Appendix

Appendix A: Laboratory Safety

Laboratory

Make sure you know where emergency exit, eye-wash station, fire extinguisher, first aid station, and buffers for acid or base spills are.

Biological Materials
The organisms and DNA molecules you will be using throughout the semester are recognized as safe. However, you must practice general microbiological safety which includes:
1. No eating, drinking, or smoking in the lab.
2. No mouth pipetting.
3. Prompt disinfection of contaminated materials.
4. Washing your hands before leaving lab.

Hazardous Chemicals
You will be working with a number of chemicals which are hazardous to humans and the environment. Material Safety Data Sheets or MSDS for the chemicals we will be using are available in the laboratories. **A SAFE GENERAL RULE IS TO TREAT ANY UNKNOWN CHEMICAL AS POTENTIALLY HAZARDOUS**. Known or suspected hazardous chemicals should be used only when wearing gloves. Your instructor will inform you when to wear gloves and/or goggles.

Try to avoid spills, especially on yourself. It is wise not to wear your best clothes when working in the laboratory since many agents are caustic. A small, unseen splash of acid, base, or phenol will result in a hole in your clothing. Please inform your instructor of any spills or broken glass.

Open flames
Turn Bunsen burners off when not in use. Extinguish alcohol burner flames when not in use. Tie long hair back. Keep all volatile and flammable liquids away from the flames. Organize your workspace so you do not have to reach over the flame. Notify others around you when using open flames.

Waste disposal

- Any uncontaminated, solidified agar or agarose should be discarded in the trash, not in the sink, and the bottles rinsed well.
- Any media that becomes contaminated should be promptly autoclaved before discarding it. Petri dishes and other biological waste should be discarded in Biohazard containers which will be autoclaved prior to disposal.

- Organic reagents, e.g. phenol, should be used in a fume hood and all organic waste should be disposed of in a labeled container, not in the trash or the sink.
- Ethidium bromide is a mutagenic substance that should be treated before disposal and should be handled only with gloves. Ethidium bromide should be disposed of in a labeled container.
- Dirty glassware should be rinsed, all traces of agar or other substances that will not come clean in a dishwasher should be removed, all labels should be removed (if possible), and the glassware should be placed in the dirty dish bin.
- Dispose of used glass pipettes in special waste buckets under the lab benches. Discard used micropipette tips in special containers on your lab bench.

Please make sure you know how to dispose of all materials and preparations you use.

CHEMICALS, REAGENTS, SOLUTIONS, ENZYMES, AND LIVING ORGANISMS
Take utmost care not to contaminate chemicals, reagents, solutions, enzymes or flasks with living organisms. Contamination might lead to failed experiments for the whole class, false results, and the mistrust of your colleagues.

In order not to contaminate reagents, pour powdered or crystallized reagents directly from the container into a weigh boat or, if necessary, into a beaker or other sterile container. Do not use spatulas. If you pour out too much, do not place excess back in the container; discard the extra. If using liquid reagents, always make sure that pipettes are sterile.

Enzymes are very sensitive to contamination and degradation. Use only sterile pipette tips. Do not touch the inside of the lid with your fingers or the bench top. When you need to remove an enzyme from the freezer for more than 1 minute, it should be kept on ice.

In some laboratory exercises we work with living organisms (e.g. amoebas, paramecia) that often come in a solution with a dropper for convenient removal. Make sure that you use the dropper labeled "*Paramecium*" for the flask containing paramecia.

PLEASE INFORM YOUR INSTRUCTOR IF YOU SUSPECT YOU MIGHT HAVE CONTAMINATED ANYTHING.

Appendix B: Laboratory Notebook

(adapted from R. Griffin, City College of San Francisco)

The essence of science is accuracy, and the essence of accuracy is careful record-keeping. Remarkable as human memory is, it is still highly fallible. All of us have had the experience of being absolutely certain we remembered something correctly, only to be confronted later with overwhelming evidence that we remembered incorrectly. In dealing with numbers, as scientific observations often do, it is very common for digits to be transposed when they are being copied. Although errors can never be 100% eliminated, forming the rigorous habit of making and keeping a careful, on-the spot record of what is being observed goes a long way toward eliminating most of the common errors.

It might be a question of a lot of money to be able to prove whether a research scientist performed a certain experiment in a certain way on a certain date. In addition, many great scientific discoveries occurred by chance, without a scrupulous notebook it might be difficult or impossible to reestablish the procedures that led to the chance discovery. Among professional scientists, any claim to a scientific discovery must be documented by the original laboratory or field record in order to be accepted. Courts of law apply the same principle, and if two scientists seek patents for the same discovery or invention, the courts award the patent rights to the one who can produce original written records of the idea with the earliest date. So seriously is this taken that companies engaged in research for profit have certain officers on the company assigned to collect each researcher's notebook at the end of each day, read over the day's entries and sign each page certifying that they have read and understood what is there and that they are signing it on that particular date. The notebooks are then locked in a safe overnight, just In case one of those notebooks might contain something that later turns out to be valuable.

In order to use notebooks to prove and replicate discoveries, they must follow a certain format that we will use in 101A.

1. The notebook must be stiff-covered, permanently bound, with the pages sewed together (but not the one with duplicate pages).
2. Number all pages in permanent ink in the upper, outer corners, at least 50 pages must be numbered prior to the second lab period.
3. Once you start your lab work, never substitute or delete pages.
4. Put your name on (a) the cover, (b) the top edge, and (c) the bottom edge of the notebook.
5. Reserve pages 1 through 4 of your notebook for a table of contents, with a left margin of 3 cm for grades. Contrary to the notebook content, your Table of Contents should be organized in a logical, not a chronological manner (see Figure 1). Below list "protocol", "results", and, if applicable "notes" or "discussion" all with the appropriate page numbers. Note that the page numbers might not be in consecutive order as your notebook is written in chronological order with the results perhaps obtained after the next experiment has already started.

TABLE OF CONTENTS

Figure 1 - Sample laboratory notebook page "Table of contents"

6. Your notebook should contain a **complete** record of **all** the data you accumulate in your laboratory investigations in this course **written at the time the observations or measurements are made.** On those rare occasions when you must use the data of your laboratory partner, your notebook must so indicate and must identify your partner by name.
7. All records must be legible, written in permanent ink, and complete before leaving the laboratory. Please **glue** (do not staple, do not tape) any chromatograms, electrophorograms, or printouts from analytical instruments into your notebook before you leave.
8. Never erase, obliterate, paste over, white-out, or tear out any part of the original record. If you think you made a mistake, draw a single line through it, making sure that the line does not render the lined-out material illegible. Write a note alongside it stating the evidence which convinces you it is truly a mistake, date and sign your note and have your instructor sign it too.
9. Just below the last line of data on each page you must write the date in the standard scientific format (7 October 2000 or 7 Oct. 2000) and sign your name. Leave a space for your instructor to sign as a witness that you actually recorded that information on that date. You need to get your instructor's signature before you leave the lab for that day (see example in Figure 2).
10. All empty space must be crossed out to prevent the insertion of data after the date indicated on the page.
11. Never record data on separate sheets of paper or in other notebooks for later copying into the laboratory notebook. Every copying introduces additional opportunity for error or even the complete loss of the data. If you forget to bring your notebook, record your data on a sheet of the appropriate size, date and sign it and later glue it into your notebook.
12. Begin a fresh page for each investigation. Write a working title (e.g. Lab 3 -Enzymes) on top of the page.
13. Whenever an experiment runs over several days or weeks, your record must be in chronological order with each day's data clearly identified by date and signed by you and your instructor. If you do other investigations in between, it is customary not to leave empty pages for continuing the one started earlier, but to put at the bottom of the last page of the first day's record: "continued on page ___". Then at the top of the page where the next day's record of that investigation begins you put: "continued from page ____" (you should reflect these interruptions in your Table of Contents, see above).
14. Remember that your notebook should be organized and written in such a way as to allow a colleague (or your instructor) to understand and replicate what you did.

Protocols
You are expected to write a protocol of the experiment to come. The laboratory binder often contains an explanation of the basic methods used in your laboratory investigation. But it is up to you to write-up each experiment in a condensed form that will allow you to perform the experiment without consulting the on-line notes. This means that you need to include all the materials used, times, techniques, etc. Think of it as something like a cooking recipe. As for such a recipe, it is important to list the steps in the most time-efficient order, e.g., you might prepare a solution for a step further down the line while waiting for something else to incubate. The write-up does not have to be very formal, best would be to simply draw numbered steps (see Figure 2); but you must include the salient information as outlined before.

For each experiment you perform, you should give a **short description of the question** we try to address in the experiment. The write-up of the purpose and procedures serves as a preparation to the investigation. You can thus clarify what you will be doing in the lab to come and identify questions that you might want to discuss with your lab partners or your instructor before you begin. Your instructor will check the completion of the protocol before you are allowed to begin your investigation. As you proceed through the experiment**, note any steps which you performed differently from the outline** (either accidentally or intentionally) and note the appearance of reactions, pellets, supernatants, etc. All this information will be important in interpretation of results and in trouble-shooting failed experiments.

Note that all **results** need to be clearly stated in the lab notebook. Remember that negative results and failed experiments are also results. Failed experiments are a great way to learn about how experiments work (and do not work).

Write a short conclusion for each investigative laboratory which answers the question stated in the beginning. You do not need to write this conclusion if you are writing a lab report on the exercise.

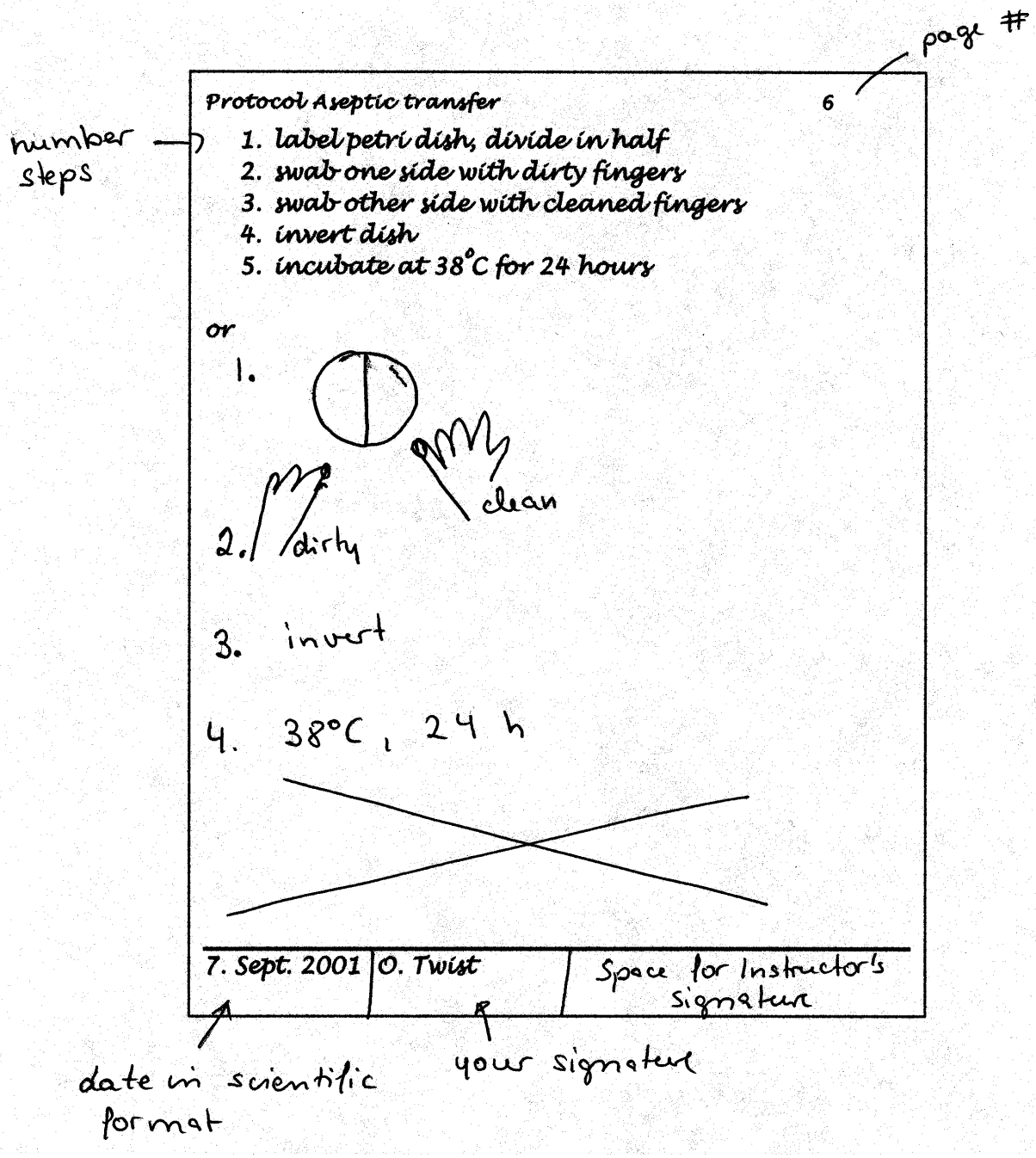


Figure 2 - Sample protocols

Appendix C: Laboratory Reports

Note: Some students in the past have turned in lab reports from students in previous classes. Obviously, they will not learn from writing a lab report, which is an important skill in sciences. But also, they were wasting their instructors' time. To avoid these problems in the future, you are required to turn in both a paper and electronic version of your lab report.

Communicating scientific findings is as important as investigating scientific questions. Most commonly, scientific findings are communicated in the form of a report or a paper. Papers that appear in scientific publications follow a traditional format that is outlined below. You will write your laboratory reports as if it were an article intended for publication.

Format of a laboratory report

1. Descriptive title (*what is this all about? - short version)*

- as short as possible
- as long as necessary to communicate the question being answered in the investigation
- remember that more people read the title than the paper
- remember that indexing and abstracting services depend heavily on the accuracy of the title

2. Introduction (*what is this all about? - long version)*

- place the topic of investigation in the context of previous investigations
- provide background information (brief review of concepts studied, normal ranges/values of measurements being studied)
- formulate the hypotheses tested
- give the bases for hypotheses, state your assumptions

3. Results (*what did you observe, measure, count?)*

- present the data you obtained from your observations, measurements, etc.
- summarize data in tables and graphs
- reference your tables and graphs in the text, the text is supposed to point out certain details in the data presented in the tables and graphs
- number tables and graphs separately; give them descriptive titles!
- refer to "rules for graphing" below for information on graphing

4. Discussion (*what happened and why)*

- analyze and interpret your results
- compare your results with previously published work (or in with the work of your classmates)
- point out any factors that might have impacted your results (e.g., methodological errors)
- if you started with hypotheses evaluate them in light of your results
- if your investigation leads to new questions, state those as a basis for future investigations

5. Conclusions *(the bottom line)*

- Summarize your major findings in a concise statement (not more than one or two paragraphs).
- As the title, conclusions are often abstracted and read much more often than the paper itself.
- Make sure the conclusions can be easily read and understood without reading the whole paper.

6. References cited

- Please use the style modeled in the lab exercises.

Guidelines

- ❑ On the first page list your name, the name of your lab partner(s), your course and section number, the date you submit your report.
- ❑ Your report should be an individual effort even if you have worked on the investigation as a group.
- ❑ Express ideas in your own words. **DO NOT QUOTE OR PLAGIARIZE.**
- ❑ Credit ideas that you take from others by referencing them in the section "References Cited"
- ❑ Type your report and submit a printed copy to your instructor. Make sure that you keep at least an electronic version of your work.
- ❑ Label each section appropriately and in capital letters or bold type.
- ❑ Data analysis of your results is NOT a restatement of the data, but interpretation of its significance.
- ❑ Refer to your data tables, summaries, graphs, and etc. to support your statements and show your logical deductive reasoning with appropriate explanations.
- ❑ Simply staple the sheets of the laboratory report; do not use folders.

Rules for graphing

Why visualize data?

- easier, faster interpretation
- increased visual impact

Continuous data vs. discontinuous data

continuous	discontinuous/interval
time	different treatments/classes
distance	height
temperature	litter size

Different types of graphs

type of graph	line graph (Fig. 1)	bar graph (Fig. 2)	pie chart (Fig. 3)
mostly for			
type of data	continuous/ discontinuous	discontinuous	percentages

Figure 1: Line graph

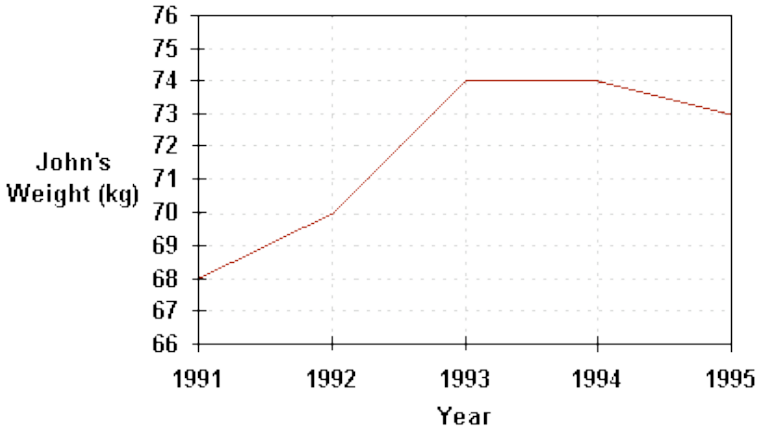


Figure 2: Bar graph

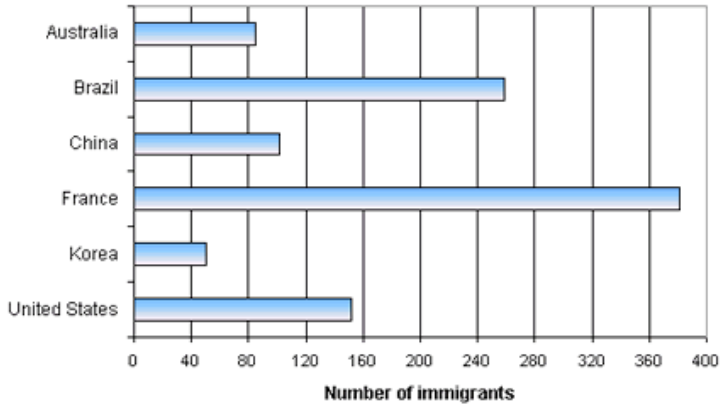
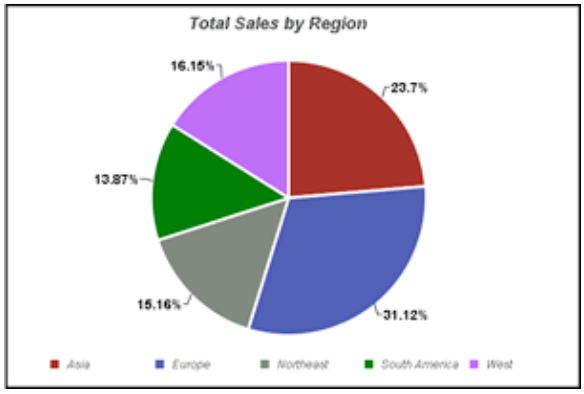


Figure 3: Pie chart



Basic rules for graphing

1. Two variables = two axes
   x: known values, independent variable; y: value that is measured, dependent variable
2. Ranges correspond to ranges of data set, should fill each axis as much as possible
3. Origin does not have to start at zero
4. Intervals between data on each axis should be a convenient number
5. Each point on the graph corresponds to a datum pair on the data table
6. Connect the points of the graph only when appropriate
7. Label axes, include units
8. Label series
9. Give graph a title, graph should be understood by itself
10. Do not put too many series in one graph (avoid clutter)

Lab Report Check-List

Title

- Describes the question of the lab **precisely**.
- As short as possible.

Introduction

- Provides context for the investigation.
- Provides background information.
- Formulates hypotheses tested.
- States assumptions for hypotheses, reasoning behind.

Results

- Presents the data obtained in a well organized manner.
- If appropriate, uses tables and graphs to summarize data.
- Tables and graphs are referenced in the text.
- Tables and graphs are numbered and have descriptive titles.
- Reports only data, not explanations or interpretations.

Discussion

- Begins with a statement of whether or not the overall results support or do not support the hypotheses.
- Provides a sufficient and logical explanation for the relationships between the results and the hypotheses.
- Compares, when appropriate, lab results to results from peers.
- Includes, where appropriate, a discussion of possible errors.
- If the investigation leads to new questions, states those as a basis for future investigations.

Conclusion

- Summarizes the major findings in a concise statement.
- Can be understood without reading the whole paper.

References cited

- The references are cited in an appropriate format.

Overall

- Sections are properly labeled.

Lab Report Evaluation Guide

Title

T1 Describes the question of the lab **precisely**.
T2 As short as possible.

Introduction

I1 Provides context for the investigation.
I2 Provides background information.
I3 Formulates hypotheses tested.
I4 States assumptions for hypotheses, reasoning behind.

Results

R1 Presents the data obtained in a well organized manner.
R2 If appropriate, uses tables and graphs to summarize data.
R3 Tables and graphs are referenced in the text.
R4 Tables and graphs are numbered and have descriptive titles.
R5 Reports only data, not explanations or interpretations.

Discussion

D1 Begins with a statement of whether or not the overall results support or do not support the hypotheses.
D2 Provides a sufficient and logical explanation for the relationships between the results and the hypotheses.
D3 Compares, when appropriate, lab results to results from peers.
Includes, where appropriate, a discussion of possible errors.
D4 If the investigation leads to new questions, states those as a basis for future investigations.

Conclusion

C1 Summarizes the major findings in a concise statement.
C2 Can be understood without reading the whole paper.

References cited

RC1 The reference are cited in an appropriate format.

Overall

O1 Sections are properly labeled.
02 Needs to work on basic grammar and spelling

Lab report progress chart

Please mark the mistakes you made in the last report and turn this sheet in with the next report. Reports without this chart count as late.

	Report 1	Report 2	Report 3	Report 4
Topic				
T1				
T2				
I1				
I2				
I3				
I4				
R1				
R2				
R3				
R4				
R5				
D1				
C1				
C2				
RC1				
O1				
O2				

Appendix D: Units and Measures

(Reprinted with permission from Heidcamp, W.H., Online Cell Biology Laboratory Manual @ http://homepages.gac.edu/~cellab/appds/appd-a.html, accessed 7/06). Also see Reed et al. page 45-49

SIZE

Cell biology deals with things which are relatively small. The units of measurement typically used are the micron at the light microscope level, and the nanometer at the electron microscope level.

Measure	Symbol	Relative Length	Exponential Notation
Meter	M	1	
Decimeter	dm	.1	10^{-1} m
Centimeter	cm	.01	10^{-2} m
Millimeter	mm	.001	10^{-3} m
Micrometer or micron	μ	.000001	10^{-6} m
Nanometer	nm	.000000001	10^{-9} m
Angstrom (old)	Å	.0000000001	10^{-10} m

From this table it is apparent that:

10 Å = 1 nm
1000 nm = 1 μm
10 mm = 1 cm

Not apparent are that:

1 inch = 2.54 x 10^{-2} m
1 inch = 2.54 cm
1 mm = 0.04 inches

VOLUME

Volumes are measured relative to a liter, with the most commonly used measurements, the milliliter and the microliter. The following table gives the relative volumes:

Measure	Symbol	Relative Volume	Exponential Notation
Liter	L	1	
Deciliter	dl	.1	10^{-1}
Millimeter	ml	.001	10^{-3}
Microliter	μ l	.000001	10^{-6}

There are 1,000 μ l in 1 ml.
1 gallon = 3.8 liters
1 quart = 0.95 liters
1 liquid ounce = 29.6 ml
1 Kg = 2.205 Lbs
1 Lb = 454.6 g

WEIGHT

The most common measurements of weight at the gram, milligram and microgram.

Measure	Symbol	Relative Weight	Exponential Notation
Kilogram	Kg	1000	10^3
Gram	g	1	10^0
Milligram	mg	.0001	10^{-3}
Microgram	μ g	.0000001	10^{-6}

PERCENT SOLUTIONS

In a solution of 2 m sucrose, there were 684.4 gm of sucrose in the final solution which weighed 1684.4 g (684.4 g sucrose + 1000 g water). The percent of sucrose on the basis of weight is therefore 684.4/1684.4 x 100, or 40.6%.

There are three means of expressing concentration in the form of a percent figure:

1. Percent by weight (w/w); g solute / 100 g solution or mixture
2. Percent weight by volume (w/v); g solute /100 ml solution
3. Percent by volume (v/v); ml solute / 100 ml solution

For dilute solutions, these differences are not significant, but at higher concentrations, they are. Chemists (when they use percent designations) usually use w/w. Biochemists and physiologists more often use w/v. Both use v/v if the solute is a liquid. It is important to distinguish among these alternatives.

Using ethanol as an example, consider a 20% solution of ethanol in water, mixed according to the three designations of w/w, w/v and v/v.

1. w/w would contain 20 g of absolute ethanol mixed with 80 g of water to yield a 20% (w/w) solution.
2. w/v would contain 20 g of absolute ethanol mixed with water to form a final volume of 100 ml.
3. v/v would contain 20 ml of absolute ethanol diluted to 100 ml with water.

The three solutions are not the same. First, the density of alcohol is not equal to that of water, and thus conversion of g to ml is not equivalent. A 20% (w/w) solution of ethanol, for example, has a density of 0.97 g/ml and 20 gm of ethanol plus 80 gm of water would have a volume of 103 ml. The % (w/v) for *this* solution (not the one in #2 above) would be 20 gm ethanol / 103 ml, or 19.4% (w/v). Similarly, absolute ethanol has a density of 0.79 gm/ml and thus 20 ml of ethanol would weigh 15.8 gm. A 20% (v/v) solution would contain 15.8 gm of ethanol in 100 ml and be a 15.8% (w/v) solution.

So, for ethanol:

20% (w/w) = 19.4 % (w/v)
20% (w/v) = 20.0 % (w/v)
20% (v/v) = 15.8 % (w/v)

In cell biology, the most common use of percent solution is as (w/v). In

practice, these are simple solutions to mix. For a 20% (w/v) sucrose solution, for example, simply weigh 20 gm of sucrose and dissolve to 100 ml with water. Unless specifically stated otherwise, solutions lacking the appropriate designation should be assumed to be (w/v).

Appendix E: Chi square analysis

Chi-square is a statistical test commonly used to compare observed data with data we would expect to obtain according to a specific hypothesis. For example, if, according to Mendel's laws, you expected 10 of 20 offspring from a cross to be male and the actual observed number was 8 males, then you might want to know about the "goodness to fit" between the observed and expected. Were the deviations (differences between observed and expected) the result of chance, or were they due to other factors. How much deviation can occur before you, the investigator, must conclude that something other than chance is at work, causing the observed to differ from the expected result. The chi-square test is always testing what scientists call the **null hypothesis,** which states that there is no significant difference between the expected and observed result.

The formula for calculating chi-square ($\mathbf{X^2}$) is:

$$\mathbf{X^2} = \sum (o-e)^2/e$$

That is, chi-square is the sum of the squared difference between observed (*o*) and the expected (*e*) data (or the deviation, *d*), divided by the expected data in all possible categories.

For example, suppose that a cross between two pea plants yields a population of 880 plants, 639 with green seeds and 241 with yellow seeds. You are asked to propose the genotypes of the parents. Your *hypothesis* is that the allele for green is dominant to the allele for yellow and that the parent plants were both heterozygous for this trait. If your hypothesis is true, then the predicted ratio of offspring from this cross would be 3:1 (based on Mendel's laws) as predicted from the results of the Punnett square (Figure 1).

	G	**g**
G	**GG**	**Gg**
g	**Gg**	**gg**

Figure 1 - Punnett Square. Predicted offspring from cross between green and yellow-seeded plants. Green (G) is dominant (3/4 green; 1/4 yellow).

To calculate $\mathbf{X^2}$, first determine the number *expected* in each category. If the ratio is 3:1 and the total number of observed individuals is 880, then the *expected numerical values* should be 660 green and 220 yellow.

Note: Chi-square requires that you use numerical values, not percentages or ratios.

Then calculate $\mathbf{X^2}$ using this formula, as shown in Table 1. Note that we get a value of 2.668 for $\mathbf{X^2}$. But what does this number mean? Here's how to interpret the $\mathbf{X^2}$ value:

1. Determine degrees of freedom (df). Degrees of freedom can be calculated as the number of categories in the problem minus 1. In our example, there are two categories (green and yellow); therefore, there is I degree of freedom.

2. Determine a relative standard to serve as the basis for accepting or rejecting the hypothesis. The relative standard commonly used in biological research is $p < 0.05$. The p value is the *probability* that the deviation of the observed from that expected is due to chance alone (no other forces acting). In this case, using $p < 0.05$, you would expect any deviation to be due to chance alone 5% of the time or less.

3. Refer to a chi-square distribution table (Table 2). Using the appropriate degrees of freedom, locate the value closest to your calculated chi-square in the table. Determine the closest *p* (probability) value associated with your chi-square and degrees of freedom. In this case ($\mathbf{X^2}$=2.668), the p value is about 0.10, which means that there is a 10% probability that any deviation from expected results is due to chance only. Based on our standard $p < 0.05$, this is within the range of acceptable deviation. In terms of your hypothesis for this example, the observed chi-square is not significantly different from expected. The observed numbers are consistent with those expected under Mendel's law.

Step-by-Step Procedure for Testing Your Hypothesis and Calculating Chi-Square

1. State the hypothesis being tested and the predicted results. Gather the data by conducting the proper experiment (or, if working genetics problems, use the data provided in the problem).
2. Determine the expected numbers for each observational class. Remember to use numbers, not percentages.

Note: ***Chi-square should not be calculated if the expected value in any category is less than 5.***

3. Calculate $\mathbf{X^2}$ using the formula. Complete all calculations to three decimal places. Round off your answer to two decimal places.
4. Use the chi-square distribution table to determine significance of the value.
   a. Determine degrees of freedom and locate the value in the appropriate column.
   b. Locate the value closest to your calculated value on that degrees of freedom row.
   c. Move up the column to determine the p value.
5. State your conclusion in terms of your hypothesis.
   a. If the p value for the calculated $\mathbf{X^2}$ is $p > 0.05$, accept your hypothesis. The deviation is small enough that chance alone accounts for it. A p value of 0.6, for example, means that there is a 60% probability that any deviation from expected is due to chance only. This is within the range of acceptable deviation.
   b. If the p value for the calculated $\mathbf{X^2}$ is $p < 0.05$, reject your hypothesis, and conclude that some factor other than chance is

operating for the deviation to be so great. For example, a p value of 0.01 means that there is only a 1% chance that this deviation is due to chance alone. Therefore, other factors must be involved.

The chi-square test will be used to test for the "goodness to fit" between observed and expected data from several laboratory investigations in this lab manual.

Table 1: Calculating Chi-Square ($\mathbf{X^2_{calc}}$)

	Green	**Yellow**
Observed (o)	639	241
Expected (e)	660	220
Deviation (o - *e)*	-21	21
Deviation^2 (d2)	441	441
d^2/e	0.668	2
$\mathbf{X^2}= \sum d^2/e = 2.668$	.	.

Table 2: Chi-Square Distribution ($\mathbf{X^2}$)

Degrees of Freedom *(df)*	**Probability** (*p*)										
	0.95	0.90	0.80	0.70	0.50	0.30	0.20	0.10	0.05	0.01	0.001
1	0.004	0.02	0.06	0.15	0.46	1.07	1.64	2.71	3.84	6.64	10.83
2	0.10	0.21	0.45	0.71	1.39	2.41	3.22	4.60	5.99	9.21	13.82
3	0.35	0.58	1.01	1.42	2.37	3.66	4.64	6.25	7.82	11.34	16.27
4	0.71	1.06	1.65	2.20	3.36	4.88	5.99	7.78	9.49	13.28	18.47
5	1.14	1.61	2.34	3.00	4.35	6.06	7.29	9.24	11.07	15.09	20.52
6	1.63	2.20	3.07	3.83	5.35	7.23	8.56	10.64	12.59	16.81	22.46
7	2.17	2.83	3.82	4.67	6.35	8.38	9.80	12.02	14.07	18.48	24.32
8	2.73	3.49	4.59	5.53	7.34	9.52	11.03	13.36	15.51	20.09	26.12
9	3.32	4.17	5.38	6.39	8.34	10.66	12.24	14.68	16.92	21.67	27.88
10	3.94	4.86	6.18	7.27	9.34	11.78	13.44	15.99	18.31	23.21	29.59
	Nonsignificant								Significant		

Source: R. A. Fisher and F. Yates, *Statistical Tables for Biological, Agricultural, and Medical Research,* 6th ed., Table IV, Longman Group UK Ltd., 1974

In short, if the differences between your model and reality are small, that is good; if huge, develop a new model! These differences are denoted at "chi-square", which equals the sum of all the squares of the deviations divided by what was expected.

The chi-square analysis of one's data does NOT tell you if your hypothesis is correct. There may be other unseen factors that make it appear so. However, if you get a huge chi-square value, your model is extremely likely to be WRONG!

Chi square exercise

You have been playing backgammon with your friend for years, and so far, winning had been pretty equal. But lately, your friend had so much luck, rolling sixes after sixes, that you wonder whether he is cheating. You both use your individual set of "lucky" dice, and you decide whether his set is naturally lucky or whether it is not. Since you are a biology major with lots of time on your hand you decide to borrow one of his dice and roll them 1310 times, recording the number coming up each time.

What should your null-hypothesis be?

Chi square worksheet

Results (observation)

Number up	Observed	Expected
1	170	
2	297	
3	210	
4	203	
5	190	
6	240	

Your result is certainly different from the expectation. But do you have enough evidence to accuse your friend of tampering with the dice? You decide to run a chi-square test to figure out how likely you would get such a deviation from expectation by chance alone.

Chi square formula:

Chi square calculation

Number	O	E	(O-E)	$(O-E)^2$	$(O-E)^2/E$
1					
2					
3					
4					
5					
6					
Total					

Compare calculated with table value

Conclusion

With a partner

1. In fruit flies, red eyes (W) are dominant over white eyes (w). A student performs a cross between a fly heterozygous for eye color and a white-eyed fly. The student counts the offspring and finds 65 red-eyed flies and 49 white-eyed flies.

2. What is the expected phenotypic ratio of this cross? _____

3. Using a chi-square test, determine if the deviation between the observed and the expected is the result of chance at a significance level of 0.05. First, formulate a null hypothesis: _____

Phenotype	O	E	(O-E)	$(O-E)^2$	$(O-E)^2/E$
Total					

4. Compare calculated with table value:

5. Come to a conclusion

Fruit fly exercise 2

In fruit flies, gray body (E) is dominant over ebony body (e). A fly heterozygous for body color and eye color (see above) is mated with a fly heterozygous for body color and with white eyes. This is the result:

- 15 flies with white eyes, ebony body;
- 31 flies with white eyes, gray bodies;
- 12 flies with red eyes and ebony bodies;
- 38 flies with red eyes and gray bodies.

In your laboratory notebook:
(You are welcome to work with a partner, but both of you need to report the results of this and the previous exercise in their notebooks).

a) Formulate your null hypothesis.

b) Calculate expected phenotypic ratio using a **Punnett square**.

c) Calculate the chi-square value using a table similar to the on above.

d) Compare the calculated value with the table value (confidence level 95%).

e) Reject or accept your null hypothesis.

Appendix F: Extra credit – Service Project

(adapted with permission from Philip Jardim, CCSF)
Biology 101A is officially classified as a university parallel course, specifically intended to prepare students to continue their studies at a four-year institution. A university can be defined as a "community of scholars". The idea is that each member of the university has an obligation to contribute to the collective fund of knowledge. Although City College does not have the resources to be a university, with the facilities and time allowances for extensive research and scholarly study, the idea of cooperation in learning is inherent in its designation as a "community college".

Another reason to offer this kind of extra credit opportunity is that it is a wonderful way to connect to other students in the course and to get your head cleared of all the abstract knowledge acquisition. To emphasize the idea of "community", the community made up of students in a class, and of the college community and the community "out there", both human and natural, up to three percent of your grade in Biology 101A can be determined by a service project.

ENVIRONMENTAL HABITAT RESTORATION
City College of San Francisco is on the forefront of an exciting new discipline in the biological sciences - habitat restoration. California has been plagued with the introduction of exotic species of plants and animals with no natural predators. These invasive species are proliferating and outcompeting the native species. CCSF has established the "Center for Habitat Restoration" to deal with the endangerment of our native species. In collaboration with the Golden Gate National Recreation Area (GGNRA) he Center will sponsor about eight restoration mornings on different weekends to help restore various parks around San Francisco. Participating in two of the restoration days would satisfy the 8 hour requirement for your service project. If you would like to participate in one of the mornings, **please sign up in the folder in the Biology Department office.** If you change your mind and cannot attend, **please cross your name out. Signing up and not showing up will exclude you from further service activities.**

You need to turn in one report (whether you went once or twice). This report should include the following information:

1. When and where did you perform your community service learning?
2. General feedback: did you think this is a good extra credit project for this class?
3. What did you learn?
4. Most important, what connections do you see between the ecosystem you worked in and the system "cell" that we have been studying in class?

Habitat restoration days are usually on Saturdays. Transportation is provided starting on Phelan Avenue at the bottom of the steps leading to the Science building. Is Saturdays do not work for you, contact your lecture instructor **early in the semester** to arrange for an alternative project. **I cannot guarantee** a project for you if you have not let me know that you are interested in extra credit by **September 30.**

Appendix G: What Is Plagiarism?

(Adapted from the LAC Writing Lab handout, with additional material by July Lewis – Bio 101A student Spring 2003)

What Is Plagiarism?

Plagiarism is the unlicensed usage of another person's work. This can include:

- Taking the words or ideas of another and either copying or paraphrasing without giving credit to the source (e.g. endnotes, quotation marks, in-text citations).
- Copying a paper off the internet and turning it in as your own.
- Cutting and pasting sections from an internet source into your own paper.
- Letting someone else do your paper, or turning in a paper that has been heavily edited by a tutor.

What can I do to avoid plagiarism?

- **Cite all sources**. Use quotation marks for direct quotes. It helps to write down the title, author and page number of your sources as you go along.
- **Paraphrase**, **don't copy**. Restate the idea in your own words. Make sure to give an in-text citation for the use of the idea.
- **Understand the subject matter** before writing your paper. If you are unclear about the subject, you are more likely to rely on the exact wording of the author. Also it is important that you understand each quote and fact from your source before you use it.

How can I tell if I'm paraphrasing or plagiarizing?

When paraphrasing sources, it is often difficult to judge how much we need to reword the source material in order to avoid plagiarism. Students who are learning English may have an especially hard time with rephrasing. What makes it even harder is that what is acceptable practice in other countries can be considered plagiarism in the U.S.! Here are some guidelines to follow when paraphrasing:

- **Use synonyms.** Avoid using the same word choices as the source.
- **Vary sentence structure.** Changing the words but not the structure can still be considered plagiarism.
- **Mix it up.** Don't present the ideas in your paper in the same order as the source that you are using. Incorporate your own ideas and those of other authors (properly cited, of course) to make your writing as fresh and original as possible. And of course…
- **Cite your sources!**

EXAMPLE—Here is a quote followed by three different paraphrases:

"The researchers reached the conclusion that undernourishment was the main cause of the decline in the mouse population."

> **Version 1:** The researchers came to the conclusion that starvation was the major cause of the decline in the mouse population (Borgia 46).

Even though the source is cited, this is plagiarism. Only three words are changed.

> **Version 2:** The group decided that starvation was the major reason for the decline in the numbers of mice (Borgia 46).

This one is better— most of the words are changed—but the form is the same. It isn't ideal, but you could probably get away with a few sentences like this in your paper.

> **Version 3:** After analyzing the data, it was clear what had caused the decline: the mice weren't getting enough to eat (Borgia 46).

In this sentence, the form is changed, the words are changed, the tone is different (less clinical, more like a news article), and it includes the slightly different bit of information: "after analyzing the data". This is a good paraphrase!

Do I need to cite information that is common knowledge?

No—the trouble is determining what is common knowledge and what is not. Original research and opinions are not common knowledge, and must always be cited. But what about established information?

To some degree, it depends on your level of expertise and on whom you are directing your paper to. For example, the fact that mosquitoes carry malaria is common knowledge for a college student, but a fourth-grader might have to cite this information. The details of the life cycle of *Plasmodium vivax,* an organism that causes malaria, are probably not common knowledge to the average BIO 101A student. Therefore, they would have to be cited. However, an expert in malaria writing for *The Journal of Parasitology* would not need to cite this information—for that group, it is common knowledge. A good rule of thumb is: if you had to look it up, cite it.

Other resources

There are a number of places to get more information on this topic. *The Bedford Handbook* and *The Little, Brown Handbook* that many English classes require have good sections on plagiarism and how to avoid it. The following websites are also good:

http://www.indiana.edu/~wts/wts/plagiarism.html

http://owl.english.purdue.edu/Files/151.htm

http://webster.commnet.edu/mla/plagiarism.htm

Finally, the writing tutors at the Learning Assistance Center in the Rosenburg Library are always available to help with students' writing assignments, including science papers.

Appendix H: How to Write a Summary

Adapted by Dr. Donna Hart (http://www.greenville.edu/faculty/dosthart/howsumm.html) from Laurence Behrens and Leonard F. Rosen, *Writing and Reading across the Curriculum*, 8th ed., New York: Longman, 2003, p. 6.

What is a summary? It is a fairly brief restatement--IN YOUR OWN WORDS--of the contents of an article. Strictly speaking, you simply report back what the other writer has said. It is not your job to make value judgments about the "rightness" or "wrongness" of what (s)he says. That would be a different kind of paper--a summary-response, a critique, or a position paper.

While it is hard to give concrete guidelines for length, many good summaries are about 1/4 to 1/3 the length of the original.

What are the steps in writing a summary?

I. Read through the whole piece--carefully. Annotate (underline, highlight, asterisk, star, flag things; comment in the margins) as you read.

II. When you finish, look back for the 1-2 sentences that state the author's main point. Write it/them down or place some special annotation in the margin of your book. This is the article's thesis statement. While it may appear early in the essay--the first paragraph or two (as you are taught to locate yours), it may not, in fact, be stated until the end of the piece (almost as if it were a conclusion).

III. Reread the selection, dividing it into sections of thought. Each section may be one paragraph, but, more likely, each section will incorporate several paragraphs.

IV. Write a sentence or two summarizing each section of thought. If you have trouble doing this, you might try writing a summary sentence for each paragraph and then revising where you see yourself repeating ideas.

V. Write a first draft of your summary, including the following items:

   A. In the first sentence or two--

      1. the author's name.
      2. the article's or chapter's name (perhaps even the magazine's or book's name in which the article or chapter appeared).
      3. the author's thesis statement.

****Here's an example: "In our excerpt from The Idea of a University, John Henry Newman argues that the real purpose of a university education is*

to help students become wise, enable each one to understand as much as possible of the world in which (s)he lives and to see clearly how each piece of knowledge relates to each other piece of knowledge."

B. Next, your summary sentences for each paragraph or section. Put them in the same order that the author presents the essay, because you are, after all, simply reporting back what (s)he says.

C. You should make every effort to put the author's ideas into your own words--to avoid plagiarism. However, you may occasionally want to quote a point directly from the author. That's okay; just be sure to place quotation marks around what you have borrowed and cite your page number.

D. Occasional supporting details, if and only if they are the most significant ones.

VI. Check your draft against the original piece for accuracy.

VII. Revise the summary to "smooth out" its choppiness. In other words, link your section summary sentences together with good transitional words or phrases (like in addition, moreover, on the other hand, however, finally).

VIII. Proofread and spellcheck.

Appendix I: SCANS competencies

The Secretary of Labor's Commission on Achieving Necessary Skills has identified particular competencies as essential for success in all jobs (the SCANS competencies, see attached list). Throughout the course, I have incorporated exercises and assignments that give you a chance to practice these skills (see list of skills below). The objectives of each laboratory exercise will highlight which of those competencies are addressed so that you can connect what you learn in college to the skills you will need in your profession.

Skills Essential For Success In All Jobs
As Identified By The Secretary of Labor's Commission On Achieving Necessary Skills:

Resources
Identifies, organizes, plans, and allocates resources.

- Time: selects goal-relevant activities, ranks them, allocates time, and prepares and follows schedules.
- Money: uses or prepares budgets, makes forecast, keeps records, and makes adjustments to meet objectives.
- Material and facilities: acquires, stores, allocates, and uses materials and space efficiently.
- Human resources: assesses skills and distributes work accordingly, evaluates performance, and provides feedback.

Interpersonal
Works with others.

- Participants as member of a team: contributes to group efforts.
- Teaches others new skills.
- Serves clients and customers: works to satisfy customers' expectation.
- Exercises leadership: communicates existing procedures and policies.
- Negotiates: works towards agreements involving exchange of resources, and resolves divergent interest.
- Works with diversity: works well with men and women from diverse backgrounds.

Information
Acquires and uses information.

- Acquires and evaluates information.
    - Organizes and maintains information.
    - Interprets and communicates information.

- Uses computers to process information.

System
Understands complex inter-relationships

- Understands systems: know how social, organizational, and technological systems work and operates effectively with them.
- Monitors and corrects performance: distinguishes trends, predicts impacts on system operations, diagnoses deviations in systems' performance, and corrects malfunctions.
- Improves or designs systems: suggests modifications to existing systems and develop new or alternative systems to improve performance.

Technology
Works with a variety of technologies.

- Selects technology: chooses procedures, tools, or equipment including computers and related technologies.
- Applies technology task: understands overall intent and proper procedures for setup and operation of equipment.
- Maintains and troubleshoots equipment: prevents, identifies, or solves problems with equipment, including computers and other technologies.

Foundation Skills

Basic skills:
Reads, writes, performs arithmetic and mathematical operations, listens, and speaks.

- Reading: locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules.
- Writing: communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts.
- Arithmetic/Mathematics: performs basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques.
- Listening: receives, attends to, interprets, and responds to verbal messages and other cues.
- Speaking: organizes ideas and communicates orally.

Thinking skills:
Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reason.

- Creative thinking: generates new ideas.
- Decision making: specifies goals and constraints, generates alternatives,

considers risk, and evaluates and chooses best alternatives.
- Problem solving: recognizes problems and devises and implements plan of action.
- Seeing things in the mind's eye: organizes, and processes symbols, pictures, graphs, objects and other information.
- Knowing how to learn: uses efficient learning techniques to acquire and apply new knowledge and skills.
- Reasoning: discovers a rule of principle underlying the relationship between two or more objects and applies it in solving a problem.

Personal qualities:
Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty.

- Responsibility: exerts a high level of effort and perseveres towards goal attainment.
- Self-esteem: believes in own self-worth and maintains a positive self.
- Sociability: demonstrates understanding, friendliness, adaptability, empathy in group settings.
- Self-Management: assesses self accurately, sets personal goals, monitors progress.
- Integrity/Honesty: chooses ethical courses of action

Source: Secretary's Commission on Achieving Necessary Skills (SCANS) (1991, June).

Workplace competencies and laboratory techniques
Biology 101A at San Francisco City College

Skill	Activity
Information	
Acquires and evaluates information	• Researches different molecular aspects of a disease • Uses online bioinformatics tools • Discusses bioethical dilemmas • Evaluates web resources • Observes microscope slides and test results
Organizes and maintains information	• Maintains scientific legal laboratory notebook • Prepares protocols • Performs metric conversions
Interprets and communicates information	• Prepares laboratory reports following the scientific format • Writes a comprehensive research paper including proper quotations • Creates biological drawings including measurements and labels • Performs chi square analysis • Analyzes data using computer tools • Graphs data • Prepares standard curves
Uses computers to process information	• Uses online biological databases • Researches online resources • Graphs data using Excel • Submits assignments electronically
Interpersonal	
Participates as member of a team	• Investigates most lab questions in a team • Solves lecture assignments in a team • Compares disease research with other group members
Provides feedback	• Provides feedback on research paper • Provides feedback on worksheet assignment • Provides weekly feedback on lecture concepts

Workplace competencies and laboratory techniques
Biology 101A at San Francisco City College

Technology	
Applies technology task: understands overall intent and proper procedures for setup and operation of equipment	• Agarose gel electrophoresis • Asepsis • Biochemical tests • Cell fractionation • Cell lysate preparation • Cell well plates • Centrifugation, low and high speed • Chromosome mapping • Compound light microscopy • Differential staining • ELISA • Koehler illumination • Laboratory safety • Microcentrifugation • Micropipetting • Microscopic measurements • Paper chromatography • PCR • Pipetting • Preparation of a standard curve • Creation of recombinant DNA molecule • Restriction of plasmid DNA • Sample collection • Serial dilutions • Spectrophotometry • Transfer bacterial cultures • Transformation of bacterial cells with recombinant plasmid • Wet mounts