Topics:

1. Email etiquette – how to (and how not to!) write emails to your professors and employers
2. How to make proper Graphs and Tables for laboratory or research reports
3. Writing tips for scientific papers
4. How to list references and include citations in science papers
5. Research definitions
6. Dimensional analysis – advice for computations in biology, chemistry, physics
7. Units and Conversions
EMAIL ETIQUETTE

Emails sent to professors, teaching assistants, university staff, current or prospective employers, businesses, etc. should be considered **formal communication** and should be styled accordingly.

**Formal, professional emails should include:**

1. **A formal address.** For example: “Dear Dr. Jones:” A colon (:) is more formal than a comma (,), however either is correct. The following are examples of **informal** addresses that should be reserved for unprofessional contexts: “Hey Dr. Jones”, “Hi”, “Dear Jane”, etc.

2. **A clear and concise text.**
   a. If the recipient doesn’t know you, you may want to introduce yourself, for example: “I am a student in your Tues/Thur basket weaving class” or “I am a junior exercise science major at Northern Arizona University”.
   b. State your question or comment. For example “I would like to have clarification on the correct answer to question 36 on the exam regarding the slime producing technique of the slug”.
   c. Use correct punctuation and capitalization. Your email should adhere to proper English grammar and style.
   d. Include contact information. If you think the recipient of your email might prefer to call you, include your phone number. If relevant, include your address.

3. **A formal signature.** You can’t actually sign an email, but you should always type your full name at the bottom. Examples of a formal closing include: “Sincerely, Joe Johnson” or “Thank you, Jill Jacobs”. Be sure to **OMIT** any informal signature line you have made for yourself such as “Bridget Jones, Bikini Modeler Extraordinaire, Check out my web page for my revealing autobiography”.

**Examples**

**A. Unprofessional email:**

hi this is crystal i was wondering how i did on the exam can you tell me my grade i am worried because i don’t want to get a c in the course call me

**B. Same email, more professional:**

Dear Dr. Jones:

I am a student in your Bongo playing class. I would appreciate it if you could email me my score on the exam of Tuesday, March 4. I am concerned about my score. If you would prefer to call, my phone number is 593-1314.

Thank you,

Crystal Clear
Components of Good Graphs and Tables

Graphs should include all of the following elements:

1. **A descriptive title.** The title can be placed above the graph or at the beginning of the figure legend (see #4 below).
2. **Labels for both axes.** An axis label is a word or words indicating what the axis measures, e.g., speed or time or oxygen consumption or body mass index etc.
3. **Units indicated on both axes.** Examples of units are kg (mass) or ml/kg/min (oxygen consumption) or minutes (time) etc.
4. **A legend.** The legend explains, in sentences, what the graph is meant to show. Sometimes the title of the figure is the first part of the legend. For example: Fig. 4. Oxygen delivery to the leg muscles as a function of exercise intensity. Symbols indicate the mean value of six subjects.
5. Any other notes or guides that will assist the reader in understanding the graph – for example, labeling the pre-exercise, exercise, and recovery periods on a graph of heart rate by time.
6. **The independent variable should be plotted on the X-axis and the dependent variable (the outcome variable) should be plotted on the Y-axis.** For example, if your graph illustrates maximum bench press weight after 2, 4, or 6 weeks of training, the bench press weight is your dependent variable and it goes on the Y-axis. Weeks of training goes on the X-axis.

**NOTE on Regression or Trend Lines (available in MS excel):**

1. If you apply a linear regression to a scatter plot, that linear regression line will have the form $y = mx + b$, where $m$ is the slope of the line and $b$ is the y-intercept.
2. The “goodness of fit” of a linear regression line can be assessed by looking at the correlation coefficient or “$r$” value. The $r$ value ranges from 1 (perfect fit, positive correlation) to 0 (no fit) to –1 (perfect fit, inverse or negative correlation).
3. The $r$-squared value (that is the $r$ value squared) can also be used to assess the goodness of fit of a regression line, but the $r$-square value ranges only between 1 (perfect fit) and 0 (no fit).

Tables should include all of the following elements:

1. **A descriptive title.**
2. **Labels for all columns and rows** (words explaining what is in that column or row).
3. **Units** (eg. Liters, or KG or Minutes or number of people) indicated on all appropriate columns and rows.
4. **Footnotes** (under table) defining all abbreviated terms.

See example of graph and table on the next page.
Example of GRAPH:

Figure 1. Percent difference in speed of male and female Thoroughbred horses (TB), Standardbred (STB) pacing and trotting horses, Greyhound dogs, and humans. For Thoroughbreds, races less than or equal to (LE) 1609m were considered separately from races greater than (GT) 1609m. Human data were taken from the winning times of the 400m, 800m, 1 mile, and 1.5 km races at the 2003 Division I American NCAA championships.

Example of a TABLE:

Table 1. Increase in SaO$_2$ and resulting increase in CaO$_2$ due to pregnancy-induced hyperventilation at SL, 1600 m, 3100 m, and 4300 m. The effect of hyperventilation increases with altitude due to the non-linear hemoglobin-oxygen dissociation curve.

<table>
<thead>
<tr>
<th></th>
<th>SL (a)</th>
<th>1600 m (b)</th>
<th>3100 m (b)</th>
<th>4300 m (c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NP SaO$_2$ (%)</td>
<td>98.0 ± 0.8</td>
<td>93.6 ± 0.5</td>
<td>90.1 ± 0.4</td>
<td>82.9 ± 1.2</td>
</tr>
<tr>
<td>Pregnant SaO$_2$ (%)</td>
<td>98.5 ± 0.7</td>
<td>95.4 ± 0.4</td>
<td>92.5 ± 0.3</td>
<td>87.4 ± 0.4</td>
</tr>
<tr>
<td>Increase in CaO$_2^*$ (ml O$_2$/dL)</td>
<td>0.1</td>
<td>0.34</td>
<td>0.45</td>
<td>0.85</td>
</tr>
</tbody>
</table>

Abbreviations: SL = sea level; NP = not pregnant; SaO$_2$ = arterial oxygen saturation; CaO$_2$ = arterial oxygen content. *Calculated increase in CaO$_2$ due to the pregnancy-induced increase in SaO$_2$ only, assuming a constant hemoglobin concentration of 14 g/dL. SaO$_2$ data from: (a) McAuliffe et al., 2001; (b) Zamudio et al., 1995a; (c) Niermeyer et al., 2001. All values mean ± SE except (a) mean ± SD.
Tips for Science Writing

These suggestions are meant primarily for students writing a thesis or grant proposal. However, these guidelines may also be useful when writing laboratory reports or papers for science classes. Do not use these tips for humanities classes – the accepted practices are different in humanities.

1. Passive or active voice? In scientific writing, use of the passive voice is traditional and still widely accepted. Active is newer, but is gaining acceptance. Generally, you are safe using the passive voice (but not in your humanities classes!). If your paper is more informal or aimed at a non-technical audience, use active voice.
   Passive: Heart rate measurements were taken at 5, 10, and 20 min after exercise.
   Active: We measured heart rate at 5, 10, and 20 min after exercise.

2. Avoid use of the first person.
   First person is “I” or “We” as in “We ran three subjects on a treadmill”. Traditionally, the use of the first person was avoided in all instances. More recently, first person has become more common, and accepted. Use same guidelines as for passive vs. active voice.

3. Contractions: “don’t use them” becomes “do not use them”

4. Use adverbs sparingly
   Quantify instead – walked slowly = walked at 2 miles per hour

5. Make minimal use of adjectives
   Quantify instead – a big difference in heart rate = the mean difference in heart rate was 10 beats per minute

6. Avoid comparatives and superlatives
   Quantify instead – a higher heart rate = heart rate was increased by 3 bpm
   - the smallest concentration = the concentration was 1 millimolar

7. Be careful with pronouns
   Pronouns, like “it” must have a clear reference. If in doubt, use the noun “the muscle”

8. Obvious, obviously: Do not use these words. If something is obvious, why take up space?

9. Affect and effect: one is a verb, one is a noun – use accordingly
   Affect – verb  Space travel is known to affect bone density
   Effect – noun  The effect of space travel on bone density ....

10. **Proof read!** Check for typos, spelling errors, clarity, and style. Look for ways to make your sentences shorter by eliminating unnecessary words or phrases.
11. Quotations: Avoid use of direct quotations from papers. If you do use a quotation, be sure to enclose the quotation in quotation marks and include the appropriate citation and reference. If you quote another paper without using quotation marks and a citation, that is plagiarism!
References and Citations for Science Papers

*Note, some instructors may require a different format from the ones described here. By all means, follow the format required by your instructor. However, if no format is specified, the following formats are recommended.

1. **How to list references:**

The easiest way to list references is in alphabetical order by the first author’s last name. An alternative format is to list references by number in the order they appear in your paper.

2. **Reference format:**

There are several different styles for reference format. Two examples follow. No matter what format you use, be consistent – all references must appear in the same format.

   **A. Journal Article**

   1. American Physiological Society format:


      *Notes: Only the first letter of the article title is capitalized. Journal title is in italics. The month of publication is NOT given. The year of publication is listed last.*

   2. Journal of Experimental Biology format:


      *Notes: Only the first letter of the article title is capitalized. Year of publication appears after authors, in parentheses, followed by a period. Journal title is in italics. Month of publication is NOT given.*

   **B. Book**

   1. American Physiological Society format:

      Entire book:

2. **Journal of Experimental Biology** format:

   Entire book:

   Chapter in book:

3. **Citations within the text – this is important!**

Each time you make a claim in the text of your paper, that claim should be backed up by a citation of your references. Citations appear as follows:

**At the beginning of a sentence:**

Bailey et al. (1999) found that....

**At the end of a sentence:**

...a reduction in VO2max was observed (Bailey et al., 1999).

*Notes:*

1. “Et al.” is an abbreviation of the Latin “et aliis” meaning, “and others”. NOTE that there is no period after the “et” only after the “al.”.

2. You use “et al.” if the paper you are citing has three or more authors. If the paper has one or two authors, you would write: (Bailey, 1999) or (Barnum and Bailey, 1999).

*Alternative format*

An alternative is to list the number of the reference in the text as a superscript. For example: A reduction in maximum heart rate and cardiac output was observed at high altitude\(^23\).

This means that the reference being cited is number 23 in the reference list. In this case, the references will be listed in order of appearance, rather than by alphabetical order.
EXPERIMENTAL GROUP
Individuals (human or animal) who are receiving a test substance, special treatment, or intervention of some kind (e.g., a drug, special diet, or nutrition education lessons), and are observed for specific characteristics or variables.

CONTROL GROUP
Individuals (human or animal) who are similar in age, sex, species, state of health, physiologic characteristics, or socioeconomic characteristics to those in the experimental group but do not receive the special treatment or test substance, and are observed for the same characteristics as the experimental group.

PLACEBO
An inactive substance or procedure with no remedial effect or value used as a control in an experiment. This substance or procedure is presented to the control group in the same form, sequence, and manner as the test substance is presented to the experimental group to allow observation of any psychological or physiologic effect of the study procedure.

DOUBLE-BLIND STUDY
In this format neither the subjects nor those collecting the data know which individuals are receiving the test substance or procedure and which are receiving the placebo, thereby avoiding any bias on the part of the researchers or staff who may expect to see certain results or inadvertently treat experimental subjects differently than control subjects.

LONGITUDINAL STUDY
The repeated observation of the same subjects (human or animal) over a long period of time so that changes occurring within individuals can be measured. This method provides information as to both actual changes and when they occur. Confounding factors include the cost of repeated evaluations and the need to maintain continued contact with and cooperation of subjects over extended periods of time. Preferred method for growth or aging studies.

EPIDEMIOLOGIC STUDY
Study of factors associated with a particular occurrence in a defined population; often used in assessing health status such as characteristics common to individuals who have heart disease.

DESCRIPTIVE STUDY
A collection of facts about an existing situation. Food intake surveys in which individuals recall what they ate the previous day or surveys of the prevalence of anemia among young children fall in this category.

METABOLIC STUDY
A study in which individuals (human or animal) are given defined and controlled levels of nutrients and biologic measurements are performed on blood, urine, feces, or body tissues.

CASE STUDY
Presentation of usual findings. May be patient’s disease, unusual laboratory findings, unusual biochemical characteristics of an organism, etc. Straight forward presentation of the case.

RETROSPECTIVE STUDY
Retrospective analysis of data for correlation and incidence studies. Examination of data and development of conclusions through the use of previously recorded data (examples: laboratory records or patient’s medical records).

PROSPECTIVE STUDY
Analysis of data as it is generated, again for correlation and incidence studies. The advantage of the prospective over the retrospective study is that the former allows the researcher more control over the data. If information is missing for the prospective study, it usually can be obtained because the study is happening in the present. However, in the retrospective study, the data was generated in the past and, if missing, it is difficult, if not impossible, to obtain.

COMPARATIVE STUDY
Comparison of various parameters of two or more procedures and/or techniques to determine accuracy, precision, ease of performance, cost, interfering substances, false negatives and positives, etc. Frequently used in product evaluation.

APPLIED RESEARCH
The results of the research studies have direct application to medical practice, educational practice, etc.

BASIC RESEARCH
The result of these research studies at present does not have direct application to medical practice, patient treatment, product development, educational intervention, etc.
Dimensional Analysis

What is dimensional analysis?
Dimensional analysis refers to the process of working out a “word problem” or computation using only the UNITS (no numbers).

Why use dimensional analysis?
Dimensional analysis can help you identify the right way to multiply, divide etc. numbers so that you get an appropriate (correct!) answer. If the units of your answer are not correct, than your numerical answer is also wrong. Dimensional analysis is easy and fast.

Examples of dimensional analysis:

1. Let’s say you can’t remember if cardiac output equals heart rate TIMES stroke volume or heart rate DIVIDED BY stroke volume. To find out, you try the dimensional analysis for both possibilities:
   (a) HR * SV = beats/min * ml/beat = ml/min
   (b) HR/SV = beats/min divided by ml/beat = beats/min * beat/ml = beat²/min·ml

   Clearly (a) is correct because the units of cardiac output are ml/min NOT beat²/min·ml

2. Let’s say you are told that a 70 kg man’s rate of oxygen consumption is 10 ml/kg·min and his oxygen extraction is 50 ml O₂/L of blood. You are now asked to compute his cardiac output. Where you start?
   (a) You know that cardiac output has units of ml or L of blood per min – ml/min or L/min
   (b) Note that L of blood is a unit in one of the given parameters (50 ml O₂/L of blood).
   (c) Ask yourself how to combine the units you are given so that L/min is the mathematical product: ml O₂/kg·min ? ml O₂/L blood = L blood/min
   (d) Note that ml O₂ must be eliminated – there is no ml O₂ in the units for cardiac output.

     You can eliminate ml O₂ by dividing - ml O₂/ml O₂ will cancel that unit out
   (d) So:  ml O₂/kg·min divided by ml O₂/L blood = L blood/kg·min
   (e) Close! Now, get rid of the kg by multiplying by kg:

           L blood/kg·min * kg = L blood/min Voila!
   (f) Finally, try it with the numbers: 10 ml O₂/kg·min / 50 ml O₂/L blood = 0.2 L/kg·min then, 0.2 L/kg·min * 70 kg = 14 L/min

   So, cardiac output = 14 L/min

   Congratulations, you have just used the Fick Equation without memorizing anything, except that cardiac output is L blood/min.
More dimensional analysis:

3. Let’s say that you need to calculate the power generated by a subject on a bicycle ergometer. You know that the person pedaled at 60 rev/min and that the ergometer is set up such that it “would travel” (if it weren’t stationary) 6 m/rev. The resistance on the ergometer was set at 40 N.

Where do you start?

(a) What are the units of power (see next section)? Power is measured in Watts (or KW). Ask yourself, how do you get Watts out of the units you are given?

(b) Remember that 1 W = 1 J/sec and 1 J = 1 N·m (see next section).

(c) Note that resistance has units of N. Also note you need to get rid of the “rev” unit.

(d) You can eliminate rev by multiplying: rev/min * m/rev = m/min

(e) Now you can see you need to multiply again – N * m/min = N·m/min

(f) Finally, convert min to sec by multiplying by sec/min:

\[ N \cdot m/min \times sec/min = N \cdot m/sec \]  

that’s a Watt!

(g) Now try it with numbers: 60 rev/min * 6 m/rev = 360 m/min

\[ 40 \text{ N} \times 360 \text{ m/min} \times \frac{1 \text{ min}}{60 \text{ sec}} = 240 \text{ N} \cdot \text{m/sec} = 240 \text{ J/sec} = 240 \text{ W} \] Done!
Units and Conversions

In science classes, we use SI or metric units. The following are some dimensions you may encounter and the appropriate units for each:

**Basic Units**
1. Mass: Grams (g)
2. Length/Height/Distance: Meters (m)
3. Time: Second (s)
4. Temperature: degrees Celsius (°C) – metric not SI
5. Amount of a substance or molecule: Mole (mol)

**Derived Units**
1. Speed: meters/second (m/s)
2. Acceleration: meters/second squared (m/s²)
3. Volume: Liter (L) – metric not SI
4. Force: Newton (N) N=kg*m/s²
5. Energy*/Work: Joule (J) J=N·m
7. Pressure/Stress: Pascal (Pa) Pa = N/m²
8. Moment of Force: Moment (N·m)

*Note – energy includes potential energy, kinetic energy, & heat

**Prefixes for Units**

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Symbol</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>10⁻¹ (tenth)</td>
<td>deci</td>
<td>dL (0.1 L or 100 ml)</td>
</tr>
<tr>
<td>10⁻² (hundredth)</td>
<td>centi</td>
<td>cm (0.01 m or 10 mm)</td>
</tr>
<tr>
<td>10⁻³ (thousandth)</td>
<td>milli</td>
<td>mm (0.001 m or 0.1 cm)</td>
</tr>
<tr>
<td>10⁻⁶ (millionth)</td>
<td>micro</td>
<td>microm (0.000001 m)</td>
</tr>
<tr>
<td>10⁻⁹ (billionth)</td>
<td>nano</td>
<td>ng (0.000000001 g)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Symbol</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>10⁶ (10X)</td>
<td>deka</td>
<td>example: daJ (10 J)</td>
</tr>
<tr>
<td>10⁷ (100X)</td>
<td>hecto</td>
<td>example: hg (100 g)</td>
</tr>
<tr>
<td>10⁸ (1000X)</td>
<td>kilo</td>
<td>example: kg (1000 g)</td>
</tr>
<tr>
<td>10¹⁰ (1000000X)</td>
<td>mega</td>
<td>example: MJ (a million J)</td>
</tr>
<tr>
<td>10¹² (billionX)</td>
<td>giga</td>
<td>example: Gvolt (a billion volts, like in “Back to the Future”)</td>
</tr>
</tbody>
</table>

**A Few Useful Equivalencies**
1. Force = mass * acceleration  
   \[ 1\text{N} = 1\text{kg}\cdot\text{m/s}^2 \]
2. Work = force * distance  
   \[ 1\text{J} = 1\text{N}\cdot\text{m} \]
3. Power = work/time  
   \[ 1\text{W} = 1\text{J/s} \]
4. Volume = distance cubed  
   1 ml = 1 cm³ = 1 cc (or cubic centimeter)
5. Volume % = ml/100 ml  
   e.g., ml O₂ per 100 ml blood

**Conversions**

For conversions between metric or SI units and other units (like inches, pounds etc.) see:
