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Converting the labs in an introductory biology course from cook-book to investigative

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http://zoology.okstate.edu/zoo_lrc/biol1114/guest

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Course Context

The Course:

- for ALL majors
- 900 students / semester
- in 6 lecture sections and 45 labs
- by 6 lecture faculty and 20 TAs

The Labs

- Labs are three hours once a week
- Students work collaboratively
- Three students per group
- Lab reports written as a group

Goals for the Lab

- To promote an understanding of the process of science, so students can
  - Form testable hypotheses to answer questions
  - Design & conduct experiments to test hypotheses
  - Analyze and graph data and report findings
  - Cope with unsupported hypotheses and design flaws
- To allow students to engage in explorations that will lead them to biological concepts
- To familiarize students with current technology and techniques.

Motivating Factors

- Student performance/attitude was lower than desired ....."Labs are BORING"
- Lab exercises were primarily verification
- Students learn nothing about conducting research

National Science Education Standards

Promote science education that stresses inquiry, experimentation, and critical thinking over memorization of detail

So what do labs look like?

So how do you get started?

Plan Outcomes

Choose your goals & objectives

- Process
  - Which experimental skills should students pursue in lab?
  - Which experimental skills should students master in lab?
- Concepts
  - Toward which concepts should students be directed?
  - Which concepts should students master?
  - Use which terms appropriately in context?
  - Apply which concepts to interpretation of results?
- Technical
  - What laboratory, computer, data analysis skills should students learn to perform?

Goals/Objectives --Example

- Target Skills:
  - Process (Scientific Method)
  - Write a clear Hypothesis
  - Design a Controlled experiment to test hypothesis
  - Recognize biases that affect results
  - Make Predictions based on hypothesis/experiment
  - Collect Data
  - Display results
  - Draw appropriate conclusions
  - Discuss in comparison to literature/theory
- Target Concepts
  - Introduce Rate
  - Introduce S/V Ratio
  - Begin to develop an understanding of the relationship of S/V Ratio and heat loss
  - Introduce gradient

Pose a Question

1. Larger *Quattro variegatus* are eaten more often because they are easier to see.
2. **Body Shapes influence the rate of heat gain of loss in a predictable way.**
3. How is metabolic rate influenced by ambient temperature?
4. How do various factors influence the passage of materials through a membrane?
5. How can cell structure be used to identify cell type, function, or location?
6. How does nut diversity and abundance influence survival of birds with different beak types?
7. How does the color of light influence the rate of photosynthesis?
8. How do environmental or anatomical factors effect the rate at which plants remove water from the soil?
9. How does drug type or UV radiation influence evolution of antibiotic resistance?
10. How can the genetic composition of bacteria be altered in the laboratory?
11. How can genetic material be identified in the laboratory?
12. How does sewage affect benthic and algal species diversity in streams?
13. How is anoxia caused in polluted streams?
14. How do guppies select mates?

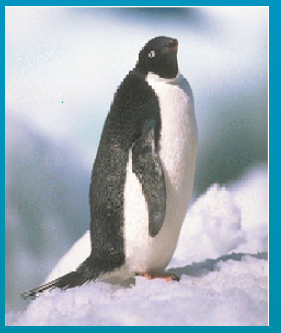
Provide a Background/Context

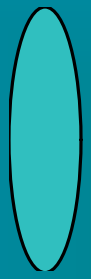
Biomes (environment)

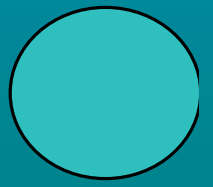
Characteristics (Adaptations)

Background Story in Lab

A scientist spent a great deal of time observing these two birds and measuring their internal body temperatures under different environmental temperatures. Based on her observations and temperature data, she is convince that body shape and thermoregulatory ability are related. Furthermore, she is convinced that she can find a way to predict the rate of heat gain or loss from some measure of body shape.

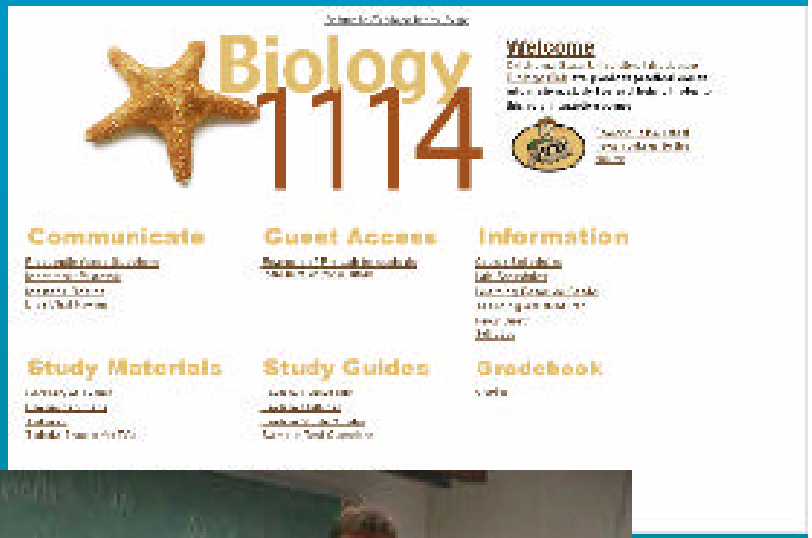






How will you prepare students?

- Pre-Lab Activities
  - Subject
    - **Technique**
    - **Analytical Skills/**
    - **Calculation**
    - **Information**
  - Sources
    - **LRC**
    - **WWW**
    - **Lab Manual,**
    - **Textbook**



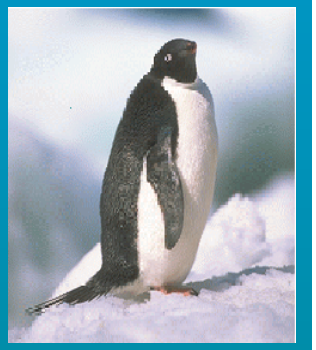
Possible Student-Generated Hypotheses

Should be:

- Derived from observations (pre-lab/ lecture/ background material)
- causal
- testable within context of laboratory
- falsifiable
- leading to specific predictions

And also:

- Basis for selecting necessary equipment for laboratory
- Not necessarily the correct answer



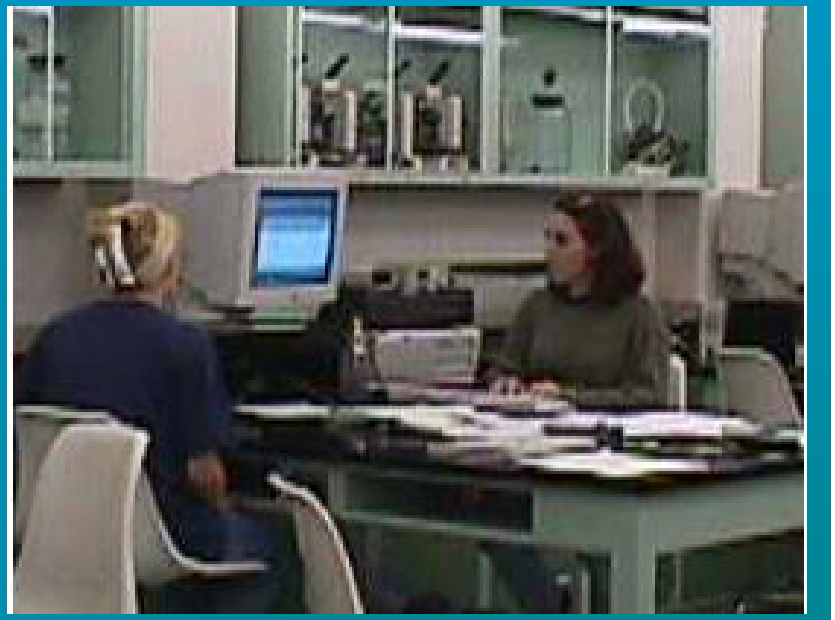
What will students need?

- Lab Specific
- Equipment
- Instructions
- Failure Points

Student Assessment

Lab Report

- by Group
- In-Class
- Grading Rubric



Alternative Lab Format

Labs are spread out over 3 weeks

- Week one: Planning week
  - Students are assigned to groups
  - Discussion of Pre-lab activities
  - Given time to work on planning forms in class with peers
- Week two: Data Collection
  - Students turn in planning forms,defend hypothesis and explain experimental design
  - Perform the experiment
- Week three: Reporting
  - Reports are written in class as a group
  - Presentation of findings

Sample Cookbook Lab

Problem: What are some factors that influence the movement of materials through a semi -permeable membrane?

Diffusion through a membrane: To study the cell membrane, you will employ a simple procedure. Experiments often utilize a simplified version of the situation that is being investigated, a model or a system that is acceptably similar to the actual case, but which is usually easier for the experimenter to control.

Materials: glucose test strip, cup or beaker, dialysis tubing, glucose solution, starch solution, and water.

Procedure:

1. Obtain a beaker (about 400 ml) or a cup as provided by your instructor and fill it approximately 2/3 full of water (preferably distilled water).
2. Use a glucose test strip to test the water for the presence of glucose. Record your results.
3. Take an approximately six inch length of membrane tubing and soak it in warm water until it becomes pliable.
4. Tie one end and place about an inch of starch solution in the bag.
5. After putting the starch solution in the bag, add about an inch of glucose solution to the bag.
6. Use your fingers to squeeze the bag on the outside to mix the starch and glucose solution thoroughly in the bag.
7. Place 30-35 drops of Lugol's solution (iodine) in the water in the beaker or cup. (Enough iodine should be added until the water in the cup is light brown.)
8. Test the bag to be certain that the starch solution does not leak from either end and that there are no holes in it. Wash the bag with water to remove any starch or glucose adhering to its surface; give special attention to the tied ends.
9. Place your bag which has now been tied on both ends and rinsed into the cup or beaker containing the iodine solution.
10. Wait for approximately 10 minutes and record your observations.

A "possible" arrangement to help you organize your data appears below.

Material Tested	Result before running the experiment	Result after running the experiment
iodine (Lugol's)		
glucose solution		
starch solution		

Your procedure needs to include a drawing of the experimental setup for this activity with the components labeled.

Things to test or comment on in your data.

a.) Is there glucose in the water in the cup after 10 minutes? (Use the glucose test strip to test this.)
b.) Was there a change in the color inside the bag?
c.) Was there a change in the color of the water in the cup outside the bag? Hint: If there was a significant change, you did something wrong with this experiment.)

Questions which should be answered in your conclusion.

1. Did glucose leave the inside of the membrane and go into the beaker? How did you prove this?
2. Did starch leave the inside of the membrane and go into the beaker? How did you prove this?
3. Did iodine enter the membrane from the water in the beaker? How did you prove this?
4. Based on this investigation, form a tentative conclusion in reference to how the size of molecules influences their ability to diffuse through a semi-permeable membrane. Explain/justify your answer.
5. You didn't investigate the diffusion of water (osmosis) in this experiment, but if you did, do you think water would diffuse into the bag from the cup or out of the cup into the bag? How could you set up an experiment to test your hypothesis about the movement of the water?

Your Turn

- Work in groups of 2,3,4
- Use the lab planning form provided to outline a lab of your own