as much as your work. You carefully constructed that poster to make your points in very few words; however, some people still won't want to read through it themselves, and other folks will demand more detail than you provided. You must be well prepared to answer their questions. Spend a little time before the meetings refreshing your memory on the relevant literature, on the various methods your predecessors have used to test this hypothesis, on the statistical tests you used and why. Think about the best way to present the material verbally to compliment what you have printed up for your poster. Remember that 25-words-or-less shtick? You will really need it at your poster session. You will be asked the same questions over and over again, about what you were studying and why, about how to interpret this graph or that statistic, so be prepared to explain those things clearly, concisely and repeatedly. This may feel redundant for you, but remember that each of them is hearing it for the first time.

Part 7: At the meeting

This is it. You have actually made it to the meeting. What now? When you arrive at the conference site, you will check in at the registration desk and, whether you've prepaid or registered on site, you will receive a packet of materials that includes (among other things) your name-tag, a conference schedule, a set of abstracts of all presentations to be offered, and a map of the meeting rooms. We recommend that you immediately find the date, time, and location of your session. As soon as possible, visit the room where your session is to take place.

Part 7A: Oral

Walk up to the front and stand in the place where you will be standing to give your talk. Practice using the equipment. You might be in charge of a microphone, the computer, a laser pointer, and lighting. Learn how everything works before the moment of truth is upon you. If you are planning to read your talk, we recommend bringing along a small flashlight, just in case there is no light on the podium. Don't overload yourself with gear, but do be prepared for emergencies.

The conference will also have arranged for a time and place to submit your PowerPoint presentation. Most PowerPoint presentations are needed at least 15 minutes prior to the beginning of your session. However, it is wise for you to check your presentation on their computers well in advance of your talk, in case you have to fix all of your symbols or reinstall your graphics. This is particularly important if you will be switching from a Mac to a PC, or vise versa.

When the day of your session arrives, get there early. Go on up and introduce yourself to the person chairing the session. Your first name isn't listed on the program, but you would probably like to be introduced as Jane Smith rather than J. Smith. The chair might also have some information to pass along to you, like the mode of keeping time, or some change in the schedule. Sit someplace where you can get to the podium easily, rather than wasting time extracting yourself from the middle of the row. Then, take a deep breath, relax, and give the talk of your life!

Part 7B: Poster

Most poster sessions are held in large "ballrooms" or other such venues. Each poster is assigned a numbered display board. You may have gotten word in advance about the day of your poster session and what number is yours. If not, this information can be found in your registration materials. When the day of your poster session arrives, go and put up your materials in a timely fashion. You will be wise to come to the meeting prepared for emergencies. Bring along pushpins AND duct tape. The ASP is great about providing information and assistance, but at future meetings you might not be so fortunate.

Remember that there may be folks out there who you'd really like to impress, even if you don't recognize them. Don't ignore someone who is standing at your poster, no matter how much you want to ask your friends about the restaurant they went to last night. Your job at the poster session is to present yourself and your work to your academic community. Greet each new-comer with a confident “Hello” and offer to answer any questions that he or she might have. Be enthusiastic about your work and engage the audience but don’t be too pushy – if someone’s body language tells you they want to read the poster before talking to you, let them. Try not to get so engrossed with one visitor that you ignore the rest. And hang in there until the bitter end because you never know what might happen. It could be the last five minutes of the session, you are tired and ready for some dinner, and you really don't feel like running through the entire spiel again. But the nondescript-looking guy in Levis and a cowboy shirt who straggled in just as you were about to start taking down your poster might be the one to offer you the post-doc of your dreams. Don't blow it.

Epilogue:
Remember that attending a conference is about more than just presenting your research. Don't forget to have fun, too. Attending a conference can be one of the most beneficial career moves you make in a year, as you renew old contacts and get to know new colleagues. Don't get so wrapped up in attending talks or reading posters that you miss meeting that professor you've always admired. Throw yourself into your own presentation, but relax and enjoy yourself once it's all over. Soon enough you'll have to start preparing the talk for next year.

Effective Presentations

An essential aspect of any research project is dissemination of the findings arising from the study. The most common ways to make others aware of your work is by publishing the results in a journal article, or by giving an oral or poster presentation (often at a regional or national meeting). While efforts are made to teach the elements of writing a journal article in many graduate school curricula, much less attention is paid to teaching those skills necessary to develop a good oral or poster presentation - even though these arguably are the most common and most rapid ways to disseminate new findings. In addition, the skills needed to prepare an oral presentation can be used in a variety of other settings - such as preparing a seminar in graduate school, organizing a dissertaton defense, conducting a job interview seminar, or even addressing potential philanthropic sources!

Here are a series of on-line tutorials I have prepared as part of a graduate course (PHSL 896) I teach in our basic sciences graduate program (other electronic course offerings may be accessed through KUMC's Virtual Classroom). My tutorials are intended to aid in:

1. Developing an Effective Oral Presentation
2. Designing Effective Visual Aids for Presentations
3. Creating an Effective Poster Presentation

Judging from the e-mail I receive about these materials, and the wide variety of folks who send these messages, there's clearly a need perceived for this information. Great! You might want to explore some of the related material at these other sites. Many of these are designed for the business community, and some of these guidelines may not be perfectly appropriate for scientific settings.

1. The MERLOT (Multimedia Educational Resource Learning and Online Teaching) website is a free and open resource for on-line teaching, aimed at students and faculty. Be careful - you may end up spending lots of time exploring this site!
2. A spiffy presentation discussing Effective Teaching with Powerpoint from the perspective of Learning Theory.
3. The Presentation Helper website is great site based in the UK that offers insights into presentations in a wide variety of settings. Even as a science geek you may occasionally find yourself making a weeding toast, speaking to kids in a classroom....
4. The Executive Communications Group newsletter was recommended to me, and I'm happy to include here a link to the series of articles. These are oriented toward presentations in the business environment, but many of the suggestions do apply to scientific settings - particularly in job interview situations.
5. I do recommend that you visit a page prepared by Mark Hill, based upon David Patterson's talk on How to Give a Bad Talk.
6. Been there, done that... A few suggestions on coping with presentation disasters! This site includes other useful tips and links to a variety of resources for presenters.
7. **Meeting Tomorrow** is an agency that facilitates event productions, presentations, and virtual communications. They have provided a series of help pages that may be useful for presenters. Check out the "How to give an effective presentation" webpage, as well as their many other "how to…" pages.
8. The folks in the Instructional Support division at my institution work tirelessly to help support faculty - and here are links to a few training resources that they've developed (perhaps in self-defense). Instructional Support (presentations, web-based learning, *etc.*) and Computers & Technology.
9. The Online Bachelor Degree Programs website offers a comprehensive and useful guide to public speaking - it's Your Online

Public Speaking Guide: Information and Tips.

10. Although the topics and advice relate only indirectly to the points I've emphasized regarding presentations, everyone should take time to review the Work Etiquette website. Useful information for all of us ...

Any other suggestions? If you have a recommendation for a not-for-profit resource, drop me a note!

There are a number of other, more detailed guides available for preparing a presentation, and for creating the visual aids to go along with that presentation. Try looking for books on the subjects at your library (key words: presentation, public speaking, lecture, effective).

1. *The Craft of Scientific Presentations*, by Michael Alley. Springer-Verlag, New York, 2003. Good information, current technologies.
2. *A Handbook of Public Speaking for Scientists and Engineers*, by Peter Kenny. Published by Adam Hilger, Ltd., Bristol, 1983. ISBN 0-85274-553-2 (Dykes library, KUMC reference number WZ 345 K36h 1982). *A bit older, but the content remains germane.*
3. *The Visual Display of Quantitative Information*, by Edward R. Tufte. Graphics Press, Cheshire, CT, 1983. One of the very best books documenting the how and why of presenting complex data in an accessible manner. Although the book predates widespread use of computers, the concepts remain pertinent. Dr. Tufte more recently has published several books on related topics - all are good reads!
4. *The Compleat Academic - A Practical Guide for the Beginning Social Scientist*. Mark P Zanna and John M. Darley (eds.); Random House, New York, 1987. ISBN 0-394-35252-1 (pbk). *If you can find this book, you'll find it a very readable guide to the perils a beginning academic may face, and has some very good suggestions for ways to cope with them (e.g., never respond the the first e-mail or memo - others with clarifications or further requests are sure to follow). If you plan to pursue an academic career, this will be very useful.*
5. For those who may prefer a non-electronic source of information about preparing poster presentations:
Woolsey, John D. (1989) Combating poster fatigue: how to use visual grammar and analysis to effect better visual communications. *Trends in Neurosciences*, **12**(9):325-332.

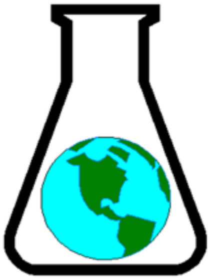
You can also, of course, visit my home page, or **RETURN** to the KU Medical Center Home Page.

Jeff Radel
Last Update: July 1999

Curriculum Resources

Application 1 - Introducing this activity
(shared by Janet Fulks)

Topical Investigations in Microbiology
by Janet Fulks



Objectives

1. Learn the steps used in the scientific method to answer a question.
2. Ask a question and state a hypothesis.
3. Prepare and carry out a controlled procedure to answer the question.
4. Be able to use appropriate tables and graphs to present data.
5. Be able to analyze and interpret data presented in tables and/or graphs.
6. Discuss the significance of the data and relate this to the original hypothesis.
7. Evaluate the procedure used, indicate possible errors, and suggestion new tests.

The Scientific Method gives scientists an SOP (Standard Operating Procedure) to examine nature and determine answers to various questions. Many everyday aspects of your life have been affected by using the Scientific Method, such as the data that allow us to attribute a certain disease to a specific pathogen, and the method by which we determine what antibiotic is most effective for an infection. This method follows a strict progression with limits and guidelines to insure that the test can be reproduced and verified.

It begins with **Observations** - things that we have seen, read, or heard that stimulate us to pose a **Question.** Material including these observations and information acquired through research are summarized in a section called **Background.** After clearly stating the question and limiting its scope, we suggest a possible answer, which is called an **Hypothesis**. The hypothesis should be short, specific and testable. Whether you support or disprove the hypothesis is not important. Both supportive and critical results help us to narrow down an answer to the question. It is expected that many hypotheses and tests will be required to get a definitive answer to the question. At this point you should be able to make a prediction as to the outcome. Predictions are usually stated in an " If....then" fashion e.g., If cultures are taken of the toilet bowl and the kitchen sponge, then more coliforms will be recovered from the toilet bowl than the sponge.

The next step is very important, an **experiment** must be devised to test the hypothesis. The experiment must be repeatable, quantitative and controllable. The **Materials and Methods** should be determined and listed completely. A **Method** should be clearly described so that anyone can follow it, similar to a recipe, and test the same hypothesis. A controlled experiment is one in which all factors that might affect the outcome are maintained constant, and only one variable is changed at any given time. A control is a test set up in which all of the variables are held constant and the only difference between the control and the experiment is the single variable in question. It represents a standard or basis to compare to the experimental or test results. To test the effect of variables on your heart rate you would need a control value. This value is selected from observations. Usually the resting pulse, your heart rate while sitting in a relaxed position at room temperature, is used as a control when studying heart rates. To test the effect of exercise on the heart rate you would determine a period of exercise, measure your heart rate and compare it to the control (resting heart rate).

The information collected during the actual testing represents your **Data**. This is presented factually without any interpretation or opinion, in a section dedicated to the facts. The data section should include graphs and/or tables that make it easy to see your information at a glance. A written summary of the data should be given as well as the graphic display.

A separate section is devoted to the interpretation of your data. This is called the **Discussion**. In this section consideration of the data and possible explanations are developed. All discussions should include any possibility of errors within the experiment and suggestions for further experimentation to answer the question more clearly. Scientists realize that they may differ on the interpretations of data. It is for this reason that experiments are published in this specific manner and reviewed by other scientists.

Curriculum Resources

Application 2 - Introducing this activity (shared by Judy Kandel)

Note: The instructor facilitates the following discussion.

PRESERVATIVE EFFECTIVENESS PROTOCOL

You are the head of the Food and Drug Administration (FDA) and are responsible for the safety of products used in or on the body. One group of products under your jurisdiction includes solutions used to clean and store contact lenses. These solutions often include chemical preservatives to prevent the growth of bacteria that might enter during use by the purchaser of the product. As head of the FDA, you must insure that any product available for purchase is adequately preserved. You therefore demand that the manufacturer test his product and provide you with the experimental data that proves his product is safe.

Your assignment (which will be performed as a class) is to design the protocol for an experiment to test preservative effectiveness in contact lens cleaning solutions. Consider the following in your design:

1. General objectives - What question are you trying to answer?

2. Hypothesis – What is your predicted result/expected outcome?

3. Overall plan – Provide a one or two sentence description of experimental design.

4. Experimental Design/Protocol - Detail the procedure so that any competent microbiology student can perform the experiment without additional guidance.

  a. What organisms will you use in your test? Why choose these organisms?

  b. What size product sample will you use and how many organisms will you inoculate? Will these organisms be tested in pure or mixed cultures?

  c. How will the samples be incubated? How and when will you monitor the samples?

  d. How many replicates will you do?

  e. What controls are necessary to make the results meaningful?

  f. Is your protocol feasible? Is it written in enough detail for another person to perform? Are all materials and equipment available?

5. Interpretation

  a. What results will indicate that the preservative is effective?

  b. What criteria must the contact lens solution meet to be considered safe?

Curriculum Resources

Application 3: Survival of microbes on surfaces: Implications for choosing and using a cutting board. (shared by Linda Fisher)

Survival of Microbes on Surfaces: Implications for Choosing and Using a Cutting Board.

Students should form an hypothesis that they will test by carrying out this experiment. If done as a class investigation, the following protocol may be used:

Materials

- plastic cutting board
- wooden cutting board
- permanent marker
- sterile, capped tubes (13 x 100 mm)
- sterile cotton swabs
- sterile pipets, 1 ml and 10 ml
- bacteria (You may use an overnight culture of *E. coli* that has been diluted to about 10^5/mL; or for, a more realistic sample, "drippings" from raw chicken or ground beef.)
- microliter pipette and sterile tips or 10 microliter capillary pipets
- sterile saline for dilution blanks
- tryptic soy (Tsoy) agar or nutrient agar plates

Protocol

1. Using a permanent marker draw sampling grids containing 12 squares of equal size on each cutting board. Number each square.

2. Pipet 1 ml sterile saline into each of 24 tubes. Number the tubes 1W through 12W, for samples from the wooden cutting board, and 1P through 12P for samples from the plastic.

3. With a sterile cotton-tipped swab carefully rub the entire surface of square #1 on the wooden cutting board. Place the swab into tube 1W, and transfer any material that has adhered to the swab to the liquid. Do the same with square #2, and transfer it to tube 2W. Repeat for squares #1 and #2 on the plastic cutting board.

4. With a permanent marker sub-divide a Petri dish of Tsoy agar into equal quadrants. Label the quadrants 1W, 2W, 1P, and 2P. Carefully transfer two 10 µL samples of undiluted 1W to quadrant 1W. Be sure that the samples are placed far enough from each other that they do not run together. Be careful not to "splatter" the sample by forcing out the last bit of liquid from the pipette. Repeat with samples 2W, 1P, and 2P. If microliter pipettes are not available, plates can be inoculated for titration by spreading 0.1 ml samples on the agar surface.

5. "Inoculate" the remaining squares on each cutting board by rubbing each with a sterile cotton swab saturated with the bacterial sample.

6. Immediately, with a fresh cotton swab, rub the surface of squares numbered 3 and 4, and transfer the swab to the appropriate tube of saline as described in 3, above. Do serial 10-fold dilutions through 10^{-5} for each sample. Subdivide 2 agar plates into 6 segments each for samples 3W and 4W. Subdivide 2 agar plates into 6 segments each for samples 3P and 4P. Label the plate segments und., 10^{-1}, 10^{-2}, 10^{-3}, 10^{-4},

and 10^{-5}. Inoculate the plates with the undiluted and diluted samples as described in #4 above.

7. After 15 minutes, swab squares 5 and 6, and transfer to saline. Swab duplicate squares at 30 minutes, 1 hour, and 2 hours. Do serial dilutions and inoculate the agar plates as described above.

8. Let the inoculum dry on the agar before incubating the plates overnight at 37°C.

9. Calculate titer from the dilution of sample producing between 3 and 30 isolated colonies in a spot.

Possible variations

1. Swab each cutting board after overnight exposure to the bacterial sample and titrate the number of viable bacteria remaining as compared to the number at the start of the experiment.

2. Determine the effectiveness of kitchen cleaners, including soapy water and water alone in cleaning bacteria from wood and plastic cutting boards.

Curriculum Resources

Application 4 - Do condoms control the spread of disease? (shared by Judy Kandel)

Do Condoms Control the Spread of Disease?

Objective: To evaluate the efficacy of condoms as barriers to transmission of bacteria and viruses.

I. Procedure for bacteria

Materials

- Non-lubricated condoms - FDA approved within appropriate expiration date
- Non-lubricated novelty condoms (if desired)
- *Micrococcus luteus* or *Serratia marcescens*, overnight culture
- Trypticase soy agar (TSA) plates
- Pipettes, 0.1 ml or micropipette
- Petri plates
- Sterile latex gloves
- Scissors
- Isopropanol for flaming

1. Aseptically open the condom package and place the condom into a sterile Petri dish.
2. Using sterile gloves, unroll the condom while being careful to preserve sterility.
3. Flame sterilize the scissors and cut the condom into approximately one inch strips. (You will first have a ring, which must be cut to form flat strips.)
4. For each test, divide a TSA plate into four sections (a-d). Aseptically place a condom strip into two of the sections (a,b) being careful not to puncture them.
5. Pipette 10:l of bacterial suspension onto one of the condom strips (a). Leave the other strip uninoculated (b). Pipette 10:l of bacterial suspension in each of the empty sections (c,d). Cover the inoculum in section c with a sterile condom strip.
6. Incubate the plate(s) at 25°C for two days. Observe for growth under the condom strips and in section c.

II. Alternative procedure for bacteria

Materials

- Non-lubricated condoms - FDA approved within expiration date
- Non-lubricated novelty condoms (if desired)
- *Micrococcus luteus* or *Serratia marcescens*, overnight culture
- Trypticase soy agar (TSA) plates
- Sterile latex gloves
- Scissors
- Isopropanol for flaming
- Sterile test tubes (large enough to use to unroll condoms)
- Pipettes, 10 ml
- Filter apparatus
- Sterile filters, 0.45 mm

1. Aseptically open two condom packages and, using sterile gloves, unroll each condom at least 3/4

of its length while being careful to preserve sterility. (Condom can be unrolled on a sterile test tube.)

2. Pipette 10 to 20 ml of bacterial suspension into one condom.
3. After 5 minutes, swirl the filled portion of the condom in a beaker of 100 ml of sterile water.
4. Filter the water through a 0.45 mm filter using a sterile apparatus.
5. Place the filter on a TSA plate.
6. Pipette 10 to 20 ml sterile water into the second condom and repeat steps 3 – 5.
7. Incubate the plates at 25°C for two days. Observe for growth.

III. Procedure for viruses

Materials

- Non-lubricated condoms - FDA approved within expiration date
- Non-lubricated novelty condoms (if desired)
- *Escherichia coli* in broth
- Bacteriophage T4
- Trypticase soy agar (TSA) plates
- Soft agar, 2.5 ml per tube
- Sterile latex gloves
- Scissors
- Isopropanol for flaming
- Sterile test tubes (large enough to use to unroll condoms)
- Pipettes, 10 ml

1. Aseptically open a condom package and, using sterile gloves, unroll the condom at least 3/4 of its length while being careful to preserve sterility. (Condom can be unrolled on a sterile test tube.)
2. Pipette 10 to 20 ml of phage suspension into the condom.
3. After 5 minutes, holding the condom by its tip (still using sterile gloves) pour out the liquid (be careful not to contaminate the outside of the condom).
4. Holding the condom by its tip, aseptically cut the condom three inches from the tip to create a piece that fits onto the surface of the Petri dish.
5. Place the piece on a TSA plate being careful not to contaminate the tip region with residual fluid from the interior.
6. Pipette 1 ml *E. coli* into soft agar. Mix and carefully pipette over the condom at the tip. Soft agar should cover no more than two inches at the tip and should extend onto the TSA surface.
7. Incubate the plates at 37°C for two days. Observe for growth.

IV. Alternate procedure for viruses

Materials

- Non-lubricated condoms - FDA approved within expiration date
- Non-lubricated novelty condoms (if desired)
- *Escherichia coli* in broth
- Bacteriophage T4
- Trypticase soy agar (TSA) plates
- Soft agar, 2.5 ml per tube
- Sterile latex gloves
- Scissors
- Isopropanol for flaming
- Sterile test tubes (large enough to use to unroll condoms)

- Pipettes, 5 ml, 1 ml

1. Aseptically open a condom package and, using sterile gloves, unroll the condom at least 3/4 of its length while being careful to preserve sterility. (Condom can be unrolled on a sterile test tube.)
2. Pipette 5 ml of phage suspension into the condom.
3. Suspend the filled portion of the condom tip into a small sterile beaker containing 1 ml of sterile water for 5 minutes.
4. Pipette 1 ml of *E. coli* into soft agar and immediately add 0.1 ml of water from beaker. Mix and pour suspension onto surface of a TSA plate.
5. Pipette 1 ml of *E. coli* into soft agar and immediately add 0.1 ml of phage suspension. Mix and pour suspension onto surface of a TSA plate.
6. Incubate the plates at 37°C for two days. Observe for plaques.

Curriculum Resources

Application 5 - Grading Sheet (shared by Janet Fulks)

Scientific Method Lab Grading Sheet

Names:

Category	Percent of grade	Earned
Introduction and background	20%	
Hypothesis	10%	
The experimental design methods and reproducibility	25%	
Data: graphs & tables	20%	
Discussion and conclusions, including possible errors and suggested further testing	25%	
Total points:	100%	

Curriculum Resources

Application 6 - Assessing individual contributions to group projects (shared by Janet Fulks)

Group Project Grading Sheet

Title of Project:

Names of lab partners	Description of work completed	% of project	Initials of each lab partner

Each partner will log the specific work they contributed to the project and will estimate the percent of the overall project they contributed to. Ideally 25% for each partner would represent equal contributions, but this is not always practical. The total of all lab partners should be 100%. You will be assigned points according to the percentage of work you contributed. Each person's estimate will be initialed, and therefore verified by each team member.