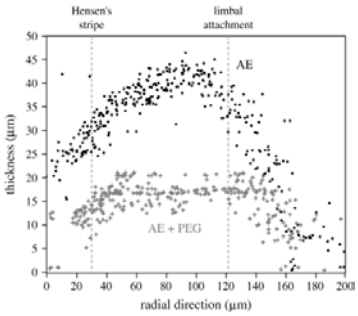
Technical Writing:

How to translate data into a written presentation of your findings



Quantitative Physiology: Cells and Tissues
Fall 2006

Goals of Technical Writing

Readability :

- Clear, simple prose that is not laden with jargon
- Appropriate use of technical vocabulary

Expected Document Design :

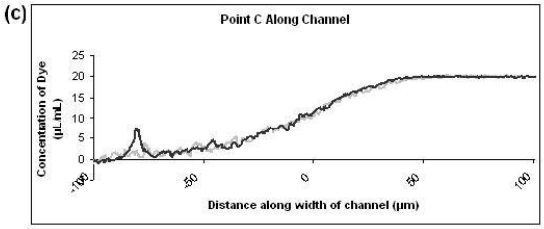
- Standard format makes it easy to locate data and compare experiments (methods, etc.)

Abstract	= 1 paragraph summary of report.
1.0 Introduction	(< 1 page) offers a rationale for your study.
2.0 Methods	describes final approach to experiment.
3.0 Results	describes but does not interpret major findings.
4.0 Discussion	offers your interpretations of your findings.
5.0 Conclusion	summarizes the report and explains future research.

Step 1: Organize your data

Writing your lab report begins in the lab.
Save all interesting images, figures, plots, tables, ...
Did you adequately document your key findings?

frame	min	max	slope
1	115.0	241.3	0.684
2	120.8	228.9	0.547
3	126.0	217.5	0.449
4	130.5	209.3	0.379
5	134.1	202.9	0.333
6	138.0	197.5	0.294
7	139.9	189.5	0.245
8	142.0	184.8	0.210
9	144.2	184.6	0.193
10	145.8	180.7	0.188
11	147.9	179.0	0.156
12	149.5	176.7	0.122
13	150.2	175.8	0.108
14	151.3	173.3	0.099
15	152.5	172.0	0.090
16	153.3	171.2	0.082

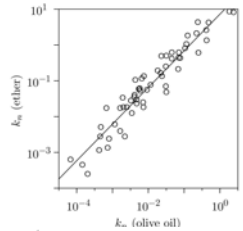


Step 2: Locate trends in data

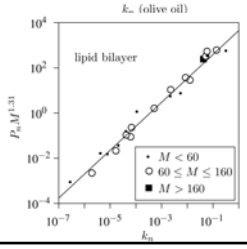
Look at the entire data set & individual plots.

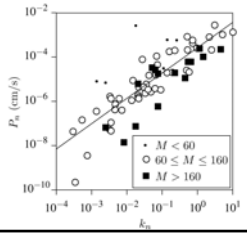
What interesting or unexpected trends do you see?

→ define main technical theme of your report



Solute characteristics			Membrane permeability (cm/s)			
Name	M	k	*Chara ceratophylla*	*Nitella mucronata*	Human erythrocytes	Artificial lipid
Water	18	1.3×10^{-3}	6.6×10^{-4}	2.5×10^{-3}	1.2×10^{-3}	2.2×10^{-3}
Formamide	45	1.1×10^{-6}	2.2×10^{-5}	7.6×10^{-6}	1.1×10^{-6}	1.0×10^{-4}
Butyramide	87	1.1×10^{-6}	5.0×10^{-5}	1.4×10^{-5}	1.1×10^{-6}	
Urea	60	1.5×10^{-4}	1.1×10^{-6}	1.3×10^{-7}	7.7×10^{-7}	4.0×10^{-6}
Thiourea	76	1.2×10^{-3}	2.0×10^{-6}	3.6×10^{-7}	1.1×10^{-6}	
Ethanol	46	3.6×10^{-2}	1.6×10^{-4}	5.5×10^{-4}	2.1×10^{-3}	
Ethanediol		4.9×10^{-4}	1.1×10^{-5}		2.9×10^{-5}	8.8×10^{-5}
Glycerol	92	7.0×10^{-5}	2.0×10^{-7}	3.2×10^{-9}	1.6×10^{-7}	5.4×10^{-6}
Erythritol		3.0×10^{-5}			6.7×10^{-9}	

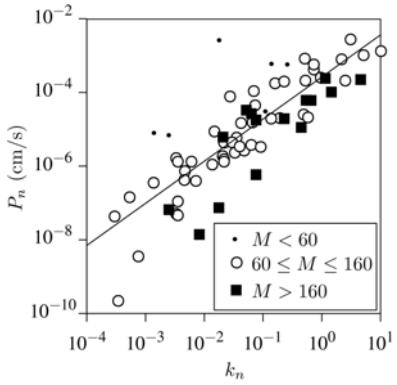




- *Pn* proportional to *kn*?
- *Pn* depends on cell type?
- *Pn* depends on solute?

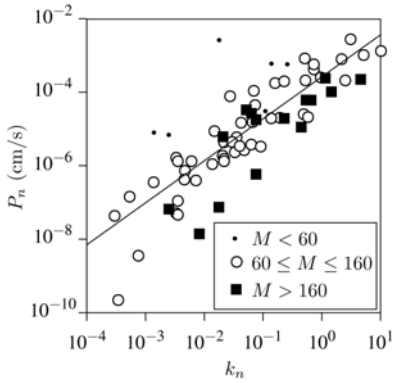
Step 3: Design figures that best tell main theme

Develop 2-3 bullet points for each figure.



Step 3: Design figures that best tell main theme

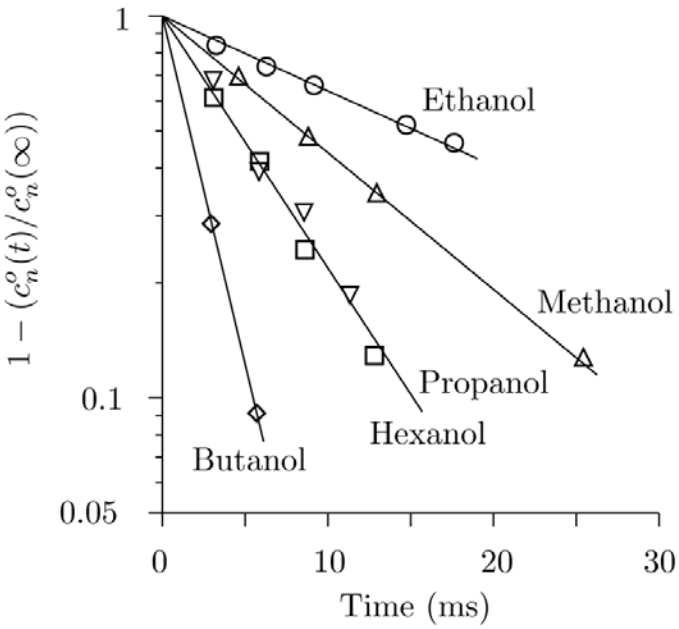
Develop 2-3 bullet points for each figure.



Methods
- measuring *Pn*
- measuring *kn*
- fitting straight lines to data
- calculating correlation coefficients

Results
- each dot represents … } caption?
- the line represents …
- large range of *Pn*
- large range of *kn*
- regression line: *Pn* =1.14 log *kn* -3.58... caption?
- correlation coefficient = 0.8
- most of *M*>160 below line; all of *M*<160 above line

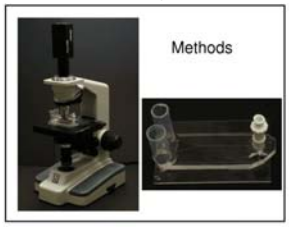
Discussion
- correlation: supports dissolve and diffuse theory
- scatter: dissolve/diffuse not the whole story
- outliers: solutes transported by other mechanisms

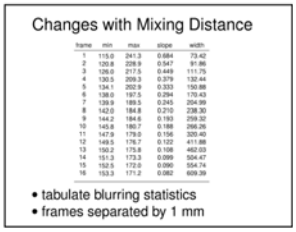


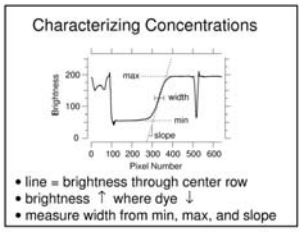
Step 4: Integrate figures into a 'story board'

- Assemble figures into a 'story board'
- Assess how each figure contributes to the major theme
- REVISE figures to focus on the major theme
- REVISE bullet points to focus on the major theme
- Add figures to fill in gaps
- Remove figures to eliminate redundancy

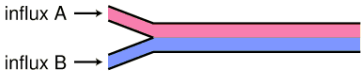
Sample Draft Storyboard



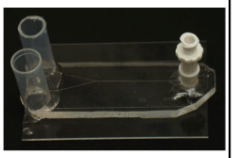




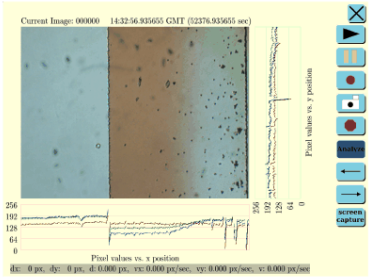
Background



Methods



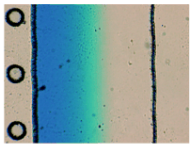
Results



Discussion

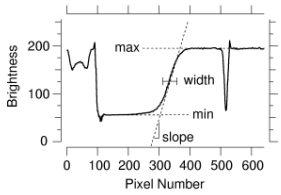
- Developed Theory
- Showed Methods
- Showed Results
- Future Work

Sample Image



- circles are distance markers (250 µm)
- blue dye in left channel, none in right
- blurring of dye in center → diffusion

Characterizing Concentrations



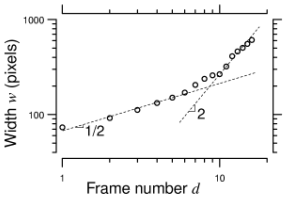
- line = brightness through center row
- brightness ↑ where dye ↓
- measure width from min, max, and slope

Changes with Mixing Distance

frame	min	max	slope	width
1	115.0	241.3	0.684	73.42
2	120.8	228.9	0.547	91.86
3	126.0	217.5	0.449	111.75
4	130.5	209.3	0.379	132.44
5	134.1	202.9	0.333	150.88
6	138.0	197.5	0.294	170.43
7	139.9	189.5	0.245	204.99
8	142.0	184.8	0.210	238.30
9	144.2	184.6	0.193	259.32
10	145.8	180.7	0.188	266.26
11	147.9	179.0	0.156	320.40
12	149.5	176.7	0.122	411.88
13	150.2	175.8	0.108	462.03
14	151.3	173.3	0.099	504.47
15	152.5	172.0	0.090	554.74
16	153.3	171.2	0.082	609.39

- tabulate blurring statistics
- frames separated by 1 mm

Width Versus Mixing Distance



- log-log plot of w versus d
- $w \propto \sqrt{d}$ → consistent with theory
- $w \propto d^2$ → "edge effects" ?

Step 5: Translate bullet points into report text

- Use “story board” as an “outline” of your report.
- Develop bullets into well-supported arguments. Integrate figures with text.
- Read & revise to fill in gaps
- Add abstract, references, and other supporting material.

If you divide the writing process, use the following division:

writer 1: Methods + Results

writer 2: Introduction + Discussion

together: Conclusion, Title, Abstract, TOC, References, proofreading

How would you improve this results text?

3.0 Results

The bacteria count and the calculated ratios and standard deviations are listed in Appendix C. Figure 5 shows a graph of the ratios of the bacteria counts with errors bars. The lengths of the error bars are the standard deviations.

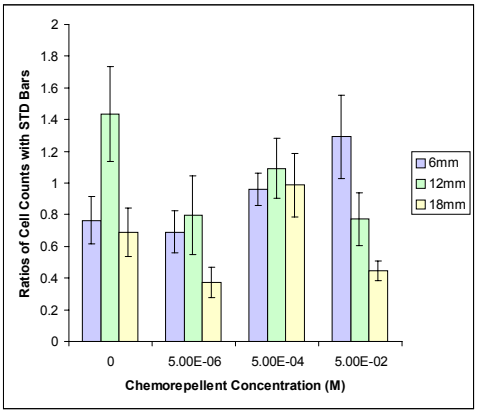


Figure 5: Results for 3 trials

Results section describes major findings

3.1 Brightness contours.

Figure 2 illustrates the effect of dye on brightnesses measured from images of the microfluidics chamber. The right portion of the profile shows the portion of the image that corresponds to the fluid-filled region. The left part of the fluid-filled region contains blue dye. The right part contains no dye. The presence of the dye clearly attenuates the brightness of the blue pixels. Furthermore, there is a gentle transition in blue brightness in the center portion of the fluid-filled region. Straight lines were fit to the center portion of the data to characterize the steepness of this transition, and results for a series of adjacent images are shown in Figure 3.

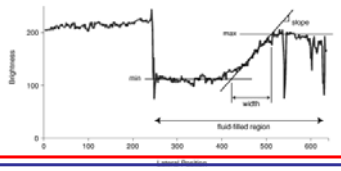


Figure 2: Sample brightness profiles. Each line in this plot shows brightness as a function of distance across the image through the center row of pixels. Each line shows results for a different color: blue indicates red pixels, magenta indicates green pixels, and yellow represents green pixels.

Subheading

Description

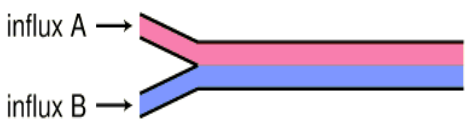
Figure

Caption

How would you improve this methods text?

2.0 Methods

A three-input device was used to perform the experiments (Figure 1). The chemorepellent mixture at input 2 of the microfluidic device was varied for each trial. All trials were performed using the same microfluidic device. The device was washed thoroughly with distilled water after each trial. The Camscope program was configured to take 30 pictures at a rate of 30 pictures per second in MONO mode. It was observed that the bacteria rarely moved to the outer walls of the channel. The chemotaxing bacteria in each of the 30 pictures were counted and averaged in order to find the number of bacteria chemotaxing into that area.



Methods describes final approach to experiment

Methods

The inputs to a laminar flow device with two input channels and one output channel (**Figure 1**) were varied for three experiments, as shown in **Table 1**. Because gravity is the driving force for flow through the laminar flow device, the heights of the solutions in each input column were adjusted so that the speeds of the two inputs were approximately equal.

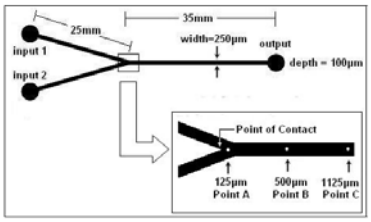


Figure 1: Schematic Diagram of Laminar Flow Chamber. A two-input laminar flow chamber was used to observe the mixing of two solutions. Fluid in the center of the channel travels down the channel at a constant speed. Therefore, a point at a fixed distance from the point of contact shown corresponds to a particular time that the solutions have been in contact. Diffusion was observed at three points along the channel, labeled as Points A, B, and C.

Table 1: Inputs to the Laminar Flow Chamber *

	Input 1 * (ratio of dye:solvent=2:100)		Input 2 * (no dye)	
Test 1	50% Water/ 50% Methanol	1.02mL	50% Water/ 50% Methanol	1.02mL
Test 2	Methanol	1.22mL**	Water	1.02mL

* All inputs contained 30μL of Microscopic polystyrene beads for measuring the speed of the fluids.
** Amount of Input 1 was increased to equalize Input 1 and Input 2 speeds varying due to solvent density differences.

Detailed thoroughly so that a reader could reproduce your experiment.

With clearly labeled device information for trials

Organize Methods by topic, not chronology

3.1 Laboratory Setup
The laboratory setup consisted of a laminar flow chamber and video microscope as described in the lab manual [1]. The width of the channels was 500 μm and the thickness was 100 μm. ...

3.2 Experimental Procedure
The diffusivities of three food colorings (red #2, blue #6, and green #5) were measured in separate experiments. For each experiment, one input reservoir was filled with food coloring and the other was filled with deionized water. ...

3.3 Data Collection
Images were obtained using the camscope program. The laminar flow chamber was oriented so that the direction of fluid motion was vertical. Static images were obtained to characterize ... Sequences of images were obtained ...

3.4 Data Analysis
Images were analyzed to determine fluid velocities and diffusivities as follows.

3.4.1 Fluid Velocity
Fluid velocities were measured by tracking the motions of microspheres ...

3.4.2 Diffusivity
Concentration profiles along the horizontal direction were constructed by averaging the blue intensity for all the pixels in a column and then plotting that average for each horizontal position as a function of horizontal position. Gradients were calculated from concentration profiles using a regression technique implemented with MATLAB. ... (more details) ...

Discussion offers your interpretations of findings

5. Discussion.

Images of dyes flowing through microfluidic chambers were analyzed to determine the diffusivities of the dyes. Our results suggest that such measurements can be quite accurate, but that care must be taken to avoid a number of potential problems. These potential problems are discussed in this section.

How your results relate to the goals of your study

5.1 Effect of side-walls on measured diffusivities.

Results from section 4.3 show two distinct trends. For short diffusion times, the transition width increases with the square root of time. However, for long difusion times, the transition width increases with the square of time. The first trend is consistent with predictions of the diffusion equation, while the second is not. We suggest that the second trend results because of edge effects due to the side-walls of the microfluidic channels. This suggestion is consistent with the fact that the measured transition width was nearly as large as the channel width for long diffusion times. However, there are a number of other possible explanations as well. For example, it is also true that the fluid velocity was more nearly uniform near the center of the channel than it was near the edge. Perhaps the fluid velocity also affected diffusive mixing. It may be possible to test these explanations more directly by repeating measurements of this time in chambers with different widths. Alternatively, both of these effects could be studied using numerical simulations. Such simulations could provide better tools for analysis of data taken from microfluidic systems.

Use evidence from results to support your interpretation

Explain limitations, questions left unanswered, lack of correlation, or experimental constraints

Introduction offers a rationale for your study

1. Introduction

In recent research, Raman spectroscopy has proven particularly useful in determining the chemical composition of coronary artery walls [1, 2, 3]. The Raman effect is an inelastic scattering phenomenon that occurs when light interacts with matter. While the majority of light that is incident upon a sample will either be directly transmitted through it, or be elastically scattered, there is a small (~10-9) probability that some of the light will lose energy to the sample, leaving the molecules in an excited vibrational state [4, 5, 6]. Because each molecule has a unique set of bonds, Raman spectroscopy allows quantitative identification of chemicals.

Prior research

Two problems, however, with *in vivo* studies of coronary arteries using Raman spectroscopy are catheter size and data acquisition speed. A catheter, or probe, intended to perform *in vivo* imaging of the coronary artery must be small enough to comfortably fit in the vessel . . . As the size of fibers and probes becomes smaller, it is important to understand the effects of scattering and absorption of laser photons by the tissue, as well the ability of fibers to collect Raman scattered photons which have also diffused through the tissue. To better understand these effects, we created a representation of a side viewing probe to model the path of photons through tissue while maximizing collection.

Problem not addressed or issue furthered

To achieve this effect we used the optical design program, Zemax. This program allowed us to create a realistic simulation of a Raman probe and then vary certain elements, such as the size and numerical apertures of the excitation and collection fibers, in an attempt to collect as much Raman scattered signal as possible.

Your approach

Conclusion summarizes results of research & study limitations

4. Conclusion

In this project, we were able to utilize the Zemax optical design program to develop a model of a side-viewing probe for taking Raman spectroscopic measurements of the coronary artery wall. Using the probe in simulations, we determined the scattering and absorption effects that the tissue has on excitation light photons. We were then able to simulate Raman scattering and isotropically send light photons back through the probe while preserving power and distribution at each depth into the tissue to precisely observe collection at the end of the fiber. We observed a retention rate of approximately 1.1% of light photons that experienced Raman scattering in the tissue. These findings further establish that Raman spectroscopy has the potential for *in vivo* evaluation of tissue compositions. These new methodologies could be used for early detection of coronary heart diagnosis.

Research summary

Future research

Abstract

The abstract is a 1 paragraph (approximately 150 words) summary of the report, including the goal of the study, summary of methods used, principal results obtained, and conclusions.

SAMPLE ABTRACT

It is generally assumed that the mixing of solutes during flows in microchannels is governed by diffusion alone. To test this assumption, two streams of water were flowed next to each other in laminar flow chambers with widths of 500 micrometers and thicknesses of 100 micrometers. Different size microspheres (1 and 2 micrometer diameter) were dispersed in each of the two streams. Mixing of the two fluids was assessed by mixing of the different diameters. Results showed an apparent diffusivity of approximately 3×10^{-4} cm^2/s, which far exceeds that which could be attributed to diffusion. Analysis of flow patterns revealed by tracking the positions of microspheres as a function of time suggest that non-uniformities in the channel walls could contribute to this unexpected mixing. Experiments with different size beads gave similar results. However, experiments with different concentrations of beads showed different levels of unexpected mixing, suggesting that the microspheres may themselves contribute to mixing.

End Matter

Acknowledgements

Give credit to anyone who helped you with your research.

Works Cited

IEEE Style

Appendices

- Notes taken during lab session
- Final proposal
- Copy of your critique of peer report
- Peer critique of your report
- Technical staff critique of your report
- Writing staff critique of your report

Submit with final report

6.021J AUTHOR GUIDELINES

CONTENT: A lab report in 6.021J Quantitative Physiology is a description and analysis of your research. The primary audience of your report is other 6.021J students. It is expected that your research was jointly conducted and authored. We do not expect you to reach grand theories or expect all your research to be successful. We do expect you to offer a rationale that explains why this research is relevant, provide a detailed and accurate methods description, disclose your results, and discuss reasons why your experiment succeeded or failed by linking that discussion to your results and methods.

STYLE: We prefer an informal by not colloquial; style of writing to a textbook style or jargon-laden prose. You may use occasional instances of personal pronouns in your report. Your readers, the students and faculty in this course, all have some background in this subject, but only a very small percentage are experts. A clear conceptual discussion is far better than a plethora of technical details that have no over-arching meaning or organization.

MANUSCRIPT FORMATTING: All pages should be numbered, starting with the first page of the report body. Please include a Cover Page that includes authors' names as well as title of your report and submission date. Please include your Abstract on this Cover Page. Do not number the Cover Page. Every report needs to include in the body the following major section headings: Introduction, Methods, Results, Discussion, and Conclusion. Within each of these sections, you may use more descriptive subheadings. A Table of Contents is optional.

LEGNTH: Please limit your report to 3,500 words. We prefer single-spaced texts with clear page breaks. Appendices are not included in the word count limit. Avoid lengthy Appendices as most readers will not read them carefully.
FIGURES: We recognize that sometimes "a picture is worth a thousand words," but please avoid the gratuitous use of figures in your results. Five to 10 figures should be sufficient for your report. Use figures to synthesize results and show trends or comparisons across findings. Integrate your figures with your text to create a "story" between text and figure. Large figures should not run across pages. Each figure needs to be numbered and include a figure caption and label. Please 'clean up' your figures from MatLab by removing unnecessary grid lines and shading. In addition, please make figures legible by using a 10 or 12-point font size for captions and axis labels.

REFERENCES: You need at least one reference for your report. Most 6.021J students reference the Weiss text. Many report Introductions also include references to research.

FURTHER RESOURCES: The Mayfield Handbook of Scientific and Technical Writing is available at https://web.mit.edu/course/21/21.guide/www/home.htm

SUBMISSION OF MANUSCRIPTS: Please submit a hard copy of your *first draft* at your recitation on Thursday, October 19th AND upload a PDF copy of your *first draft* by Thursday, October 19th at 5pm EST. All drafts should be uploaded to the 6.021J course website at http://umech.mit.edu/freeman/6.021J/2006/php/online.php.

Final Draft:(1) Please submit a hard copy of your *final draft* at your recitation on Thursday, November 2nd. All supporting materials for the Appendix should be submitted with your final report on November 2nd. (2) Please submit a PDF copy of your *final draft* by Thursday, November 2nd at 5pm EST. All drafts should be uploaded to the 6.021J course website at http://umech.mit.edu/freeman/6.021J/2006/php/online.php.

Grade Sheet

First draft of report (10%).
A: Complete report, professionally written.
B: Significant work, but report needs further clarification before final submission.
C: Incomplete descriptions, missing sections, or poor figures.
D: Few results, few figures, few discussion points, report not complete.

Critique of peer report (5%).
A: Several helpful high-level suggestions (e.g., suggesting major restructuring, new figures,...) plus probing questions (could your result be caused by...?) plus appropriate low-level comments (e.g., on grammar or graphics).
B: At least one helpful high-level suggestion or probing question plus appropriate low-level comments.
C: Helpful low-level comments.
D: Few helpful comments.

Report Structure (15%).
A: All information is present and is well organized in proper sections, using standard scientific report structure. Appropriate use of source materials. Reader can easily follow from section to section of report.
B: All information is present but poorly organized in no more than one section. Reader may have difficulty following one section of report but generally understands overall report structure.
C: All information is present but multiple instances of misplaced information, and/or repeated minor organizational problems that interfere with report coherence. Reader struggles to understand relationship between various sections of the report or has difficulty following structure in several sections.
D: Information is missing from report, report does not follow standard scientific report structure and/or misuse of source materials. Reader cannot follow overall structure of report.

Clarity and Conciseness of Exposition (10%).*
A: Content of each paragraph is readable with clear, simple prose and appropriate use of technical language. Each graph clearly supports the prose.
B: content is readable with minor slips in clarity or a single unclear passage/graph.
C: Major slips in clarity and/or multiple unclear passages/graphs.
D: Repeated wordiness or lack of clarity, poor presentation of visual information, and/or accumulation of stylistic errors that interfere with readability.
* Grades may be reduced for reports that unnecessarily exceed he 10 page (3,500 word) limit.

Technical Clarity and Conciseness (10%).
A: Methods, Results, and Conclusions are technically clear and concise.
B: Minor lapses in technical clarity or occasional extraneous technical points.
C: Significant lapses in clarity and conciseness, but clear enough to assess results and conclusions.
D: So unclear that results or conclusions cannot be assessed.

Conceptual Correctness (20%).
A: Thorough investigation of at least one topic, authors demonstrate a clear understanding of this topic, and there are no technical errors.
B: Thorough investigation of at least one topic, and no technical errors.
C: Thorough investigation of at least one topic, but one or more minor technical errors.
D: Investigations are insufficiently thorough (e.g., measured too few cases to support a trend) or contained major technical errors.

Insightfulness (30%).
A: Clever experimental design, compelling experimental results, and imaginative analysis.
B: Clever experimental design, compelling experimental results, or imaginative analysis.
C: Acceptable experimental design, adequate experimental results, and acceptable analysis.
D: Unacceptable experimental design, inadequate experimental results, or unacceptable analysis.