RET@ND Handbook of Lab Experiments

January 2010 Volume 3.

Handbook of Open-ended Laboratory Experiments

One of the desired outcomes of the RET@ND Program is to formulate open-ended lab investigations which will excite, stimulate and encourage students to enter the fields of science, engineering and mathematics as careers. It is our goal to place these investigations on the RET@ND web site, as well as to compile handbooks of these investigations contributed by the summer participants. These handbooks will be made available to each participant, to other teachers and to science coordinators requesting them.

These investigations reflect a range of science and mathematics topics. It is assumed that teachers in the different disciplines would select the appropriate activity and that no teacher would utilize all of the listed activities. With this Volume (3) of the RET@ND Handbook, all lab activities were abbreviated to the first two pages. However, the entire lab activity can be downloaded from the RET@ND Website. (www.nd.edu/~ndrets)

Lab activities in this RET@ND Handbook include the following areas:

Biology	**Bio-Technology**	**Chemistry**
Earth Science	**Engineering**	**Mathematics**
Physics	**Statistics**	

Recommended Laboratory References

References for Developing An Open-ended Inquiry Based Curriculum

It is almost unanimous among science educators that the best Inquiry Based curriculum materials (BSCS, ESCS, Chem Study, Project Physics) were originally developed by the Curriculum Study Committees. Fortunately, some of these books have continued to be updated and printed. It is also most fortunate that a low cost internet site has these used books available in a limited number. This site, www.bestbooks.com, which is essentially a very low for-profit organization, directs their profits into improving educational opportunities for students in third world countries. We have found their books (used/new) to be in excellent condition and to be sold for a small fraction of their newly published price.

Considerable interest has also developed among teachers using the inquiry approach to science teaching as incorporated in the International Baccalaureate (IB) Curriculum. In brief, the IB Curriculum focuses more on science as a process rather than science as a collection of concepts and facts. However, an understanding of the concepts is required in order for the student to propose reasonable hypotheses and to appropriately discuss the results of the investigation. While the IB Organization does not specially endorse any one textbook, individual teachers and seminar leaders tend to select many activities from the Curriculum Study Committee texts listed below.

In addition to endorsing the Curriculum Study Committee's curricular materials of 30 years ago, IB also strongly recommends the use of interface equipment such as Vernier develops. The easiest method for introducing simulated open-ended lab investigations is with computer-interface equipment using various probes. Here the students can extensively alter most variables. Even with just one demonstration unit, different pairs of students can easily get different data by altering the variable.

Biology/Physiology

BSCS Biology: A Molecular Approach by Jon Greenberg, Revision Editor
Pub. Glencoe McGraw-Hill, New York, New York ISBN 0-538-69039-9
(also available at BetterWorld.com)

BSCS Biology: An Ecological Approach by William J. Csirney
Pub. Kendall Hunt Pub. Co. Dubuque, IA ISBN 0840396597
(also available at BetterWorld.com)

Biology Labs That Work: The Best of How-To-Do-It, Several Volumes edited by Suzanne Black, Randy Moore and Heidi Haugen ISBN 0-941212-28-9
Pub. National Association of Biology Teachers, Reston, Virginia 2000-2005

Biology with Computers, by David Masterman and Scott Holman
Pub. Vernier Software and Technology, Beaverton, OR

Recommended Laboratory References

Human Physiology with Vernier by Diana Gordon and Steve Gordon Pub. Vernier Software and Technology, Beaverton, OR

Water Quality with Computers, by Robyn Johnson, Scott Holman and Dan Holmquist Pub. Vernier Software and Technology, Beaverton, OR

Free sample biology labs from Vernier at www.vernier.com/labs

The American Biology Teacher is a monthly journal published by The National Association of Biology Teachers, 12030 Sunrise Valley Drive, #110, Reston, VA 20191

Senior Biology 1 by Tracey Greenwood, Lyn Shepherd and Richard Allan Biozone International , Hamilton, New Zealand 2006 ISBN 1-877329-66-5

Senior Biology 2 by Tracey Greenwood, Lyn Shepherd and Richard Allan Biozone International , Hamilton, New Zealand 2007 ISBN 1-877329-68-1

Earth Science/Environmental Science

Investigating Earth Science ESCS by ESCS Staff Pub. Kendall Hunt Pub. Co. Dubuque, IA ISBN 0757501044 (also available at BetterWorld.com)

BSCS Science Tracs Connecting Science and Literacy Investigating Earth Materials by BSCS Staff Pub. Kendall Hunt Pub. Co. Dubuque, IA ISBN 0757516041 (also available at BetterWorld.com)

Prentice Hall Science Explorer: Earth Science
By Michael Padilla, Ioamis Micoulis and Martha Cyr Pub. Prentice Hall ISBN-10:0130540714

Earth Science with Computers, by Robyn Johnson, Grethen DeMoss and Richard Sorensen Pub. Vernier Software and Technology, Beaverton, OR

Water Quality with Computers, by Robyn Johnson, Scott Holman and Dan Holmquist Pub. Vernier Software and Technology, Beaverton, OR

Free sample earth science labs from Vernier at www.vernier.com/labs

Chemistry

A Portfolio of Investigations for IB Chemistry (paperback), by John Green, IBID Press, ISBN -10-1876659122 (also available at BetterWorld.com)

Further Investigations in IB Chemistry (paperback) by John Green and D. Greig, IBID Press, ISBN-10-1876659246 (also available at www.BetterWorld.com)

Water Quality with Computers, by Robyn Johnson, Scott Holman and Dan Holmquist Pub. Vernier Software and Technology, Beaverton, OR

Advanced Chemistry with Vernier: Experiments for AP and IB Chemistry by Sally A. Vonderbrink, Don Volz, Dan Holmquist, John Gastineau, Greg Dodd Pub. Vernier Software and Technology, Beaverton, OR

Recommended Laboratory References

Free sample chemisitry labs from Vernier at www.vernier.com/labs

Journal of Chemical Education is published by The American Chemical Society, P.O. Box 1257, Bellmawr, NJ 08099-1267 www.jchemed@egpp.com

Physics

Physics: International Baccalaurate
By G. Paul Ruth and Greg Ketor
Pub IBID Press 2001
ISBN – 10-1876659351

Lab Manual to Accompany Applied Physics: Concepts Into Practice
By Gregory Romine Pub. by Prentice Hall ISBN 9780130870643
(also available at BetterWorld.com)

Physics for Scientists and Engineers IB
By Raymond A. Serway and John W. Jewett Pub. by Brooks Cole Pub.
ISBN 0534408427

Physics with Computers, by Kenneth Appel, John Gastineau, David Vernier, et. al. Pub. Vernier Software and Technology, Beaverton, OR

Physical Science with Computers, by Donald Volz and Sandy Sapatka
Pub. Vernier Software and Technology, Beaverton, OR

Free sample physics labs from Vernier at www.vernier.com/labs

The IBID Press publishes primarily for the International Baccalaureate Program
Their address is
IBID Press ,
P.O. Box 396 Washroonga N.S.W.
Sydney, Australia

Email address ib@pronin.com.au

Index of Lessons
Biology

BioTechnology

BioTechnology (cont.)

Index of lessons
Chemistry

Earth Science

Engineering

Index of Lessons

Useful Statistics

Mathematics

Scanning Electron Microscope SEM

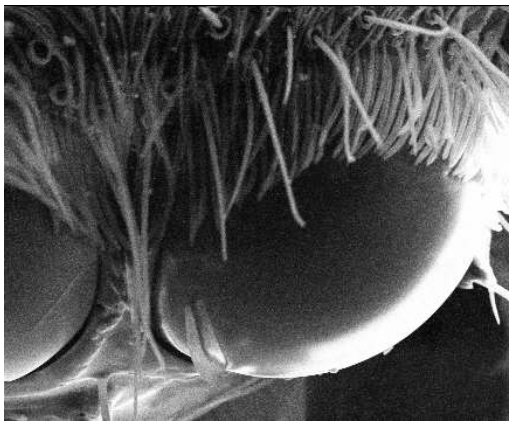
TEACHER'S Lesson Set

"Here's Looking at You Kids"

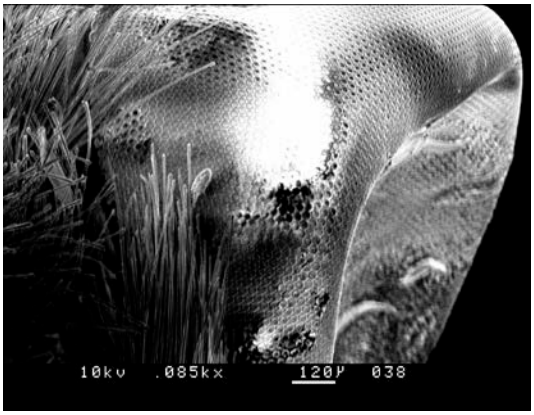
Why use this activity?

It's a chance for students to do some measuring and comparison of scale, to have exposure to what SEM images look like and a little of how that microscope works, students look at the anatomy of the eye of different arthropods and using the internet-find some interesting images of their own to use.

These pictures are available on the website: http://www.remc11.k12.mi.us/~lsmith/



Ant Eye



Green Bug Eyes

Scanning Electron Microscope

These pictures are taken from a Scanning Electron Microscope (SEM). This microscope uses electrons to help form an image instead of light-as in your light microscopes. The SEM bombards a specimen-like these bugs-with a steady stream of electrons that are focused into a very tight stream that sweeps back and forth (rasters) across the specimen. This stream of electrons then hits the specimen and this in turn causes the specimen to release some electrons called secondary electrons. These weaker secondary electrons are then used to form an image. There's more to it than that-but that's enough to get started with understanding how it works and looking at the images.

This lab can be downloaded from the RET@ND Website. (www.nd.edu/~ndrets)

Answer the questions on lined paper or word process. There are a number of terms that may be unfamiliar to you-look them up. ☺

What do you notice about these pictures? Name at least five different things.

Answer: Possible answers-they are black and white, they look three dimensional, there is some writing at the bottom of some of the pics, they differ in magnification, they have a different scale that is shown at the bottom, etc.

1. How are these pictures different from what you see when you look through your light microscope?
   Answer: not color, don't see through it-not a cross section, looks three dimensional, etc.
2. What is the top magnification of this set of pictures?
   Answer: Picture 5 Green bug eyes 0.60kx = 600x
3. What is resolution? What determines the resolution of a microscope? (Lots of things can help or hinder resolution-what's the main thing?)
   Answer: Resolution is the ability to tell two points apart as separate things. In electron microscopes, you use magnets to focus the stream of electrons to get higher resolution.
4. Find five other electron micrographs of insect/arthropod eyes. Save to a word file and print them. Be sure to copy the name of the website by each picture. Some sites don't want their pictures to be copied-please respect their wishes-many don't mind if it is for educational uses.
   *What is the same/different among different types of insect/arthropod eyes? (Are they compound eyes or simple eyes, are the numbers of ommatidia different, the shape, are there hairs, etc…) Name at least four similarities/differences.
   Answer: Students should save their picturess to a word file-label them and then answer the questions based on those pictures. I ask my students to cite their sources – this is one of their early assignments as freshmen-and I want to develop the skill of how to give proper credit for using work. We will then learn how to use APA citations using the information they have collected. (My freshmen do this with our media specialist or librarian-and talk more about when and how you cite a source. If they don't get the right info-they have to find it again and get it right. It is expected then that every time students use others' work that they will cite it.
5. Determine the size of the green bug eye, ant eye and monarch butterfly. Draw a picture of the relative size of these eyes to each other. (Yes, that means you will have to determine the scale of the eye size and sketch and label which eye is which.)
   Answer: I take these photos and project them on a wall-that enlarges the view enough for students to use a meter stick. Not necessary-but makes it easier for the students to see and measure. Get these pictures from the website-and any others you want as well.
   Lynda Smith
   Lakeshore High School Lakeshore, MI

This lab can be downloaded from the RET@ND Website. (www.nd.edu/~ndrets)

Submitted by
Teresa Pariritz
South Bend, IN

In A World of Flies…..

Introduction:

L.B. Slobodkin defines population genetics as a "complex of mathematical models in which selection, mutation rates of various kinds, linkage patterns and assumed population distributions and mating systems produced changes in gene-frequency distribution with the passage of time". (2003)

The following background information is a synopsis of the article *Theories of Speciation,* by Hope Hollocher.

Understanding how one species splits into two (speciation) is key to understanding evolutionary biology. First, however, one must define *species*. It must be noted that there is no single, universally accepted definition, and that most are a function of the types of questions being pursued. The inherent problem of trying to categorize groups of organisms undergoing a continual process of change must also be considered. It must also be acknowledged that speciation is not caused by a single mechanism, but by a collection of different mechanisms of divergence affecting different traits at potentially different rates. As a result, boundaries that encircle these natural groups are often blurry. Depending on which process is being emphasized, the actual definition may vary based on circumstance. In most cases, conflicting boundaries are not so much a problem of competing species definitions, as they are a reflection of the biological processes that govern speciation.

One criterion used to determine species is the Morphological Species Concept, which simply states that groups that look different are different species. This is typically used as a starting point for identification; however, a problem arises when you are working with cryptic species (those that look the same but have different gene pools due to reproductive isolation, or those with the ability to change phenotype based on environmental conditions). The Phenetic Concept, which states that morphological difference are usually accompanied by genetic differences, is typically considered along with the Morphological Species Concept

A second species concept is the Biological Species Concept (BSC) put forth by Dobzhansky and reiterated by Mayr (1937 and 1982, respectively). The BSC states that speciation is the development of biological barriers to gene flow between the multiple gene pools (interbreeding groups are reproductively isolated from other groups). Barriers include both the premating (seasonal, sexual, and mechanical isolations) and postmating (inviable or sterile offspring) sort.

While there are other species concepts to consider, for practical purposed I will limit the content to these two. Within the context of these, however, one must also consider evolutionary forces, modes of speciation, and genetic patterns of differentiation.

Evolutionary forces, such as natural and sexual selection, genetic drift, and mutation, can work independently or in concert within specific geographical, ecological, behavioral and genetic contexts, the extent to which can significantly impact variation. For example, natural selection can serve to both cause and prevent change if one part of a coadapted gene complex is not exactly the most fit. Any change here requires a population to experience a decline, both in fitness and population, before obtaining a better optimum fitness. While genetic drift is random, without immigration or mutation, variation may actually decrease. Populations may actually respond differently to genetic drift in the absence of natural selection, resulting in an altogether unique divergence. With sexual selection, adaptations tend to revolve around mating purposes rather than environmental conditions. And finally, mutations are the primary source of genetic variation. Most spontaneous mutations decrease fitness and/or are bound by DNA properties making some changes more common. As a result, one needs to consider whether the mutation has an impact on phenotype and/or fitness, since allele frequency changes depend on whether or not the allele is already at a low frequency.

Various combinations of the above four forces give rise to numerous modes of speciation (such as allopatric v. peripatric speciation), most of which incorporate the action of all the evolutionary forces discussed above, accentuating the operation of certain forces over others.

Allopatric speciation considers the physical barriers that prevent gene flow between populations (gene pools) which may diverge and be different on either side of the barrier, but may still be under the influence of mutation, genetic drift, and sexual selection. Rates of divergence caused by these various forces, and which traits may most easily be affected can be explored. The outcome depends on the circumstances of the isolation.

Peripatric speciation (founder's effect) focuses on actions between genetic drift and natural selection or sexual selection early in speciation. It is possible that peripatric speciation may occur more rapidly than allopatric speciation due to large population size; however, the actual size of the population does not affect probability of changing fitness as much as the underlying genetic architecture may. Genetic drift and natural selection may work to affect divergence when traits with high epistasis (interaction between different alleles at two or more loci such that the phenotype differ from what would be expected if each locus acted independently) are involved. Also, reproductive isolation can be significantly affected by rapid change because of male/female coevolution when genetic drift and sexual selection are both driving divergence.

Ultimately, analyzing the genetic basis of traits having diverged between species could be useful in determining whether genetic patterns of change can tell us about the evolutionary forces that had a role in divergence. Although very early in speciation research based on genetics, some models have already begun to take form. One such pattern is Haldane's Rule. In 1922, Haldane's observations led him to conclude that "When in the F1 offspring of two different animal races one sex is absent, rare or sterile, that sex is the heterogametic sex." The rule is true for males as well as females, and appears to be fundamental to speciation in all taxa. Explanations, however, depend on whether or not hybrid inviability or sterility is being considered.

In conclusion, the study of speciation can no longer be considered a singular entity. It must be considered along with and in terms of population genetics, molecular and developmental biology. They need to be fused coherently in order to offer possible explanations where no simple ones exist.

This lab can be downloaded from the RET@ND Website. (www.nd.edu/~ndrets)

Variations in the Concentrations of Different Fresh Water Organisms in a Column of Lake Water
(First Lab Activity of the School Year)

Introduction (Revise, enlarge and rephrase an Introductory Section)

Earth is home to a wide diversity of living plants and animals. Although biologists have been studying living organisms for hundreds of years, some basic questions still remain to be answered. In uncovering concepts, students critically investigate arrays of objects and events and seek their common attributes, often called "hidden likenesses." In finding these hidden likenesses students uncover the unity among living organisms. Questions like the following lead to our understanding of living organisms. How are organisms distributed over the surface of the earth? How do nonliving factors affect living organisms? Why do different organisms occupy different niches?

General Procedures The general conditions in which you will be conducting this investigation are – a 500 ml graduated cylinder (40cm high) was filled with lake water 8 hrs. ago. Using a clean pipette, remove 2 ml of water from 3 different regions of the cylinder. (Record the depths of the water samples.) Place water drops on three clean slides. Add cover glasses and observe under 100X magnification. Sketch, label and count the different types of organisms found in the different layers.

State a hypothesis
Identify independent and dependent variables.
What were the controls?
List materials used
List procedural steps
Collection of data
Calculate the number of organisms of each type/field of view. Move the slide a short distance and repeat the counts. Repeat these counts 5 times with each water sample.
Secure data from 5 other persons and compare their data with yours in a table.
Evaluate the data using measurements of Central Tendencies and Tests of Significance.
Discussion of Data and Results
Compare similarities and differences among the groups of data.
Suggest explanations for differences among the layers.
Form Conclusions
Discuss reliability of the data collection procedures and the results using stats and test of significance
Discussion of possible sources of error.

Submitted by Nevin Longenecker-John Adams High School-South Bend, IN

The Effects of Altering pH Solutions on the Germination Rates of Rye Grass Seeds

Introduction(elaborate, revise, rewrite)
While the pH scale is commonly known to measure the amount (or power) of H^+ ions (H_30^+) in a solution, pH can have a tremendous impact on the growth and development of plants and animals. These problems develop because H^+ and OH^- are very reactive on other molecules. The pH of bodies of water impacts the organisms that live there. If the pH rises too high or falls too low it could result in massive fish kills, algal blooms, a drop in oxygen content in the water and ultimately devoid the lake of all life. Young, immature cells tend to be more sensitive to pH changes in their environment.

Materials
4-Small plastic petri dishes, filter paper disks, rye grass seeds (25/dish), 0.1 M HCl solution, 0.1 M NaOH solution, pH meters, pipettes, make different dilutions of the HCl and NaOH solns and use 25 drops of the solution in each Petri dish, small beakers to make 2 acidic solution and 2 alkaline solutions

Variables
The independent variable was
The dependent variable measured was
The controlled aspects of this experiment were

State a Hypothesis

List Procedural Steps

Collection of Data at +48 hrs and +72 hrs
Evaluate the data using measurements of Central Tendencies, Standard Deviation units and Tests of Significance.

Discussion of Data and Results
Compare similarities and differences among the groups of data.

Suggest explanations for differences among the dishes.

Form Conclusions
Discuss reliability of the data collection procedures and possible sources of error.

Submitted by Nevin Longenecker-John Adams High School-South Bend, IN

An Inquiry Based Experiment on Natural Selection to Follow Up a Bacterial Transformation Kit Lab

(Once Transformed, Always Transformed?)

Introduction & Objectives

Teaching about the process of transformation in bacteria has been made easier with the availability of kits that include all the background information, materials, and procedures necessary in one relatively small box. Both Carolina Biological and Edvotek market a variety of transformation kits. Lab equipment such as water baths, Bunsen burners, incubators, micro-tube holders, and beakers are also necessary, but most labs have these, or there are simple ways to improvise. For example, if a classroom does not have an incubator, cultures can be left to incubate at room temperature for a slightly longer period of time. These kits utilize well tested protocols so students can successfully transform bacteria. However, these kits can also be used to create an inquiry-based activity that ties into natural selection.

Materials & Plan

A good kit to use is one that utilizes a plasmid with an ampicillin resistance gene and a color marker gene such as β-galactosidase, which produces blue colonies (Edvotek pGAL kit or Carolina pBLU kit). From this particular kit, students are able to transform and grow bacteria that are resistant to the antibiotic, ampicillin, and which produce colorful blue colonies when grown on media with X-Gal.

Once students obtain these colonies, the lab experience does not have to end. This lab can be extended by asking students the following question. “Once bacteria are transformed, do all their descendants maintain and keep these new traits?” In other words, “Once transformed, will bacteria always be transformed?” The transformation kit lab takes on a new objective from this point. Students can design a controlled experiment to answer this question.

Extra sterile Luria broth, Luria broth agar media, ampicillin, X-Gal, and sterile petri dishes, like the ones used in the kit, are necessary for the students to design their experiment.

Pre-lab

The post-lab for the transformation can lead directly into the pre-lab for the extension. For example, assuming the transformation lab was successful, the students should be able to explain properties plasmids must have to be useful in biotechnology:

- Why selection genes?
- Why color marker genes?
- Why restriction sites?

At some point, the teacher poses this question to the students. Are these transformed bacteria permanent? In other words, if these bacteria are allowed to continue to multiply

and grow, will all the future bacteria maintain their new traits or will they lose these traits over time? The discussion can include the following:

- If plasmids are useful to bacteria, why don't all bacteria have plasmids?
- What are the benefits and disadvantages of plasmids to a bacterium?
- What role does the environment play in shaping the traits of bacteria?
- Do bacteria with plasmids multiply at the same rate as bacteria without plasmids?

Eventually, the teacher asks the students to write a hypothesis to the original question: Will transformed bacteria remain so in future generations?

Lab Activity

Using the same kinds of materials from the transformation kit, the class can design a controlled experiment to test their hypotheses.

For example, students might use a sterile inoculating loop to streak transformed colonies onto three different plates: a plain Luria broth plate, a Luria broth plate with X-Gal, and a Luria broth plate with ampicillin and X-Gal. Incubate the plates overnight at 37˚C, or 48 hour if at room temperature and record results.

Another possible protocol might be to use a sterile inoculating loop to transfer transformed colonies to two different culture tubes of sterile Luria broth, one treated with ampicillin and one without. After incubating overnight (at 37˚C if possible), plate 250 μL of each culture on three different agar plates; Luria broth agar, Luria broth agar with ampicillin, and Luria broth agar with ampicillin and X-Gal. Incubate the plates overnight at 37˚C, or 48 hour if at room temperature.

Post Lab

The results students observe will depend on the design of their experiment, but it is highly likely that some of the new bacteria will no longer carry a plasmid if the laws of natural selection hold true. Transformed bacteria grown on media with ampicillin have a decided selective advantage over bacteria without the plasmid. But will transformed bacteria continue to replicate their plasmid if there is no selection pressure? Replicating the plasmid takes added resources and time, so there may be a time when a transformed bacterium is better off not replicating the plasmid, or even "throwing out" the plasmid during the replication process. Thus the transformation experiment has become an experiment on natural selection.

Bryan Smith
LaLumiere School
LaPorte, IN

This lab can be downloaded from the RET@ND Website. (www.nd.edu/~ndrets)

Submitted by
Kathleen Feltz
LaPorte High School
LaPorte, IN

Bayes'Theorem and DNA Testing

Topic: Bayes' Theorem w.r.t. DNA Fingerprinting **Grade Level:** 10 – 12
Objective: Use the specificity and sensitivity of DNA fingerprinting along with Bayes' Theorem to determine the reliability of DNA fingerprinting.
Prerequisite: Understanding of conditional probability
Time: 40 minutes

Introduction

The purpose of this activity is for the students to understand the parameters that affect the reliability of a test, specifically if it is to be used as evidence in a legal matter. They will use conditional probability to determine this reliability. Also, they will use Bayes' Theorem to calculate impact these tests should have on convicting a suspect.

Discuss with Students

Forensic scientists have worked for many years in perfecting the process of DNA fingerprinting. Even though they have refined the process, the test is not infallible. The use of DNA fingerprinting has been used successfully in court cases to aid in the conviction of criminals, but how reliable are the results? Should the results have a bearing on the decision of the jury?

DNA fingerprinting has undergone many improvements in recent years. Each improvement strengthens its reliability. There are two types of errors with this type of test. The first is when there really is not a match and the test indicates there is a match. This is called a false positive. The other type of error is when there is a match and the test indicates there is not one.

The following table indicates the various possible outcomes of the testing:

	ACTUAL	
TEST RESULT	**MATCH**	**NO MATCH**
MATCH (POSITIVE)	**$Pr(P \mid M)$**	**$Pr(P \mid M^c)$**
NO MATCH (NEGATIVE)	**$Pr(N \mid M)$**	**$Pr(N \mid M^c)$**

The formulas for sensitivity and specificity are given below.

SENSITIVITY

$$\frac{Pr(P \mid M)}{Pr(P \mid M) + Pr(N \mid M)}$$

The **higher** the sensitivity of the test, the **fewer** false negatives there are.

SPECIFICITY

$$\frac{Pr(N \mid M^c)}{Pr(N \mid M^c) + Pr(P \mid M^c)}$$

The **higher** the specificity of the test, the **fewer** false positives there are.

Questions may be directed to Kathy Feltz: kathyfeltz@yahoo.com

Representative Open Ended Laboratory Investigations

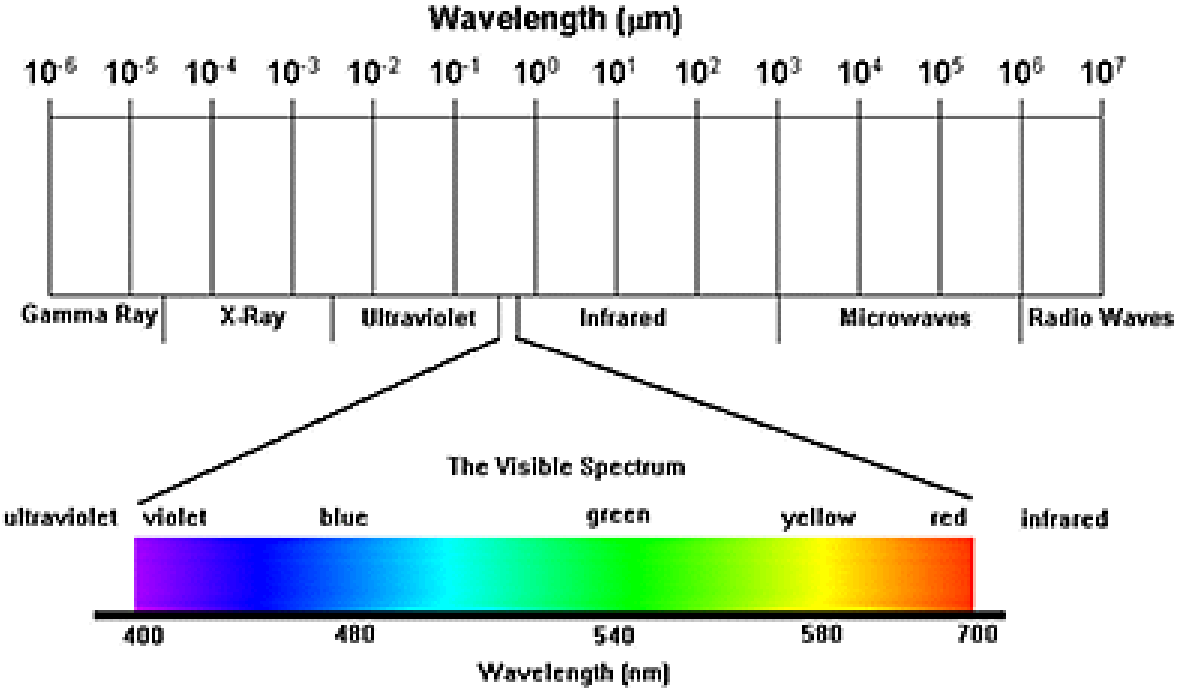
ND-RET2009 Flame Test of Chemicals

(Kit by Neo Sci #20-1693 Cost $127.98 @www.neosci.com)

The use of experimental kits can assist a teacher in explaining certain concepts. The use of flame spectroscopy has its roots in medieval alchemy. Why are fireworks different colors? Let's find out!

As a result of differing numbers of protons in each element the electron configuration of each atom differs in the number and location of its electrons. It turns out that if you excite an atom, for instance applying heat, the electrons move up to higher energy levels. (Quantum Number) As the energy dissipates these electrons radiate energy returning to their ground state. As nature would have it some of these energy changes produce specific visible light.

Newton divided the spectrum into seven named colors: red, orange, yellow, green, blue, indigo, and violet (**ROY G BIV** *old school*)



Source of above visual (http://www.daviddarling.info/encyclopedia/V/visible_light.html) 8/01/2009

The stated kit objectives:

- Observe and record the colors emitted by metallic elements upon heating
- Relate the results to known standards to identify unknown samples
- Learn about the electronic structure of an atom
- Explore the relationship between color and energy in the electronic spectrum

Representative Open Ended Laboratory Investigations

The paperwork that comes with the kit can be used right out of the box.
A phone number is provided for questions and support. The kit contains "homemade" spectrometers which can be used by more mature students. They do work and the spectra lines are visible. I would recommend spending the extra money for commercially available spectrometers which provide actual wave length scales.

The kit uses metal chlorides ($CaCl_2$, LiCl, KCl, NaCl, and $SrCl_2$) to produce the various spectra. No mention is made of the production of chloride gas (toxic) during the exercise. If ventilation is available it should be used. Normal safety precautions should be exercised. (Gloves, Goggles, Apron) I have seen this done with solutions containing the salts. In this experiment the chemicals adhere to the nichrome wire loops by dipping in distilled water and then into the crystalline salts prior to putting into flame. To adequately see the spectra decrease light intensity as much as you feel safe with, or is possible. Having different types of lights also produces varying spectral lines. An incandescent will provide you with a continuous spectra, as does the Sun without blinding the students. Florescent will produce a mercury spectrum; think about why these lights are not as green as you have been told. Sodium lights are common for many parking lots with their distinctive orange color. Neon lights containing various gasses and coatings are another great source. Got some LED's give them a try!

I will leave you with some thoughts from other teachers concerning this laboratory kit:

"This would be a good lab for chemistry students. I will most likely transfer this into a Demo Lab for my Integrated Chem/Physics class." Rich

"I would think this kit would be excellent for a chemistry teacher looking to save time. Rather than have to collect flame test material, everything is right there. Also, the kit would complement a qualitative analysis lab." Bryan

"While I can see and appreciate the value of this lab, I am wary of the frustration level some students may encounter. Some results were very difficult to distinguish...but if you can eliminate most all outside light sources, it might yield better results." Teri

"This is a good lab for setting up an unknown lab based on different chemical 'known tests'. I would eliminate the spectrometers though unless you have good ones and just concern yourself with the actual flames. Other chemicals that have good flame colors are barium chloride, and copper(I think, II) sulfate. Fun lab. When we have eighth grade visitation days, we use this one when they sit in on a chemistry class. They love that they get to wear goggles and play with fire." Deb

For additional information or your comments visit
http://peterka.wikispaces.com/RET+2009+Molecular+Bio.

Representative Open Ended Laboratory Investigations

The Case of the Silent Sentinel Lab

Evaluated by Carrie Bidwell (Clay High School)

Product Information

- **Inquiry Investigations™ The Case of the Silent Sentinel Lab**
- Frey Scientific
- $79.95
- Includes 5 forensic lab activities
  1. Toxicology Analysis
  2. Chromatographic Analysis
  3. Fingerprint Analysis
  4. Document (Handwriting) Analysis
  5. Blood Analysis

- **This lab would be useful in either a DNA or a Genetics Unit. It could also be a cross-unit lab to connect DNA to Genetics.**

The Case

In this lab your students are part of a forensic team that has been assembled to determine if a crime has been committed. The "crime" involves a fictional murder in which the teacher constructs the evidence for prior to the class. The main piece of evidence in which this lab is centered around is a body found next to a bottle of poison. The identity of the victim is determined by the teacher. Each of the five tests included in this kit will provide scientific findings or facts that will help you determine if a crime was committed and who the primary suspect(s) might be.

Various Clues Also Observed at the Crime Scene

1. A suicide note was found near the body. The teacher provides a photocopy of this letter in each group's Evidence Folder. The original is in police custody (teacher has the copy) and can be subpoenaed for chromatographic analysis and document analysis.

2. Near the note a pen, know to be the victim's was found. It has been put into police custody. The pen can also be subpoenaed for chromatographic analysis.

3. Fingerprints have also been recovered at the scene. Forensic technicians have lifted four latent (hidden) fingerprints from the poison bottle. These latent fingerprints have been grouped on a Fingerprint Evidence Sheet and placed in your Evidence Folder. The fingerprints are used for the fingerprint analysis.

4. Blood is also found near the body. "Tests" done prior to the students arrival to the crime scene confirm that drops found where the body was discovered are human blood. This blood is used in the blood-type analysis.

5. The students are given a urine sample from the victim to use for the toxicology analysis. The students will determine if poison was present in the victim's body. The bottle of poison is in police custody so students must also subpoena the poison to compare results.

- **Materials Provided**
  -Anti- A serium (simulated)
  -Anti-B serum (simulated)
  -Blood typing trays
  -Chromatography vials
  -Chromatography paper strips
  -Finger printing cards, inkless
  -Magnifying glasses
  -Medicine cups
  -Poison test strips (simulated)
  -Rulers
  - Samples
  -Poison (simulated)
  -Urine (simulated)
  -Blood (simulated)
  -Striring stick- blue and yellow

- **Materials Needed but not provided**
  -Envelopes (10)
  - Paper towels
  - Pencils

-Permanent marking pen
-Transparent tape
-Goggles (suggested)

Lab Evaluation

Forensics is a high interest topic and this lab will appeal to teacher and student alike. This lab activity itself is very engaging and will very easily lead to classrooms discussions about the processes "real" forensic scientists use.

From a teacher's standpoint, this lab involves some time to initially set-up. The lab instruction manual lists the amount of time it takes to prepare each of the five parts. After the initial assembly of the lab is complete however, this same "crime" scene can be used in future classes. In fact, teachers may want to change the results of the "crime" between classes to vary results . Also, once the lab is created, most of the work is student driven. Students have to work with minimal teacher assistance to run the different analysis activity and most of the work is inquiry based. Students must complete all of the forensic tests in order to create a clear picture of the evidence. Upon completion of this lab, it is recommended to have the students write formal lab reports to present their findings.

Murder at Notre Dame
DNA Fingerprinting
Presented by: George Azar
(A murder mystery: Flinn Scientific Inc.)

Background:

DNA Fingerprinting is relatively new to the field of Biology. The concept behind the procedure is looking at specific sequences of DNA base pairs between a sample DNA segment and possible suspect's DNA samples. Normally the entire DNA sequence is started with and then cut with restriction enzymes to isolate specific sequences to compare.

Purpose:

The purpose of this lab is to look at the process of DNA Fingerprinting from the stance of a forensic scientist.

Activity Scene:

- Nevin Longenecker was murdered on the football field during the run through for his honorary doctorates from Notre Dame. This gruesome

murder is being investigated by 3 teams. These teams are the foremost experts in the field of DNA fingerprinting. YOU are a member of one of these teams! There are 3 suspects who have been identified for this particular murder:

- Suspect 1: Dr. V
- Suspect 2: Charlie Weiss
- Suspect 3: Mike Brey

Procedure:

1) Construct DNA – each member of team is responsible for a specific person's sample.
2) Use Restriction Enzymes – cut DNA at sites identified by NoRoI and NoRoII.
3) Use Gel Electrophoresis – use template gel and separate DNA segments by base pair size.

After working through this lab with a group of teachers, several suggestions were made to enhance the students' learning potential. The following were some suggestions:

- Create a demo model of the DNA molecule the students will create to give them a frame of reference.
- To save some time, exclude the 5' → 3' strand which will eliminate the use of Hydrogen bonds that are small and tedious.
- Differentiate the DNA strand that will be created per lab station. This will eliminate communication between groups.
- Mark/Identify the first 3' → 5' bead to avoid flipping strand.
- These models can be used in looking at the processes of transcription as well as translation.
- The green beads should be Guanine.
- Rather than using small beads, small tab sticky notes of various colors could be used.

Representative Open Ended Laboratory Investigations

Using Gene Chips to Study the Genetics of Lung Cancer (A DNA Microarray Lab)

Evaluated by Teresa Pairitz, Marian High School, Mishawaka IN; ND RET Molecular Workshop, 2009.

Carolina Biological
DNA Chips: Genes to Disease (#211520 $49-$82)

No significant materials are needed prior, except a hot water bath or microwave to keep the agarose reagents liquefied; most schools have this readily available.

Per the *Teacher Instructions*, the primary purposes of this investigation are to teach the following:

1. gene chips (DNA microarrays) are a powerful new technology that scientists use to measure the activity (transcription) of thousands of genes at one time;
2. microarrays highlight important connections between genetics, cell biology, genes, DNA, chromosomes, gene expressions, transcription, cancer biology, proteins, technology and bioethics;
3. genes are differentially regulated: all cells in an organism contain the same genes, but different genes are expressed (transcribed) in different tissues under different conditions which is what gives different tissues their different phenotypes;
4. and even genes that are not highly expressed (transcribed) may play an important role in the cell and that the lack of expression of a gene may also play an important role in the cell.

Microarray analysis is a powerful new research tool that enables technicians to view and interpret at one time, on one small surface, the extent to which thousands of genes have been expressed in cells. Researchers developed and continued to refine the technology by merging strides in genomics, computer science, and nanotechnology.

Detecting patterns or changes in transcription in cells is a way to understand both normal and abnormal aspects of cell function. A researcher who wanted to look for changes in transcription in a specific cancer gene could use microarray analysis. As the first step in the process, a gene chip would be created. DNA chip, microarray, gene chip, and genome chip are all terms that describe a solid matrix, such as a glass slide, that is imprinted with a precisely arranged pattern of spots, each made up of many copies of a specific nucleotide representing part of genome.

As the next step, the DNA chip would be used to analyze complementary DNAs (cDNA) that were made from mRNA isolated form cancerous and noncancerous parts of the same tissue. The cancerous and noncancerous DNA samples are flagged with dyes and applied

to the prepared chip. The extent to which each flagged gene adheres to its complement on the chip directly indicates the extent to which transcription occurred. Computer analysis of the DNA chip reveals which genes were transcribed in the cancerous tissue and which in the normal tissue, and thus indicates which genes might be important in the development of the cancer. The use of a microarray in this application allows suspect genes to be identified years sooner than would have been possible with previous technologies that were unable to analyze so many genes so precisely at one time.

A single microarray can contain more than 30 000 spots of DNA, each representing a different gene in an organism. In this investigation, the concept of a DNA microarray is used to study the expression of six different genes in normal lung cells and lung cancer cells. These results will show how these six genes are transcribed in normal versus cancerous lung cells. Students will use reagents that simulate the process, composed of various combinations of basic indicators in an agarose solution.

Scientists have found that some genes are not transcribed as much in cancer cells as in normal cells. These repressed genes may play an important role in allowing the cancer cells to spread and grow. Other genes are transcribed more in cancer cells than in normal cells. These genes may also play an important role in making the cells cancerous. There are also many genes that are transcribed at the same level in both cell lines. These genes probably do not play a significant role in causing cells to become cancerous. There are also some genes that may not be expressed at all in normal or cancerous lung cells. It is important to have a discussion with students prior to the lab that cancerous effects can be caused by both over- and under-expression of certain genes, and that some genes on being tested may fall into either “housekeeping” or specific to cell type, in which case they would express differently.

Limitations

The primary limitation was that the protocol, as followed, provided the same results to each student group. As a result, student understanding and execution of the protocol is difficult to evaluate, as is their overall understanding of the underlying concepts. Changes considered for the next run included simply changing the gene numbers on the droppers. However, after a brief online search, the reagent combinations were located and it was decided that new stock solutions would be produced with new combinations of the two primary indicators (phenolphthalein, thymolphthalein), agarose and water (and/or student groups would be given different combinations). This then insures that each unique student group will have a unique set of results, known only to the instructor, and making evaluation of student understanding more authentic. With this change, the door is open to bring in scenarios other than cancerous versus normal lung cell genes, and students can then further investigate the function of those genes to determine whether or not they would have a role as a disease agent. OR—with unique student group results, each group would be given the task of testing for activity within a specific group of genes for a possible diagnosis. This investigation shows students practical application of

current work, and allows further investigation of how using gene activity information could potentially lead to a treatment. Students would need to be provided information regarding gene expression in different diseases in order to make such determinations.

When this kit was modeled with peer teachers, the general impression was such that while the results were good, the concept would be more appropriate for advanced level classes rather than a regular level biology class. My experience with a regular (freshman) level biology class was such that most students did have a basic grasp of the idea and were able to read the results accurately, more time needs to be dedicated to the discussion of gene expression and how they can impact phenotype.

Possible Alternative Diseases

High Grade Astrocytoma:
Nine genes are known to be dysregulated: 4 ribosomal proteins are upregulated, 5 other genes were downregulated. One, APOD, was the most differentially expressed and has been shown to inhibit tumor cell and smooth muscle cell proliferation, suggesting that APOD might be critical for malignancy, and therefore a possible source for therapy.

MacDonald TJ, Pollack IF, Okada H, Bhattacharya S, Lyons-Weiler J. "Progression-Associated Genes in Astrocytoma Identified by Novel Microarray Gene Expression Data Reanalysis." *Microarray Data Analysis: Methods and Applications*. (5/2007): 203-221.

Retinoblastoma:

RB1 Gene Microarray Gene Expression Data Reanalysis." *Microarray Data Analysis: Methods and Applications*. (5/2007): 203-221.

Retinoblastoma:
RB1 Gene is a tumor suppressor gene and is typically downregulated in retinoblastoma, and therefore allowing retinal is a tumor suppressor gene and is typically downregulated in retinoblastoma, and therefore allowing retinal cells to divide uncontrollably.

(http://ghr.nlm.nih.gov/condition=retinoblastoma)

Representative Open Ended Laboratory Investigations

RET Molecular Biology Session
An Evaluation of "What is An Epidemic and How Does Infection Spread"
Shelly Gregory
Adams High School

Distributed by Edvotek - $49

Purpose of the Lab

- This lab tracks how an infection transmitted through the exchange of body fluids spreads through a population
- Educators may choose any specific disease or leave it open ended and discuss the results with students after the lab is completed

Objectives

- Students will learn and implement simple lab techniques
- Students will keep accurate records
- Students will collaborate to determine with whom the disease originated

Materials Needed

- One data table
- One numbered test tube with 5ml of "body fluid" solution (one or two should have the "infectious agent" – this can be any solution that works with an indicator)
- Three empty test tubes
- One pipette
- Indicator solution
- Sharpies
- Test tube rack

Procedure

- Label the numbered test tube "self" - This represents your body fluid such as blood or saliva
- Carefully pipette one mL of solution from the "self" test tube into each of the three other tubes
- Randomly choose another student and "exchange fluids" – each person will transfer solution from one of their extra tubes into the other person's "self" tube
- Record the name of the person and the number on their "self" tube in the data table

- Repeat this procedure with two other students
- An indicator will be added to the "self" tube to determine who has been infected
- If your solution turns pink you ARE infected

Data Analysis

- Using the data that has been collected determine the following:
  - How many were originally infected?
  - Who is/are the student(s) who introduced the disease into the population?

Possible Discussion Questions

- How many students became infected?
- What implications do these results have for students? Teachers? Healthcare or other service industry professionals? (ie who is at risk)
- Why are some ethnicities at higher risk? (can talk about lifestyle, genetic "immunity" in some groups etc.)
- How can transmission be prevented?
- What other diseases are transmitted through body fluids?
- What is the mode of transmission for other diseases?
- How is prevention different for various types of disease transmission? Is one type easier to prevent?

Evaluation of the Kit

Positives:

- Good introduction to immune system/ health issues
- Short, simple activity
- Gets students on their feet & moving around
- Have to communicate/create graphic organizer to determine "patient zero"
- Easily reproducible
- Do not HAVE to buy in order to do the activity

Negatives:

- Lab protocol includes materials for only 8-10 students (class sample instead of entire class)
- Would need replenishing kit (or an extra supply of the chemicals) for each class
- A lot of test tubes to track; cumbersome for the students

Final Thoughts

- Use with entire class instead of just a small sample
- Use only one test tube instead four and have students use pipette to "exchange fluids" directly from "self" test tube – this is a truer representation of how an infection spreads

- Overall I like the kit. It is simple, requires minimal prep time and there is a lot of great discussion that can branch from the activity. There was also good background information that can be used in lecture before or after the activity.

The Use of a Dihybrid Indian Corn Cross to Reinforce and Foster Appreciation of Gregor Mendel's Work

Submitted by:
Louann Kensinger
James Whitcomb Riley High School
South Bend, Indiana

Introduction and Objectives: Indian corn is an excellent material for teaching Mendel's Laws. It has readily observable traits and a large enough sample size per ear to approximate Gregor Mendel's famous ratios, especially when class results are pooled. Carolina Biological Supply offers a kit (FA-17-6380: $139.95) that includes 15 segregating ears of purple/yellow, starchy/sugary dihybrid cross. They also offer a variety of other crosses such as red/white and waxy/non-waxy that can be purchased separately (for $8 or $9) and used as unknowns. The materials can be used over again for any number of years.

One of my objectives, apart from reinforcing Mendel's Laws, is to foster an appreciation of the hard tedious work that so often accompanies the brilliant flash of insight that makes the scientific headlines. Students will spend about 45 minutes counting and tabulating: Mendel spent his lifetime doing just that. In addition, it is a wonderful opportunity to point out that as a mathematician, Mendel thought in mathematical terms.

Background: Corn endosperm typically is either yellow or white. It has an outer layer called the aleurone which contains some protein. The aleuronic layer is surrounded by the outermost layer, the pericarp, which is transparent. Sometimes the aleuronic layer contains pigments which mask the color of the endosperm below, therefore any color other than yellow or white would be dominant.

Corn endosperm can also be either starchy or sugary. Sugary endosperm loses water to evaporation, causing a shriveled appearance. Starchy endosperm retains its rounded shape. Starchy is dominant.

Uses of this Activity: This activity can be used at just about any level from middle school to college. For younger students, the teacher could teach the unit first and then use the activity as a reinforcement. For more mature students, the teacher could lead a discussion centered around students' observations about the corn first, before revealing which alleles are dominant. In their teacher's manual, Carolina also includes an opportunity to conduct a chi square analysis of the students' data.

Representative Open Ended Laboratory Investigations

Lab Activity: Students work in pairs to tabulate phenotypes. Each team then posts their results on the chalkboard (see chart below). Once all data are in, students can calculate what the expected numbers would have been using the 9:3:3:1 ratio.

Phenotype	purple/starchy	purple/sugary	yellow/starchy	yellow/sugary	total
Actual count					
Expected					

Students should be able to reconstruct the genotypes of the P generation, the F1 generation, and the F2 generations.

What Conditions Influence Enzyme Activity?

Deb Semmler St. Joseph's High School

dsemmmler@saintjoehigh.com

As a biology and chemistry teacher, I am always on the look out for labs that will visually demonstrate concepts that I am trying to teach in the classroom. One of the sticky subjects for my students involves catalysts and enzymes. As a result, a couple of the lab kits that I chose to evaluate center around enzymatic activity.

The Kits

The first lab kit was purchased from Ward Scientific. The kit (*What Influences Enzyme Activity?)* sells for $56.95 (with a refill kit of $34.95) and contains enough material for a class of 30 in groups of two. This kit will be extremely useful in helping students understand the conditions necessary for optimum enzyme activity. Variables are changed with regard to temperature, pH and enzyme concentration in order to determine the optimum conditions for enzyme performance.

The second kit was also purchased from Ward Scientific. The *Organelles* kit sells for $67.00 and likewise contains enough materials for 30 students. One of the activities in this kit demonstrates how a cell organelle would catalyze a reaction using dialysis tubing and the enzyme *catalase* that is found in potatoes. The lab calls for short stretches of dialysis tubing to be stuffed with a potato 'slushie' made by processing a potato with ice shavings. The flimsy potato tubes are then placed in a hydrogen peroxide solution where two different enzymatic reactions will occur causing the tube to expand and the color of the potato to darken.

Representative Open Ended Laboratory Investigations

Background

Catalysts help to control the rate of chemical reactions by either speeding them up or slowing them down. Although they are an important factor in the ability of a chemical reaction to take place, they are unchanged and therefore a small amount of catalyst can be used and reused in a reaction.

Enzymes are protein molecules that act as catalysts of biological systems. They are, however, extremely specific and tend to act on only one substrate (the substance altered by an enzyme) changing it to only one product. This is called the 'lock and key' model and the human body uses hundreds of enzymes to regulate bodily functions. A variety of enzymes are used to catalyze the chemical reactions involved in digestion. Some of the digestive enzymes utilized by the body are:

- ***lactase – breaks down lactose (milk sugars)***
- ***diastase – digests vegetable starch***
- ***sucrase – digests complex sugars and starches***
- ***maltase – digests disaccharides to monosaccharides (malt sugars)***
- ***pepsin – breaks down proteins into peptides***
- ***peptidase – breaks down small peptide proteins to amino acids***
- ***trypsin – derived from animal pancreas, breaks down proteins***
- ***lipase – breaks down fats found in most dairy products, nuts, oils, and meat***

Factors that affect enzyme performance

Some of the factors that influence how an enzyme performs in a given situation include how much of the enzyme is available (enzyme concentration), as well as the temperature and pH conditions the enzyme is working under.

At a constant concentration of enzyme, the reaction rate increases with increasing substrate concentration until all of the available enzyme is joined with substrate. The reaction rate is maxed out and adding more enzyme or substrate will have no further effect on the rate.

Since the lock and key principle is dependant on the shape of the enzyme molecule and its ability to fit together with the molecule of the substrate, anything that affects that shape affects the rate of reaction. Since enzymes are proteins they are highly dependant on changes in temperature and pH.

As the temperature is raised or lowered, the shape of an enzyme is altered slightly. As a result of this change in shape, it can become either more or less effective as it may fit together better or worse with the substrate. This gives the enzyme a range of temperature where it can effectively facilitate the reaction. There is also a maximum temperature, above which the enzyme is denatured, or deactivated.

Like temperature, enzymes are very sensitive to changes in pH. The acidic and basic ions, which have varying concentrations as the pH of a solution changes, react with enzyme molecules. These reactions change the shape of the enzyme much like a change in temperature does, with similar effects on enzyme activity.

The Lab

In this lab, students investigate the activity of the enzyme diastase, and examine the effects of enzyme concentration, temperature, and pH on the ability of diastase to digest starch. Starch is a common nutrient used by many organisms, yet it is insoluble, and cannot be effectively absorbed. It must therefore be broken down to sugars, which are used to produce energy in living systems. Although this reaction would occur on its own, the time it would take to occur spontaneously is so prohibitive that it is not a possibility for organisms. *Diastase* is an enzyme that facilitates this conversion of starch to sugar and will be used in this lab to demonstrate the principles of enzyme activity.

Procedures

To determine the effect of enzyme concentration, students are given a spot plate where they add a drop of diastase to wells containing a starch solution. Every thirty seconds they test for the presence of starch (with an iodine indicator), recording the amount of time it takes for the diastase to convert the starch into glucose. They repeat the experiment with differing amounts of diastase and graph the effectiveness of the varying concentrations.

To determine the effect of temperature on enzyme performance, the diastase is kept at four different temperatures (0-10 degrees C; 20-25 degrees C; 35-45 degrees C and near boiling at 90-100 degrees C) with the help of ice baths and hot plates. Students then test the enzyme effectiveness with iodine indicator.

The final part of the lab will test using the enzyme in solutions in which dilute hydrochloric acid or sodium hydroxide has been added.

Kit Evaluation

The basis of the kit is a good one although for use in the classroom I would change a few things.

The student directions are a bit confusing. I will rewrite these to make them a bit more user friendly. I would also change the order of the experiment as the concentration timing requires the most amount of time and will be the hardest for students to interpret. I would save this for last so that they have had enough time working with the other reagents to get a feel for the process.

Two problems that we encountered with the kit would also have to be addressed. The iodine solution that the company sent is far too concentrated. It will need to be diluted to about the color of strong urine in order for the reactions to show the proper color changes. We also found that the glucose test strips (for whatever reason) did not work. This is easily remedied by purchasing inexpensive diabetic glucose test strips from any pharmacy.

Finally, I would include a more open-ended approach with the students formulating their own hypotheses on how they expect the enzyme to behave under the varying conditions.

How I will use these labs

Using the second kit as a demonstration of how an enzyme works, followed by the adjusted first kit will be an effective tool in helping students gain a better understanding of enzymes. My department has already discussed and added this as a performance assessment in our Biology curriculum for use in our chemistry of macromolecules unit.

Introduction to Microbiology
(Frey)
Presented by: Emily Zablocki

Background

Where do Microorganisms come from? EVERYWHERE!!!! They are all around us; in this lab we will examine various microorganisms in the environment around us. This lab makes students aware of the microorganisms that are all around them, looking at them in basic forms.

Purpose

The purpose of this lab is to examine a variety of microorganisms in the environment around us and in varying environments.

Set-up

Representative Open Ended Laboratory Investigations

Student will examine microorganisms in many settings:

1. Microorganism found in soil under a microscope
2. Grow microorganism on agar using soil as a source of microorganisms
3. Grow fungi on tomato soup
4. Examine yeast cells under a microscope
5. To see yeast cells multiple over time
6. Examine algae and protozoa from pond water

Personal Opinion

This lab is not only a good introduction to microorganisms, but it also is an outstanding lab to emphasize lab technique and basic laboratory procedures. This lab is also beneficial because it is easily duplicable and has affordable materials. I plan to use this lab during my characteristics of life unit at the beginning of the year, prior to the ecology unit. I think this lab will easily and quickly show living things and the variety of locations they can live.

ND RET 2009 – Evaluation

Mark Wilson
John Adams High School
South Bend, IN

Rutherford's Atomic Interaction
"Atomic Target Practice"
*Adapted Flinn ChemTopic Labs –Atomic & Electron Structure Vol. 3

Background:
Earnest Rutherford came across the presence of "atoms" indirectly. Using an "alpha-cannon" to shoot alpha particles (Helium nuclei - 2+ charge) at a metallic foil, Rutherford noticed that the particles did not go through the foil, as expected. The fact that the particles scattered randomly, led Rutherford to believe that some "hard" core within the foil was present. He later concluded this core to be the "nucleus" of the atom (which he proposed was also positively charged) and the open spaces between the atoms, which allowed the particles to pass through the foil, was a "cloud" of sorts (electron cloud).

The Exercise:
With this exercise, the students are mimicking the experiment of Rutherford. As Rutherford was projecting alpha particles at unseen objects, the students will be rolling marbles at covered objects, and based on the paths of the marbles, the location, shape, and size of the object can be discovered.

Representative Open Ended Laboratory Investigations

Purpose:
The purpose of this exercise is to develop an understanding as to how interactions determine the existence of matter

Objective:
By indirect means, determine the size, shape and location of an unseen object using a rolling marble.

Materials:
- Cardboard/Pegboard box covers (Around 8.5” x 11”) *consider using box tops/edges
- Rubber stoppers (serve as supports) about an inch in length
- Various shapes (cubed, rectangular, triangular, cylinder, hexagonal, etc)
- Marbles/Steel balls
- Printer paper
- Pencils
- Glue
- Velcro Adhesives

Representative Open Ended Laboratory Investigations

Set up:
The apparatus consists of a 3-dimensional objects (cube, cylinder, triangular prism, etc.). A "cover" (cardboard, pegboard, some type of rigid, flat surface) is mounted upon rubber stoppers, screws, or other supports that are about an inch in length. On the bottom side of the "cover" attach the 3-D (the target) object. Attaching with small Velcro adhesives or with glue works effectively. Centering the objects is easiest for students to locate. A piece of printer paper will be needed as well.

Procedure:
The whole apparatus is given to the students WITHOUT them seeing the shape of the object. Using a pushpin, attach a piece of printer paper on top of the cover. Students are to roll the marble under the cover to hit the target. As the marble is rolled, the path, from when it entered to the cover to when exited the cover, is to be traced out on the printer paper. Rolling from different angles should provide the location, shape, and size of the object.

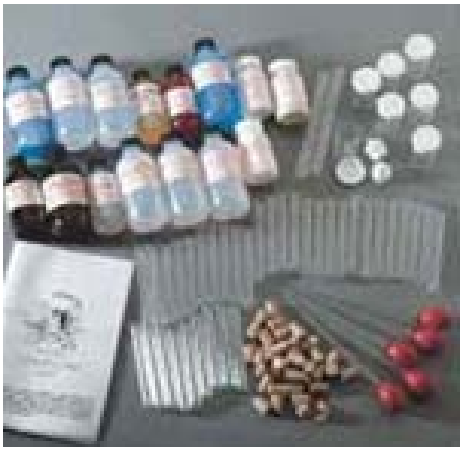
Follow-Up:
Students can prepare “whiteboards” or presentations of their findings, how they came about their conclusions, sources of error, and answer questions to help conclude the lab and tie in the concepts addressed.

Some Follow-Up Questions:
- Discuss if marble size compared to the target size could be a factor.
- Why is it important to trace ALL of the marble paths?
- How was the speed of the marble a factor?
- Provide some limitations/sources of error.

Helpful Hints:
- Attaching a “grass skirt” to each cover, that drapes down will help the concealing of the object as the set-ups are being passed around and used during the lab.
- Try to keep the height of the objects to an inch so as to keep a lower profile and more difficult to see.
- Provide examples on the board as to how a marble will be deflected if it hits a side at particular angles.
- Each group was given two marbles. Have extra is some are lost or do not roll smoothly.
- Using a pushpin to hold the tracing paper on top of the cover will keep the tracing paper in place.

Food Chemistry

Evaluated by Brenda Mueller (Elkhart Memorial High School)



Product Information

- Food Chemistry Module Lab Activity
- Ward's
- $129.95
- **Includes 8 food chemistry lab activities**
  1. Test for Fats, Starches, and Protein
  2. Fresh Fruit Discoloration
  3. The Composition of Milk
  4. The Presence of Iodine in Salt
  5. Calcium Propionate as a Bread Preservative
  6. The Qualitative and Quantitative tests for Vitamin C
  7. The Presence of Sulfur Dioxide in Dried Fruit
  8. The Presence of Iron in Foods
- **This lab kit can be useful not only in the Biology and Chemistry curricula but also in Family Consumer Science.**

Experiment #1: Test for Fats, Starches, and Protein

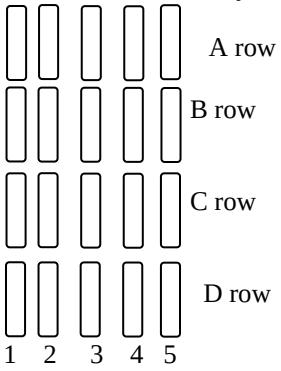
In this experiment the students are using a series of chemicals on a food product, or chemical solution to be able to visually see what type of macromolecule it is. The lab originally starts out with five groups, sugar, starch, vegetable oil, protein, and a control. These are what will be tested by each of the chemicals, Benedict's solution, Sudan IV, Buriet reagent, and Potassium Iodide solution. The lab will have the students handle each food product and chemical to perform in the correct procedure. This gives the students the lab skills needed as well as showing them the differences between each macromolecule. What can also be done is to give the students food unknowns to figure out using the tests. This gives more inquiry as well as changing the outcomes for each lab group.

- **Preparation:** All of the testing solutions need to be divided up for the groups. The kit only

comes with one bottle of each solution. Putting the solutions in separate bottles and having one for every other group would work out well. As well as preparing the food solutions. If using the chemical food samples that came with the kit, then a 4% dextrose solution needs to be made as well as Gelatin solution. If using unknowns then try and make them as colorless as possible. Placing them in separate containers with a code on the front that the teacher knows what food they are. Also testing these unknowns beforehand so the teacher knows what to expect is also a good idea. Some foods get multiple results, and knowing this beforehand can help the when trying to guide the students in their search.

- **Procedure:** There are multiple ways to set this lab up this is one that is useful.

  20 test tubes per group. In four rows, five columns. Label each test tube in that row with a letter, A-D for all four rows. Then label test tube in that columns with a number, 1-5 for all five columns. See below. That way the teacher can give each test a number, and when giving the unknowns the teacher will have a key that shows what the group's results should look like. This is just one way to set it up. The kit does not give a specific way to handle this many tubes and the labeling system is helpful when trying to keep the unknowns a secret. Otherwise would could just label the rows to what macromolecule they correspond with.



- **Materials Provided**
  -Test Tubes (20)
  -Eye droppers (3)
  -Sudan IV
  -Buiret Reagent
  -Potassium Iodide Solution
  -Dextrose Powder
  -Gelatin Powder
  -Vegetable Oil
  -Benedict's Solution
  -Starch/Acetic Acid solution

  Materials Needed but not provided
  - More Test Tubes (20 per group of 3 students)
  -Hot plate

-Test tube rack (1 per group)
-Food samples
-Distilled water (to dilute samples, tap could be used, but test results first)
-1ml pipettes (4)
- Bottles for chemical tests (recommended 4 for every other group)
-Containers for food samples
(as many as needed for the amount of unknowns per group, estimated 14 per class of 21)

Lab Evaluation

This single macromolecules kit could be completed without the entire Food Chemistry kit. The Lab manual that came with the kit is less than desired. The directions need to be modified, as well as the creation of analysis questions, and a data table. This could also be an opportunity for the students to create a formal lab report. Thankfully the wonderful collaboration efforts of our group have produced many ideas, as well as concepts of merging other labs to create a wonderful student manual for the section. This lab does involve teacher creativity as well as time to test the unknowns. Some ideas for unknowns what were brought up was, testing lettuce (or green water), egg whites, Knox Gelatin, potato flakes (plain), Apple juice, and melted butter. This is an amazing concept to add to the Biology curriculum, but the need of purchasing the kit is lost when this is the only goal. The chemical testing materials can be bought in bulk for much cheaper, and the directions can easily be typed out in one afternoon. As a final note the Potassium Iodide solution sent to us did not work. Our hypothesis is that the Iodine is too dilute in the solution.

The Mystery of Lyle and Louise
A lab on Forensic Entomology
Fisher Scientific
Alicia Harkins-Pritchett

Student procedure:

- Examine six life stages from two species of fly.
- Develop a dichotomous key that will separate maggots into life stages and species
- Use key to identify maggots collected from bodies of two victims
- Finally students will use know insect life-cycle information and Nation Weather Service data to estimate a time of death for each victim
- Once lab results have been analyzed, students may conduct a mock trial to synthesize information from the investigation

Materials needed

- Species A Life Stages (3 sets of 6)
- Species B Life Stages (3 sets of 6)
- Evidence Collections (6 vials)

- Weather Service Data (6 Sheets)
- Forceps
- Dissection microscopes or hand lenses
- Pre and post lab questions

Lab Procedure- 3 parts
Part 1

- Students familiarize themselves with the morphology of each life stage of two species of fly.
- Identify key characteristics and develop a system tot separate the two species and six life stages
- Use ABSOLUTE characters so that identifying can be made with out needing comparison

Part 2

- Students use the system (or taxonomic key) they developed to identify samples of flies collected from the two bodies
- Aggregate data so everyone has a complete set

Part 3

- Analyze data collected and determine and approximate time of death

History of Forensic Entomology

- Have discussion before lab
- “There is considerable need for forensic entomologists to engage in such growth a development studies, both in the laboratory and field. As this research is performed and results are published, forensic entomology is becoming an increasingly useful tool in a crime scene investigation
- Achieve an advanced degree (either M.S or Ph.D.) in entomology, ecology biology or zoology
- Become certified by the American Board of Forensic Entomology by completing a minimum of 3 years of professional experience in casework,

publishing at least one scholarly paper and giving on professional presentation in the field of forensic entomology.

EDUCATOR COMMENTARY:

This lab is set up to take 4 or 5 class days. In a normal biology classroom this would not be possible as we are required to follow state standards and most of this lab would be an adjunct and not mandatory material. I found that parts of this lab would be useful but to complete it in its entirety would be useless. The following were some of the comments my fellow educators had to say about this lab:

Louann says: This activity has a "gross-out" factor that kids will love! It would be very helpful to develop skill in identifying the species and stages of flies before doing the mystery.

Emily- Not sure I would use this lab. I think it would be a good way to incorporate the use of dichotomous keys but not sure that I like it for use in genetics.

Carrie - This lab would be helpful to have students practice making a dichotomous key. The setup of the lab should be modified to reflect each teacher's organizational styles.

Kasi-I would suggest that each stage of the flies be place on the petri dish, as to compare the two group side by side. The larvae was hard to see, must have a dissecting microscope. I'm not sure when I would use this lab.

Bryan - This was an interesting kit that I see using more with a science club than in a classroom. I do not think the average science student would have the patience to carefully study the details of the different larval stages to distinguish between different species. For students with an interest in science, it serves the purpose of developing keen observation skill, gathering data, and analyzing results to solve a problem.

Joseph: I would suggest that you set up stations for comparison. I fear too much damage will become of the bugs if they are freely disbursed. Place elements side by side with labels. Allow them time at each station to sketch what they see. You might be surprised with some of the results.

Rich: This is a lab that I would really like to do. There needs to be some adjustments for students to be capable of identifying organisms and their stages. An option would be to place your specimens within a harden resin

Representative Open Ended Laboratory Investigations

Submitted by
Bryan Smith
LaLumiere School
LaPorte, IN

A Sequential Approach to Teaching Transformation, Gene Splicing, and PCR in a Biotechnology Unit

Introduction

When teaching a unit on biotechnology, hands-on labs are essential for students to understand the many techniques used to manipulate DNA. Because these techniques are so new to students, they are often intimidated when faced with common biotechnology skills such as micropipetting, loading gels, or spreading agar plates. Labs done only once do not give students confidence with these skills, nor do they help them understand how the different processes are connected. To aid in building students' confidence with biotech skills, and understanding important techniques and processes, I propose teaching a sequence of three transformation lab activities, using three different kits over a three week period.

Materials

Edvotech kit #221 – Transformation of *E. coli* with pGAL
Carolina Biological kit #211162A – E-Z Gene Splicer DNA Recombination and Transformation
Peyer Laboratories – Cloning a Fluorescent Gene
37^{o} Incubator
42^{o} water bath
ice
Refrigerator/freezer
Microwave oven or hot plate

Procedure

Beginning with the Edvotek kit, students get their first introduction to bacterial transformation. The kit comes with LyphoCells^{TM} *E. coli* which make the teacher prep very easy. Students learn about the "heat shock" method for bacterial transformation, as well as basic principles of plasmid selection and marker genes. The success rate of transformation is high so students will see blue colonies of transformed bacteria when plated on LB agar plates with ampicillin and X-Gal.
The follow-up to the above lab is the kit from Carolina Biological. In this lab, students must ligate genes from two different plasmid digests in order to make a recombinant plasmid containing genes for both ampicillin and kanamycin resistance. In this part of the lab, students learn about the importance of restriction enzymes, "sticky ends," and ligase for cutting and pasting DNA. Then using a similar heat shock method, students transform E. coli bacteria with the recombinant plasmid. Only the bacteria transformed with the recombinant plasmid will grow on LB agar plates with ampicillin and kanamycin.
The final lab of the sequence is the kit from Peyer Laboratories. In this lab, students amplify the Green Fluorescent Protein gene(GFP) by the Polymerase

Chain Reaction (PCR) using a thermocycler that is leased from the company. At this point, students learn about the role of primers and Taq polymerase in the PCR sequence. After many copies of the gene are made, students ligate the gene to a vector carrying an ampicillin resistance gene to make a recombinant plasmid. The recombinant plasmid carries two genes, one for ampicillin resistance and one for GFP. Finally, *E. coli* and the recombinant plasmid are heat shocked to induce transformation. Transformed bacteria will glow when exposed to a long wave UV lamp.

Comments

Except for the lab items list in materials section, each kit comes with all the necessary supplies. If you have micropipettes, these can be used in place of the ones that come in the Edvotek and Carolina kits. The Peyer kit is different in that company leases a thermocycler for PCR, a long wave UV lamp to spotlight the bacteria transformed with the GFP gene, and micropipettes.

In terms of teacher preparation, the Edvotek LyphoCells™ come ready to go, which saves a lot of time. Carolina sends an *E. coli* slant culture which means the teacher needs extra time to prepare streak plates to obtain fresh bacteria colonies for the transformation. Peyer sends a ready prepared streak plate as well as pre-poured agar plates, which saves time. Edvotek and Carolina kits come with melt & pour agar, so agar plates must be prepared ahead of time.

All the kits come with extensive instructor manuals to compliment the student manuals. The Peyer student manual is exceptional in the details of each process, and could be used in place of a textbook chapter on transformation, gene splicing, and PCR.

Finally, by using all three kits, students work with three different plasmids so there is variation in the final transformed bacteria phenotype they observe. The sequence of adding a new process with each kit should help students grasp how PCR, gene splicing, and transformation are connected, while at the same time, they should become more confident and adept with the lab techniques.

Representative Open Ended Laboratory Investigations

Changing Over Time Laboratory Kit Evaluation

251014 Carolina Biological Supply

Rich Stein

Carolina Biological Supply Company has produced multiple labs within a series labeled "Inquiries in Science." Labs within these series claim to "help students understand hard-to-grasp concepts." With the laboratory kit Carolina supplies instructors with suggestive teaching techniques. The recommended techniques were designed to help students "through guided inquiry." The teacher's manual gives the instructor background information on each activity and suggested discussion question. The Changing Over Time laboratory kit supplies the instructors with three activities. Each activity investigates one area of the evidence of evolution.

Activity 1: Kinship Activity Sheet

Each pair of students receives a "Kinship Activity Sheet." Within their pair students must discuss with their partner about which organism out of a group of three does not belong. Students must find the two organisms most closely related and document which organism is the least related. The activity sheet contains six groups of organisms and students should record their answers within their science notebook.

This activity is an excellent discussion starter for the evidence of evolution unit. Many students will struggle with the reasoning for some organism's relationship. It is recommended that the instructor provides cladograms or any type of phylogeny diagram to help facilitate the discussion. It is also recommended that the sheets provided to the students are laminated to preserve the color and structural integrity of the paper.

Activity 2: Structure Cards

Working in the same groups, students are given a stack of cards. On one side of the cards is displayed an organism or an organism's body part, on the other side is a short description of the particular part being investigated. Students are asked to put the cards into groups. Students should consider: what the structure does, the function of the structure and their appearance.

This is another activity that could bring up many great classroom discussions. The instructor does not tell how the cards should be grouped; he/she just gives factors to consider. In that respect, there are multiple ways to group the cards and the instructor should be prepared to have large classroom discussion about why cards were grouped a certain way. It is recommended the instructor encourages the students to read the back of the cards and fill out the table provided in the lab manual for what cards are grouped, the category description and the reasoning. Within the instructor manual it is recommended you do not reveal the correct ordering until after all activities are complete. As an evaluation committee we did not see the reason why to wait; activity 3 plays a role in evolutionary change over time but the instructor may run into some difficulty meshing the two concepts together with a lower level biology class.

Representative Open Ended Laboratory Investigations

Activity 3: Antibiotics and Resistance

Students will be working within groups to investigate the antibiotic resistances of *Escherichia coli* to ampicillin. Students streak a culture of *E. coli* onto an Ampicillin Concentration Gradient agar plate. The culture is allowed to grow for 24 hours and students should observe multiple colonies of *E. coli*, majority growing in the least concentrated ampicillin region. From this agar plates students are then asked to design an experiment to investigate ampicillin resistant bacteria. Students have at their disposal agar plates with ampicillin, agar plates without ampicillin and blank sterile antibiotic disks.

This activity requires a lot of teacher preparatory time. The instructor needs to prepare 25 agar plates; three different types with each requiring some type of modification. The instructor also needs to be precise in the preparatory technique or else students will not obtain any accurate results. This activity provides students with excellent hands on examples of real bacteria going through real evolution in a time frame they can observe. The experimental design gives students freedom to conduct their own guided investigation but instructor guidance will be needed. Depending on the level of biology students the experimental design section may need to be completed as a class, as many students may not see the big picture idea. This activity can easily be substituted with another activity depending on time; such as "Natural Selection & Antibiotic Resistance" by Ward's Natural Science, which may only require 30 minutes

Carolina Biological Supply put together a multi-level laboratory kit for biology students of all abilities. Some activities are more advanced and can easily be explored into more detail depending on the curriculum goal of the class. This is a highly recommended kit as it provides the instructor with excellent discussion material that can be manipulated, expanded, or shortened without hurting the overall goal of the kit, "help students understand hard-to-grasp concepts." Instructors should be prepared to pay a high price for the kit but the materials given to the instructor will last for years and refill kits for *E. coli* samples and ampicillin are available or can be purchased elsewhere.

Reference:

Carolina Biological Supply
http://www.carolina.com/product/life+science/inquiries+in+science+biology+series/inquiries+in+science-+changing+over+time+kit.do?sortby=ourPicks

Ward's Natural Science
http://wardsci.com/product.asp?pn=IG0034777&name=Natural+Selection+and+Antibiotic-Resistant+Bacteria+Lab+Activity&bhcd2=1249437783

Buffering Capacity

Topic: Buffering capacity of four buffering systems used in biological research.
Purpose: To test the buffering capacity of four buffers at pH 7.4 with concentrations between 0.1M and 0.15M when a known amount of acid or base is added. An objective measure of buffering capacity will need to be defined so that buffers can be compared based on their effectiveness.
Prerequisite: Understanding of acid-base chemistry, skill in titrating and use of pH meter, knowledge and ability to standardize an acid and base solution, and computational skills for determining molarity, unknown concentrations using titration techniques, osmolarity, and logs. This lab is intended for students in a second year high school chemistry class, e.g., AP/ACP chemistry.
Time: Two 50 minute lab periods.

Introduction: see student handout
Review with students: Instructors should review titrations, use of pH meter, standardization of acid, base solutions, osmolarity, and buffers with students. Also, you need to cover the sample computation covered in the student handout.

Students are to devise their own measure of buffering capacity and they need to develop their own procedure for carrying out the experiment. For example, students could utilize some sort of pH change with a set amount of acid or base added as their measure of buffering capacity. Encourage students to be creative and also reinforce the idea of a quantitative measure that can be used for comparison of the buffers.

Materials:
Na_2HPO_4
NaH_2PO_4
Carbonic Acid (conc)
$NaHCO_3$
HCl (conc)
NaOH
Potassium hydrogen phthalate
Tris (Tris[hydroxymethyl]aminomethane)
HEPES (4-[2-hydroxyethyl]piperazine-1-ethanesulfonic acid)

Reference:
Chang: Chemistry, chapter 16, “Acid-Base Equilibria and Solubility Equilibria,” pp. 683-690.
Douglas R. Sisk, Ph.D., Marian High School, Mishawaka, IN dsisk@marianhs.org

Representative Open Ended Laboratory Investigations

Buffering Capacity

Mathematical Implications:

1. Students should be able to calculate molarity of acid, base, and buffer solutions, including computing the number of grams or volume of a concentrated solution need to make a specific volume of known concentration.
2. Students should be able to calculate the concentration of an unknown acid or base based on the results of titration.
3. Students should be able to utilize logs to calculate the ratios of salts needs in a buffer solution to achieve a desired pH value.
4. Students should be able to generate a quantitative measure of buffering capacity and a basis for comparing results to decide which buffer is best.
5. Students should be able to calculate the osmolarity of their buffer solutions and demonstrate how changing concentration of the buffer affects osmolarity.
6. If statistical analysis is attempted through repeated trials for each buffer, computation of variance, standard error, and t or F values will be required of students.

Student page 1

Buffering Capacity

Introduction: A buffer solution is composed of a weak acid or base and its salt. The solution has the ability to resist changes in pH upon addition of small amounts of either acid or base. Buffers are very important in chemistry and biology. Indeed, in biological systems such as the human body pH varies greatly from 7.4 for blood to 1.2 for gastric fluid. These pH values are maintained by buffers.

In biological laboratories, several buffer systems are used, including HCO_3^-, PO_4^{3-}, Tris, and HEPES buffers. Their buffering capacity, that is the effectiveness of a buffer solution to resist change in pH, depends on the amount of acid and conjugate base from which the buffer is made. While buffer solutions should contain a relatively large concentration of acid to react with added OH^- and a similar concentration of base to react with added H^+, in biological systems care must be taken to balance osmotic pressures so concentrations are typically held in the range of 0.1M – 0.15M.

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Mishawaka, IN

This lab can be downloaded from the RET@ND Website. (www.nd.edu/~ndrets)

Solution Composition

Topic: Solution composition specifically % solutions, molarity and dilutions, including computations and experimental analysis.

Purpose: The purpose of this learning activity is for students of all levels in high school chemistry to acquire the necessary computational skills to determine solution composition and provide students an opportunity to experimentally analyze a solution's composition. Students' precise method of solution analysis can be either determined by the teacher or discovered by the students. The amount of direction given students should be determined by the teacher, taking into consideration the level of knowledge and skill of the particular chemistry class involved in the activity.

Prerequisite: Basic ability in algebra and dimensional analysis (factor-label) as well as an understanding of molar mass, chemical formulas, moles, and Avogadro's number are required for this activity. The computational problems could constitute the pre-lab portion of the activity and teachers may desire to review each of the types of computations with their students. For experimental analysis of a solution, the teacher may choose from four lab activities, depending upon the level of their chemistry class. Exact procedures for analyzing a solution's composition are not provided. However, suggestions for possible methods of analysis and references for specific laboratory techniques are given. Teachers should provide students with the necessary background for performing each solution analysis. Alternatively, teachers may decide to give very little direction and background thereby challenging students to discover an approach for themselves.

Time: One to two 50 minute lab periods.

Introduction: See student handout.

Pre-lab Answers:

1) **10.8 g NaCl**
2) **4.12% KI**
3) **5.46 M HCl**
4) **7.5 g NaOH**
5) **21.3 mL**
6) **0.0074 M**

23

Student Handout Page 1

Solution Composition

Background: An essential tool in most any laboratory setting involves making specific concentrations of various solutions. Some of the more common solution compositions include: percent, molarity, and dilution.

- Percent is one of the simplest methods of combining solute and solvent since the identities of either is unimportant, only amounts are needed.

Mass/Volume Percent = % (m/v) = grams of solute/total volume of solution x 100

Volume/Volume Percent = % (v/v) = mL of solute/total volume of solution x 100

Mass/Mass Percent = % (m/m) = grams of solute/total grams of solution x 100

- Molarity often uses a more involved calculation in that it typically requires a conversion of mass to moles before dividing by the volume of solution.

  $M = \text{molarity} = \frac{\text{moles of solute}}{\text{liters of solution}} = \frac{\text{mol}}{\text{L}}$

- And finally, a dilution is adding a specific amount of solvent to a measured volume of the stock solution to decrease the molarity. Since the amount moles of solute do not change, the following equation holds true where M_1 and V_1 are the stock solution molarity (or % solute) and volume, while M_2 and V_2 are the resulting dilution molarity and volume.

  $M_1 \times V_1 = \text{moles of solute} = M_2 \times V_2$ or simply $M_1 \times V_1 = M_2 \times V_2$

Purpose: To prepare solutions using percent, molarity and dilution calculations. Then, devise a method to experimentally determine the composition of a given solution.

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and
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This lab can be downloaded from the RET@ND Website. (www.nd.edu/~ndrets)

Le Chatelier's Challenge

Aim To apply a working knowledge of Le Chatelier's Principle in order to accomplish specific tasks.

Equipment Test tubes, 100mL beaker, stirring rod, test tube rack, 10mL Graduated Cylinder, Funnel, Filter Paper

Chemicals Concentrated HCl, 0.1M HCl, Ethanol, Solid Na_2HPO_4 (removes Fe^{3+} from solution), Solid KSCN, 0.1M NaOH, 0.2M iron (III) nitrate, solid cobalt (II) Chloride, 0.1M $AgNO_3$, Bromothymol Blue Indicator solution, 0.002M KSCN, solid NaCl

Method

Note: You and your lab partner are in charge of devising an appropriate method for each experimental task. It may be helpful to review Le Chatelier's principle prior to starting this experiment. Collaborating with your lab partner as well as analyzing the given equilibrium equations will be key to your success in devising methods to solve each of the tasks given below. Take the time to think about how you will accomplish each task. Feel free to reference available resources as you work through the tasks that follow. Have fun! Think like a chemist!

Example

$$N_2O_{4(g)} \quad \leftrightarrow \quad 2NO_{2(g)} \qquad (\Delta H_{rxn} = 58.02 \text{ kJ})$$
$$\text{colorless} \qquad \text{brown}$$

Obtain a sealed syringe filled with an equilibrium mixture of dinitrogen tetroxide and nitrogen dioxide. Devise a method to accomplish each of the folowing:

1. Make the gas in the syringe as colorless as possible.
2. Make the gas in the syringe dark brown.

Solution

For (I), we need to shift the equilibrium to the left. There are two ways to do this. If the pressure in the syringe is increased, we know that the reaction will favor the side that minimizes the pressure increase (the side with the least number of gaseous particles) and we can predict that the gas solution will become colorless when compressed. So, we can take the syringe filled with the gas and compress the plunger. A second solution lies within the enthalpy of the process. In this example, heat can be considered a reactant, so if we cool the gas in the syringe in a ice-water bath (we would need an appropriate beaker, ice and water for this), the solution will also become colorless. If we reverse either of the methods used for (I), we have viable solutions to accomplish (II).

Representative Open Ended Laboratory Investigations

Pre-lab

Carefully read through each task below. Notice that each task begins with a given chemical equation to help guide your thinking. Working with your lab partner, devise a method using the chemicals and equipment available, to accomplish each task. Have your method validated by your instructor before beginning the lab. In your lab notebook, make a section entitled **notes**, where you will detail how you accomplished each experimental task. It is extremely important that you record your results carefully. If you make a mistake in your report, do not erase it or cross it out, but rather draw a single line through it, so that your instructor may still be able to read your notes.

Experimental Tasks

(1)

$$NaCl_{(s)} \leftrightarrows Na^{+}_{(aq)} + Cl^{-}_{(aq)}$$

Make a saturated solution of NaCl in a small test tube. Note how you made the saturated solution. Using the available chemicals, make solid NaCl precipitate from your saturated solution. [HINT: The chemical you use will require the use of a fume hood.] Carefully detail how you solved this task in the **notes** section.

(2)

$$H(BTB)_{(aq)} \leftrightarrows H^{+}_{(aq)} + (BTB)^{-}_{(aq)}$$ (HIn is Yellow, $H^{+} + In^{-}$ is Blue)

Half fill a small test tube with distilled water, and add a few drops of Bromothymol Blue Indicator (BTB). Devise a method to cause the solution in your test tube to turn yellow. Then, turn the solution back to blue. Record how you solved this task in the **notes** section.

(3)

$Fe^{3+}_{(aq)} + SCN^{-}_{(aq)} \leftrightarrows FeSCN^{2+}_{(aq)}$ ($Fe^{3+}_{(aq)} + SCN^{-}$ is colorless, $FeSCN^{2+}$ is red)

Pour about 25mL of 0.002M KSCN solution into a beaker. Add 25mL of distilled water and 5 drops of 0.2M $Fe(NO_3)_3$ solution. Stir the solution and note your observations.

Split the solution in the beaker equally into three separate test tubes. Accomplish each of the following and record your method in the **notes** section:

(I) Determine two *different* means by which to turn your solution deep red.
(II) Make the solution in the third test tube change to colorless.

Submitted by Phil Cook
Culver Academy Culver, IN

Representative Open Ended Laboratory Investigations

This lab can be downloaded from the RET@ND Website. (www.nd.edu/~ndrets**Plotting Earthquakes using Wikispaces and Google Maps**

Learning Objectives:

To create a Google Map containing enough earthquake data points so that students can ask and answer interesting questions about the locations of earthquakes around the Earth. The collaboration between students will be facilitated by a Wikispaces page created by the teacher. Some examples of interesting questions may include: Why do earthquakes happen where they do? What causes some earthquakes to have a shallow focus and some to be deep focus? There are many open ended questions that students may ask and investigate as a result of this exercise.

The standards that this activity covers are:

Indiana Earth Science Standards

ES.1.23 Explain motions, transformations, and locations of materials in Earth's lithosphere and interior. For example, describe the movement of the plates that make up Earth's crust and the resulting formation of earthquakes, volcanoes, trenches, and mountains.

ES.2.6 Describe that early in the twentieth century the German scientist Alfred Wegener reintroduced the idea of moving continents, adding such evidence as the underwater shapes of the continents, the similarity of life forms and land forms in corresponding parts of Africa and South America, and the increasing separation of Greenland and Europe. Also know that very few contemporary scientists adopted his theory because Wegener was unable to propose a plausible mechanism for motion.

ES.2.7 Explain that the theory of plate tectonics was finally accepted by the scientific community in the 1960s when further evidence had accumulated in support of it. Understand that the theory was seen to provide an explanation for a diverse array of seemingly unrelated phenomena and there was a scientifically sound physical explanation of how such movement could occur.

Indiana Technology Standards

Standard #3

Understand the integrated relationship of technology with other academic fields, particularly language arts, math, science, and social studies and opportunities using appropriate technical means.

Standard #5

Work cooperatively and productively in groups to design and use technology to solve technological problems.

Materials Plan:

- Computers with internet access for students to lookup data and collaborate with each other.
- Earthquake data that includes the latitude, longitude, depth and magnitude of the earthquake. The United States Geological Survey provides this information.
- A Wikispaces or similar hosted wiki page set up with a Google map for students to record their data on.

Pre-Lab Activities:

The teacher should have a Wikispaces page created with a Google map set up for student collaboration. Before the students participate in this activity there may need to be some preliminary types of computer training for the students, however it is possible that some of this training may take place while completing the lab activity.

- Students should be familiar with using the school's internet service and its use policy.
- Students should be familiar with logging into and using a wiki space.
- Students should be familiar with using Google Maps to plot points on a map.
- Students should be familiar with using the United States Geological Survey Data Base.
- Students should be introduced to the basic principles of earthquakes and plate tectonics.

This information could be discussed with students on the day before the lab or much earlier in the year depending on the extent to which Wikispaces is used for student collaboration.

Lab Activities:

On the day of the lab either assign or allow students to choose a day to look for their earthquake data. Each student should locate 10 to 15 data points using the United States Geological Survey Earthquake Data Base and place them on a collective Google map with their classmates. Each earthquake should have a callout box that contains the Latitude and Longitude of the earthquake, the magnitude, and the depth of the earthquake. Each earthquake should also have an icon on the map to represent the magnitude of the earthquake according to a preassigned color code.

Tim Hardt Washington High School
South Bend, IN
This activity is outlined in an I2U2 E-lab located at http://www18.i2u2.org/.

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EXPLORING TRANSISTORS

Transistors are devices in an electric circuit that act as switches and amplify current. In this unit we will learn about the characteristics of transistors by experimenting with some simple transistor circuits.

Activity I
The purpose of this activity is to measure circuit voltages and calculate the collector current and base current. Also, we will determine the range of resistance values that can be used in this circuit.

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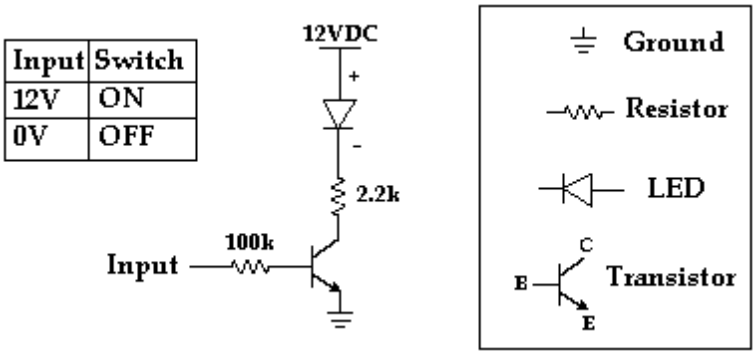

Instructions:

1. Construct your circuit according to the schematic diagram given. Ask the teacher to inspect your circuit before applying power to it. When 12 volts DC is applied to the circuit, the LED should light up. Also, the voltage measurement between the base and the emitter should be about 0.7 volts. If not, check your circuit for errors.

2. **Measure the voltage across the 2.2 kΩ (R1) resistor and record it to the nearest 10^{th} of a volt.** Then use Ohm's Law to determine the current through this resistor. This is the collector current, (Ic).

3. The highest collector current that can be applied to this transistor is 200 mA. **Use Ohm's Law to determine the lowest resistance that can be used for R1.**

4. **Measure and record the voltage across the 100 kΩ (R2) resistor. Then use Ohm's Law to determine the base current, (Ib).**

5. **Calculate the amplification factor: Ic/Ib = β .**

6. **Now use Ohm's Law estimate the lowest resistance value that can be used for R2**. Assume that the highest possible voltage is 12 volts. The highest current that can be applied to the base of this resistor is 2 mA because the minimum amplification factor is 100**.**

Activity II

In this activity, you will devise an experiment to determine how to make the LED brighter or dimmer.

1. **Write a hypothesis about how you could make the LED brighter or dimmer**. Remember that you must be able to test your hypothesis by manipulating variables that can be measured.

2. **Describe in detail the procedure you will use to test your hypothesis.** What variable will be manipulated and what measurements will be recorded or calculated? What are the controls of your experiment? Also, describe any qualitative observations that are relevant. Remember that you must stay within the parameters that you determined in Activity I.

3. **Construct an appropriate data chart and be sure to use correct symbols and units.**

4. Carry out your experiment, recording the results in your data chart. **Record results for variables that are measured as well as those that are calculated. Also, record qualitative observations.** Do at least 5 trials.

5. **Show at least one sample calculation for each type of calculation you did.**

6. **Write a conclusion paragraph**. Did your results support your hypothesis? Why or why not? Also, discuss any problems you had and possible sources of error.

This lab can be downloaded from the RET@ND Website. (www.nd.edu/~ndrets)
Kim Bergeron

Representative Open Ended Laboratory Investigations

Making MicroElectronic Chips

Instructor notes

A. Lift off exercise and testing of a silicon wafer

We have discussed the lithographic techniques that go into the design and production of nano and microchips (refer to "Making a Chip"). Today you are going to perform lift-off on a wafer and test the resulting circuit using digital multi-meters.
Important notes:

• Students will be using the mini-SST trainer checklist and run as Mechanic / Data teams.

• Students will need to take careful notes by hand, and then transcribe them into the computer to document everything. Consider which lab paper they wish to use to document the exercise.

• Consider which images they wish to capture and take the appropriate images. They will need to share the camera.

• You will be using acetone. Students need to wear the gloves to protect skin from drying, and safety glasses to protect from splashes.

B. This is considered a training exercise. What students need to do:

1. Determine the Mechanical and Data roles
2. Mechanic will gear towards the lift off – make a rough outline based on completing the lift off successfully.
3. Data will gear towards the voltage divider measurements – be prepared to take data and take measurements that will test the chip.
4. Mechanic will need to use probes, and document a working procedure that will get the data to the Data coordinator.
5. Data will need to analyze the curves in Excel or LoggerPro to get a best fit and relevant data (will need to discuss this in class.)

C. Materials and supplies needed prior to lab:

Slide show of the lithographic process
Explanation of the lift off procedure
Explanation of the DMM
Explanation of voltage divider, with exercises
Wafers, ready for lifting
Microscopes
Acetone
Squeeze bottles
Safety glasses

C. Materials and supplies needed prior to lab (continued):

Disposable latex gloves
Flash drives and computers preloaded with mini-checklist, lab manual paper for lab books, and camera(s)
Use:
"wafergridLGJPEGPOS.jpg"
as mask when exposing resist.
Using the student lab group assignment roster, students will know ahead of time who is coordinating each role. It would be good to have a WORD primer with the students on basic skills (dropping in images, etc.). They will need to back up all work onto their flashdrives, including their partner's work.

D. As of 2008: Wafers will need to be processed initially at a fabrication lab
(I am using Notre Dame's nano-fabrication lab). This involves:

a. 500 Ang. Oxide layer
b. 700 Ang. Poly-Si layer
c. PMGI layer (for undercut)
d. 1813 layer
e. Apply mask and expose/develop pattern
f. Deposition of 500 Ang. Ti
g. Deposition of 3000 Ang. Au

E. Students will complete process by rinsing with Acetone.
AP Physics
Lift off exercise and testing of a silicon wafer
We have discussed the lithographic techniques that go into the design and production of nano and microchips (refer to "Making a Chip"). Today you are going to perform lift-off on a wafer and test the resulting circuit using digital multi-meters.
Wafers were processed initially at the Notre Dame Nano-Fabrication laboratory. This involved:

a. 500 Ang. Oxide layer
b. 700 Ang. Poly-Si layer
c. PMGI layer (for undercut)
d. 1813 layer
e. Apply mask and expose/develop pattern
f. Deposition of 500 Ang. Ti
g. Deposition of 3000 Ang. Au

This lab can be downloaded from the RET@ND Website. (www.nd.edu/~ndrets)

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Calculating the Mean and Standard Deviation with Excel

1. Enter the scores in one of the columns on the Excel spreadsheet.
2. After the data have been entered, place the cursor where you wish to have the mean (average) appear (usually in the box after the column of data) and click the mouse button.
3. Move the cursor to the Function **Wizard (*fx*) button** and click on it.

4. A dialog box will appear. Click on **AVERAGE**, then click **OK.**

5. Enter the cell range for your list of numbers in the **number 1** box. For example, if your data were in column A from row 1 to 11, you would enter A1:A11. Instead of typing the range, you can also move the cursor to the beginning of the set of scores you wish to use and click and drag the cursor across them.
6. Once you have entered the range for your list, click on **OK** at the bottom of the dialog box.

7. The mean (average) for the list will appear in the cell you selected.

8. Place the cursor where you wish to have the **Standard Deviation** appear and click the mouse button. (Select the box right after the mean.) Now move the cursor to the Function **Wizard (*fx*)** button and click on it.
9. A dialog box will appear. Click **STDEV**. After you have made your selections, click on **OK** at the bottom of the dialog box
10. Enter the cell range for your list of numbers in the **number 1** box. For example, if your data were in column A from row 1 to 11, you would enter A1:A11. Once you have entered the range for your list, click on **OK**.
11. The **standard deviation**(sd)for the list will appear in the cell you selected.

Calculating the Mean and Standard Deviation with Excel

(continued)

12. In most investigations you will be comparing the means and sd of two or more groups. You can list both columns of data before you do the calculations on either. You may find it useful to leave an empty column between the two columns. As an example--the mean and standard deviation would be listed in your lab report as 5.4cm +/- 1.4sd.

13. In discussing these values a **small** sd adds more importance (weight) to the difference in the means, since it indicates that **the data were more consistent**. A large sd indicates that there was considerable variation in the data.

Using the T-Test of Significance on Excel

1. Create two columns, side by side, for the variables of interest (e.g. length of one group versus the length of a second group).

2. Click on another blank cell where you wish the P value to appear. Then **click "fx"** on the Excel toolbar and **choose "TTest"** , **then OK.**

3. For **"Array1" highlight the cells in one variable column; For "Array2", highlight the cells in the second column.**

4. Tails refer to the possibility of where your expected value may fall.
5. **Choose two-tailed** unless your instructor has approved the use of a one-tailed test.

6. Lastly, you will have to select the "Type" of t-test. This will depend upon the amount of variation (variance) between the data sets. **For our purposes choose 3, unequal variance.**

7. After answering these questions **click "OK"** and the P value will appear. The P value will fall between zero and one.

What does my P value mean?

Say you get a P value of .10 or 10%. This means that there is a 10% chance that the differences between your two groups or collections are due to random chance alone. Another way to say this is that there is a 90% chance that the differences between these two groups or "collections" is due to some other variable or variables.

Normally will say that a p value < 0.05 is significant.
A p value <0.01 is highly significant
A p value <0.001 is very highly significantly

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T TEST Problems Using Excel

Evaluation of Ideal Data

1. List on this paper 10 data points for each of the following groups. Keep the mean values of the three groups separated by approximately 20units between each group. Select data points with very little variance.

Control	Experimental 1	Experimental 2
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

Determine the mean value and standard deviation for each group. CROSS OUT all values outside the +2 and -2 sd units. If values are eliminated, recalculate the new means and standard deviations. Analyze the differences of the means for significance using T-Test. Record all values on the reverse side of this worksheet.

Evaluation of data with a small (n) number

2. Eliminate the last 6 data points in each of the columns of #1. Determine the mean value and standard deviation for each group. CROSS OUT all values outside the +2 and -2 sd units. If values are eliminated, recalculate the new means and standard deviations. Analyze the differences of the means for significance using T-TEST. Record all values on the reverse side of this worksheet.

Evaluating data with a large variance

3. Add 6 data points in each of the columns of #2 to represent a very large variance. Determine the mean value and standard deviation for each group. CROSS OUT all values outside the +2 and -2 sd units. If values are eliminated, recalculate the new means and standard deviations. Analyze the differences of the means for significance using T-TEST. Record all values on the reverse side of this worksheet.

4. Compare your p-values. Discuss how these values changed as these 3 factors were altered.

Linear Regression and Correlation Coefficient Using Excel

1. Select Excel and enter data on blank spreadsheet. First add a Title on each column then enter associated values under the appropriate title. **(SAVE data)**

2. Using the mouse, **Highlight** the data you wish represented on the graph. **DON"T** include the title of the column.

3. Select the bar graph icon at the top of the screen**. (Chart Wizard).**

4. Scroll down the choices and select the actual graph style you want to use. Most of the time you will use a scatter graph or a bar graph**. (Select next).**

5. The Chart Wizard will lead you through the graph construction process.

6. On step 3 you should add a graph **Title** and the axes **Titles**.

7. Other options can be added at this time i.e. Trend line with formula. **Select Chart Add Trendline.** Under Trendline click Options- display equation and display R2.

8. Proceed to the last step. **(Finish)**.

9. Click on the graph to make it active .
Type in a value or word on the formula line, such as **Con vs Exp 2 p<0.001**.
Click on return- then drag this box around outside and inside the graph.

10. **Select Chart options**- click legend. **Select Remove "show" legend.**

11**.** Enlarge graph by dragging from the corner.

12. Double click on the graph and change the background color of the graph.

13. Double click any object on the graph and change its color.

14. Double click on a graph axis- change the font size.

15**. SAVE** graph both with and without data table.

16. Use the supplied data and construct different styles of graphs. Print out 3 different formatted graphs.

Data to use on Microsoft Excel xp

A. 1 line- scatter graph (with trendline and r^2)

Mean Mass Changes (g)

Time	0 wks	3 wks	6 wks	9wks
Mass	31.54	32.32	32.65	32.43

B. 2 line- line graph (with trendlines and r^2)

Percentage Mass Changes (%)

Time	2 wks	4 wks	8 wks
% change	0.82	1.79	1.05
Exp	-4.28	-9.5	-8.75

C. Bar Graph

Mice Food Consumption (g/mouse/day)

Time	1 wk	5 wks	10 wks
	5.9	5.13	4.85

D. Pie Graph

Leukocyte Percentage (%)

Lymphocyte	Monocyte	Neutrophyll	Basophyll	Esoinophyll
76.8	9.6	7.2	3.0	3.4

RET@ND Program

The Research Experience for Teachers at Notre Dame (RET@ND) is a program of summer research projects for high school teachers of the Michiana region. The projects are directed by faculty members from several academic departments in the College of Engineering and Science at Notre Dame and explore a wide choice of mathematical, scientific and technological topics. They vary in duration from 4 to 8 weeks with stipends for participating teachers ranging from $1500-$6000. Graduate credit for the course work can be earned and applied to Continuing Education Units of credit in the state of Indiana. Tuition costs for the participants are paid by Notre Dame. Housing arrangements and travel costs are the responsibility of the participant.

The overall goals of the program are to acquaint teachers in high schools with research methodology and instrumentation, to develop inquiry focused open-ended science investigations which are applicable for their own teaching assignments and to encourage more students to pursue science and engineering as a career.

Participating teachers are required to create new curricular modules incorporating the open-ended inquiry approach for use in their classrooms. Representative activities are included in this RET@ND Newsletter. All of the modules are available on the RET@ND website. In addition, research Power Point presentations of the 2008-09 RET participants can also be viewed at this address.www.nd.edu/~ndrets

Inquiries and applications related to the 2010 RET program should be addressed to the Kaneb Center at Notre Dame.

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