MOTIVATION

1. Biology is the 21st century science.

2. Our world is rapidly changing, and biology is intimately involved.

3. One day you or someone you love will get sick.

4. Biotechnological innovations are raising important ethical questions.

IT IS TIME FOR NEW APPROACH TO TEACHING BI 1

1. Unifying principles – micro to macro

2. Integration with other scientific/engineering fields

3. Experimental emphasis (featuring Caltech research)
The 3 domains of life are predominantly microbial

Bacteria
Archaea
Eucarya

C. Woese, N. Pace
RNA-based family tree
All of life’s metabolism is microbial in origin

C. Woese, N. Pace
RNA-based family tree
Microbes collapse the hierarchy of life

We are not alone!

- We have 10X number of microbes on/within us than human cells
- Gut microbiome encodes >100X human genome!
- Microbial ecology linked to autism, celiac disase, colitis, obesity...

\[ 10^{12}/\text{human} \]
Outline for today:

- Principles of biology – key concepts that structure the course
- Diversity of the biosphere
- Evolution – how diversity arose
- Syllabus
Summary of principles – outline of course

1. Life must EXIST (interface/interact with external environment)  
   week(s): 1, 3, 4, 5

2. Life must PERSIST (replicate into next generation +)  
   week(s): 6, 7

3. Life achieves #1 and #2 through EVOLUTION  
   week(s): 1, 2

4. Life CO-EVOLVES with the natural world  
   week(s): 2, 8, 9

5. Life’s organizational rules are captured by ECOLOGY  
   week(s): 8, 9

To be an engaged 21st century citizen, you must understand biology  
week(s): 10
EXIST  All organisms must:

- Define a cell/organismal boundary  
- Build it using conserved materials  
- Maintain internal environment (homeostasis, repair damage)  
- Generate energy (growth, maintenance)

What are the limits to life? (physical? chemical? thermodynamic?)

→ what are the design principles that push against these limits?
Acidophiles ←
Bioleaching of ores

Andina Cu Mine (low pH)

Pilar Parada, Biosigma
Dead Sea (28% salt)

Halophiles use special photopigments to grow (why salt flats appear purple)
Black Smokers

Barophiles
Live at extreme pressures
Symbioses fed by sulfide sustain abundant marine life (>1000 atm)
Geysers
High temperature

*Thermophiles*

*Thermus aquaticus*

[Taq] polymerase

Biotechnology
Bioremediation

Amazing omnivores
Diverse microbial communities metabolize (break down) oil
PERSIST

- Cells/organisms reproduce
- To do so, must copy
  $\Rightarrow$ mistakes
  $\Rightarrow$ drives evolution

* Microbes have persisted for a LONG time
* Microbes have reproduced a LOT

\[
\begin{array}{lcl}
\text{Population of} & \text{Los Angeles} & \sim 10 \times 10^6 \\
& \text{California} & 38 \times 10^6 \\
& \text{United States} & \sim 313 \times 10^6 \\
& \text{World} & 7 \times 10^9 \\
\end{array}
\]

MICROBES

See “Microbiology by Numbers” in Reader
“Prokaryotes: the Unseen Majority” (Supplemental Reading)
**DIALECTIC** with Natural World (CO-EVOLUTION)

- Life
- Environment
- $\uparrow CO_2, O_2$
- Ocean acid.
- Ore-deposits

**ECOLOGY**: Organizational principles that hold living things together

*What makes an ecological systems robust? stable?*

- John Doyle (CDS, EE, Bio Eng) – *internet design*
Part 2:
Key concepts for today

1. **DIVERSITY**
   - HIERARCHY
   - EMERGENT PROPERTIES
   - ORDER/RELATIONSHIPS

2. **EVOLUTION** (≠ ENGINEERING)
   - FITNESS

< NO DESIGN >
LIFE’S HIERARCHY

biosphere

BACTERIA/ARCHAEA

EUKARYA

ecosystem
community
population
organism [cell]
molecule
atom
LIFE'S HIERARCHY

biosphere

BACTERIA/ARCHAEA

Single-celled

EUKARYA

Multicellular (plants/animals/fungi)

NESTED ecosystem

ecosystem
community
population
organism [cell]
molecule
atom

organ 

organ system

tissue
EMERGENT PROPERTIES - whole > sum

In your readings:
Cohen (your reader) Math & Biology
Davies (PDF, Bi1 Website) Emergent biological principles and the computational properties of the universe.
Emergent Properties

Host's body selects for specific microbes

↑ Bacterial community affects host health
RELATIONSHIPS

Limits of RESOLUTION

- BC - EYES
- ANIMALS / PLANTS

Late 1700s
Magnifying Lenses

A/P/Microbes

- Better Lenses (TEM)
- 1960
- ANIMALS / PLANTS / FUNGI / PROTISTS / MONERA

Sequence RNA
pre 2000

Aristotle

Anton van Leeuwenhoek

Transmission Electron Microscope

1979
1990

Bacteria
Archaean
Eucarya
Are we done? - Maybe not

Each time biologists are sure they had the final picture

THE DNA IS NOT STATIC!

[END OF Bi1 – Myles Jackson, NYU – ethics in modern biology]
How does diversity arise?

Evolution
Charles Darwin
1809 - 1882

galapagos Islands

Beagle
Divergence

Galapagos Finches

UTube video – possible idea for your writing assignment:

http://www.youtube.com/watch?v=_UZ5u5sN1WQ
April 04, 2012

ON

THE ORIGIN OF SPECIES

BY MEANS OF NATURAL SELECTION,

ON THE

PRESERVATION OF FAVORABLE RACES IN THE STRUGGLE

FOR LIFE.

By CHARLES DARWIN, M.A.,

FELLOW OF THE ROYAL SOCIETY, LIRNH.K.B. ECC., ETC., ETC.;

AUTHOR OF "JOURNAL OF RESEARCHES DURING H.M. S. BEAGLE VOYAGE

ROUND THE WORLD;"

LONDON:

JOHN MURRAY, ALBEMARLE STREET. 1859.

The right of Translation is reserved.
How did the diversity of the biological world arise?

Evolution:
Δ in genetic makeup (DNA) of a population over generations

Basis - genetic variation
Δ fitness
Fitness \( W = \) Capacity of a particular genetic makeup (= genotype) to leave offspring to the next generation

\[
W_{\text{ABS}} = \frac{N_{\text{AFTER}}}{N_{\text{BEFORE}}}
\]

\( W > 1 \), genotype ↑ in population

\( W < 1 \) ↓
How did the diversity of the biological world arise?

MECHANISMS:

1. Change in the genome
   e.g.,
   genetic drift - changes
   horizontal gene transfer
   (lg pieces of DNA) *

2. NATURAL SELECTION - INDIVIDUALS
   w/more fit

* [not acquired within a generation]
Change in the genome

Frequency of changes in DNA:

Error rate in DNA replicate

DNA damage > 1000 lesions/cell

HGT - variable

Evolution through laboratory experiment
DESIGN

Frances Arnold
Chemical Engineering
Darwin was all about natural selection

His precepts:

1. Life had a common beginning
Darwin was all about natural selection

His precepts:

1. Life had a common beginning.
2. Random variation
3. Environment selects
4. Accumulate
5. Gradual change
PUNCTUATED EQUILIBRIUM - STEVEN GOULD - long periods of stability + short episodes of change

KEY INNOVATION –

Trait that enables a group to diversify e.g.,
KEY INNOVATION – e.g., hardened forewings (elytra) of beetles

Vortex field contour during one cycle of hind wing flapping

Le et al. (2010) Numerical investigation of the aerodynamic characteristics of a hovering Coleopteran (beetle) insect.
Key concepts for today:

Principles of biology – Key concepts that structure the course

Diversity of the biosphere

Evolution – how diversity arose

Syllabus
BI 1
Micro-to Macro-Biology: Integrating Basic Principles Across the Life Sciences
Spring 2012

COURSE INFORMATION

Instructors:
Diane Newman: dkn@caltech.edu (302 Braun, x3543); Office Hours: Tues, Thurs 3-4pm or by appointment
Margaret McFall-Ngai: mmn@caltech.edu (429 Beckman Institute, x4839); Office Hours: Tues, Thurs 3-4 pm or by appointment

Administrator:
Patricia Minoff: minoff@caltech.edu (216 Beckman Labs)

Lead Coordinators:
Dr. Nora Sullivan: nsul@caltech.edu (Expertise: Microbiology) Office Hours: Thurs, 12-1 PM North Mudd 210;
Molly Phillips: mphil@caltech.edu (Expertise: Marine Biology) Office Hours: Thurs, 4-5 PM 210 North Mudd

Teaching Assistant Teams
Writing TA: Eliza Walsh: ecolias@caltech.edu (Undergraduate, Biology) Office Hours: Wed. 2-3 PM at Red Door Cafe

Section 1: Wednesdays 1-2 PM; Room: 024 KRK
- Hira Hassenzahl-Stutz: hhassenzahl-stutz@caltech.edu (Undergraduate, Mech En) Office Hours: Sun. 9-10 PM in Dining Room of Blacker
- Dr. Janol Q Yang: gy@caltech.edu (Postdoc in D. Rees lab, Molecular Motors) Office Hours: Wed. 9-10 AM in Broad 2nd Floor Kicthen Area

Section 2: Wednesdays 1-2 PM; Room: 101 KRK
- Catherine Xie: catherine.xie@caltech.edu (Undergraduate, Bioengineering) Office Hours: Fri. 3-4 PM in SFL room 2-2
- Nolie Bieker: noliebierker@caltech.edu (EBM Graduate, Biochemistry, Synthetic Biology) Office Hours: Mon. 3-4 PM in 370 Braun

Section 5: Wednesdays 1-2PM; Room: 3 BBB
- Kajsa Laxen: klaxen@caltech.edu (Undergraduate, Chem En) Office Hours: Fri. 1-2 PM in SFL room 2-1
- Jessica Ricci: jricci@caltech.edu (BIO Graduate, Microbial Ecology) Office Hours: Mon. 2-3 PM in 370 Braun

Section 4: Wednesdays 7-8PM; Room: 204 KRK
- Po-Yin Shih: po-yin@caltech.edu (BIO Graduate, Molecular Biology) Office Hours: Fri. 9-10 AM in 101 Braun
- Michael Datare: mdatare@gmail.com (Undergraduate, Biology) Office Hours: Sun. 8-9 PM in SFL Room 2-2

Section 5: Wednesdays 7-8PM; Room: 101 KRK
- Pankhi Gaba: pankhi.gaba@gmail.com (Undergraduate, Biology & BEM) Office Hours: Sun. 12-1 PM in Fleming House Lounge
- Dr. Cai Noubauer: cnoubauer@gmail.com (Postdoc in D. Newman lab, Structural Biology) Office Hours: Mon. 9-10 AM in 370 Braun

Section 6: Thursdays 4-5PM; Room: 101 KRK
- Greg Donaldson: gregd3@gmail.com (BIO Graduate, Bacterial Genetics) Office Hours: Tues. 2:30-3:35 PM in 370 Braun
- Giulio Rotaru: rotaru@caltech.edu (Undergraduate, Physics) Office Hours: Mon. 9-10 PM in Ruddock House Lounge

Section 7: Thursdays 7-8PM; Room: 024 KRK
- Katie Stetina: kstetina@caltech.edu (BIO Graduate, Development & Behavior/Environmental Response) Office Hours: Sun. 7-8 PM in 3FL Room 325.
- Stone Jiang: sjiang@caltech.edu (Undergraduate, Chemistry) Office Hours: Mon 8-9 PM in SFL Room 2-2

Section 6: Thursdays 7-8PM; Room: 3 BBB
- Josie Kho: jskho@caltech.edu (Undergraduate, Computer Science) Office Hours: Sun. 10-11 PM in Blacker Lounge
- Nazim Reamer: nreamer@gmail.com (BEB Graduate, Enzymes & Regulatory Networks) Office Hours: Thurs. 2:25-3:55PM at the Red Door Cafe
Section 6: Fridays 1-2PM; Room 101 KRB

- Kipper, Kipper: schneider@caltech.edu (CECS Graduate, Cell biology, Biochemistry, DNA-protein interactions) Office Hour: Mon. 1-2 PM outside of Chandler
- Atul Gopinath: argens@caltech.edu (BIO, Graduate, Bioinformatics) Office Hour: Fri 2-3PM in 370 Braun

Section 10: Fridays 3-4PM; Room 5 BBB

- Yang Sun: yus@caltech.edu (Undergraduate, Biological) Office Hour: Fri. 4-5PM in 3 BBB
- Yirui W. Wu: wy@caltech.edu (Graduate, Structural Biology) Office Hour: Thurs. 11-12PM in 351 Broad

Meeting times:
Lecture: 1 - 2:30, T, Th; recitation sections, as registered.

Course reader (required): An introductory biology text that integrates across all domains of life to teach fundamental biological principles does not exist. A reader has been created specifically for this class.

Synopsis:
The last 10 years of biological research have demonstrated that microbes have dominated the biosphere throughout Earth's history. Microbes play major roles in such broad processes as maintenance of human health and ecosystems. Concomitant with this growing awareness of microbial centrality, advances in technology have given us the ability to now articulate basic biological principles in much the same way as was done in physics and chemistry decades ago. The fundamental assumption that guides this course is that the biology of microbes provides a unique opportunity to present these unifying principles. Therefore, for each topic, our point of departure will be the microbial world. With this foundation, we will explore how other life forms, such as animals and plants, have diversified in form and function, abstracting from the basic "rules" provided by the microbial world.

Lectures and Quizzes:
Most classes will include the following components: (1) Lectures by Prof. Newman and Prof. McFall-Ngai to cover the micro- and macrobiological worlds, respectively. You are welcome to record the lectures, but recordings will not be made available on the website. Only audio recordings are allowed. Course notes, however, will be posted as PDFs after each class. (2) An iClicker quiz will be given. Each quiz will have two multiple-choice questions: one question will cover material that is presented that day, the other will concern material from any previous lecture or reading assignment to encourage you to continuously review the material you are learning. These questions may be asked at the same time or separately. You will receive full credit for the quiz if you get either answer correct. Half credit for completing it whether your answers are right or not, and zero credit if you do not take the quiz. The correct responses will be given to you afterwards. We encourage you to ask a question during class at any time if you are confused about the material being presented.

Recitation sections:
Because the recitation sections will build upon the material that is being presented that week and will give you the background information necessary to complete your homework assignment, it is vital that you show up on time weekly to your assigned recitation section. In addition, your active participation in these sections will factor into your course grade (see below). For this reason, you must always attend the same section unless you make arrangements with your assigned TAs to attend another section because of an exceptional circumstance. If you need to change your recitation section permanently because of a time conflict, you must contact the TAs of your registered section and Molly Phillips. Permanent changes are not allowed after the first week. Each week's recitation section will be different but will generally consist of:

- A brief review of the weekly lecture material (10-15 min)
- A 10-15 minute teaching module to complement that week's topic. These modules will introduce you to a variety of state-of-the-art biological methods and experiments, among other things.
- An introduction to the week's homework assignment, to be handed in at the beginning lecture the following Tuesday.
- On occasion, there will be a "mini lab" built into the recitation section. You will be expected to actively participate in this activity.
- Your recitation grade will derive from both your participation in section as well as your homeworks.
Grading:

- This class may only be taken for a grade.
- Writing Assignment (see below for details): 15%
- Lecture Quizzes (two questions per lecture, per above): 20%
  - In Class Exam 1: 15% - Thursday, May 3.
  - In Class Exam 2: 15% - Thursday, June 7.
  - Final Exam: 20% - A 30 minute oral exam upon arrangement (for seniors, on June 8; for everyone else June 13 or 14). During the course there will be ~40 lecture quiz questions. If you get 70% or more correct, you will not have to take the oral final exam and will receive 100% credit for it. Note that this is different from getting 100% credit for the quizzes (see above).
- Homework and Section Participation: 15% - There will be 8 homework sets throughout the course. We will drop your lowest score from your grade to allow for emergencies. Active participation in lecture discussions and mini labs will also be taken into account when assigning your grade.

Honor Code:
We take plagiarism and other forms of cheating extremely seriously and do not tolerate it. We reserve the right to give a "D" grade as the highest possible passing grade to any student who violates the honor code in any way, regardless of how well the student has done on other parts of the course where cheating has not been observed.

Course policies:

- Attendance. We expect everyone to attend each lecture and recitation section; you will not be able to pass the course otherwise.
- Electronic devices. Please leave your cell phone and computer outside the lecture hall. As helpful as these devices can be, they can also be a major distraction to you, your fellow students, and your professors. Paying attention in class is important to get the full benefit from the course. In addition, we may call on you to answer questions in class from time to time.
- iClickers. You will need to purchase an iClicker to participate in the lecture quizzes. This will be the only expense for the course, and we are subsidizing the cost (we will pay the device back from you for a fraction of its cost during finals week, to be credited to your Banner’s account). You can purchase your iClicker online, either from the company directly (www.iClicker.com) or Amazon. (NOTE: please include iClicker, Jent iClicker 2). For your class, you will be able to write your answers down on a piece of paper to turn into Molly Phillips or Nora Sullivan in class. You will need to register your iClicker online ASAP so you can use it in class on April 5. Go to http://www.iClicker.com/registrar. Note that the remote ID number is found on the back of your iClicker beneath the barcode. Take care to complete the registration without typos. You must bring your iClicker to class on April 5 to complete the registration and use it for the first quiz. From this point forward, it will be your responsibility to bring the iClicker with you to every class. A significant portion of your grade has the potential to emanate from the in-class quizzes, so do your best not to lose your iClicker. If you do, you will be responsible to pay the full cost for a replacement. It is obviously an honor code violation to use another student’s iClicker in any way. To discourage wandering eyes, please conceal your response to the quiz questions by shielding your iClicker response.
- Collaboration. Studying together is encouraged, and you may discuss homework problems together, but the writeup of the homework assignments must be in your own words and by your own hands. Lecture quizzes and in class exams will be taken on the honor code.
- Late work. Homework assignments will be handed out in recitation sections and are due at the beginning of class the following Tuesday. If you cannot complete your homework on time for a legitimate reason, you must have either a dean’s note or a health center note to justify why it is late and you will need to let your recitation TAs know that it will be late before it is due. The final written assignment will be due Tuesday May 29 at the beginning of lecture.
LECTURE SYLLABUS

Lectures will be held Tuesdays and Thursdays, 1:00 – 2:30 pm in Kerckhoff 119.

**Week 1** – Life from 30,000 feet – basics about biotic systems
Lecture 1 (Apr 3) – Orientation to the course/life’s organization/evolution as the unifying principle
Lecture 2 (Apr 5) – The structure of life forms: The cell as the unit of life/the eukaryotic cell – the patterns and consequences of multicellularity


**Week 2** – History of the biosphere and forces shaping its trajectory
Lecture 1 (Apr 10) – Origins
Lecture 2 (Apr 12) – Mechanisms underlying continuing evolution of the biosphere/patterns of radiation

**Week 3** – Sensing the environment, integrating the information, and responding
Lecture 1 (Apr 17) – Sensing: integrating and responding to the environment
Lecture 2 (Apr 19) – Consequences – Effects on population/community dynamics and behavior

Guest lecturer: Prof. Kenneth Nealson, USC


**Week 4** – Resisting perturbation and damage from the environment/energy acquisition
Lecture 1 (Apr 24) – Exchange with the environment: Protecting the home

Guest lecturer: Prof. Ann Hirsch, UCLA

Lecture 2 (Apr 26) – Overview of metabolism and nutrient acquisition

**Week 5** – Metabolism
Lecture 1 (May 1) – Mechanisms of energy acquisition

Guest lecturer: Dr. Nichy Galizia, Synthetic Genomics, Inc., http://www.syntheticgenomics.com

In class EXAM 1 (May 3) Reading assignment: none

**Week 6** – Mechanisms underlying persistence of life forms: The molecular basis for growth and reproduction
Lecture 1 (May 8) – Mechanisms underlying the central dogma
Lecture 2 (May 10) – Mechanisms of gene exchange: cell division/cell cycle


**Week 7** – Patterns of development
Lecture 1 (May 15) – Cell determination and differentiation
Lecture 2 (May 17) – The ecological and evolutionary mechanisms underlying developmental patterns


**Week 8** – Living with others – populations and communities
Lecture 1 – (May 22) Patterns of diversity – predator/prey dynamics/competition for resources
Lecture 2 – (May 24) Syntrophy and other forms of symbiosis


**Week 9** – Ecosystems biology – global issues
Lecture 1 – (May 29) Biogeochemical cycling/sustainability/Gaia

Lecture 2 – Our imported planet – the effects of climate change/feasibility of proposed solutions (e.g., geoengineering)/conservation biology


**Week 10** – Horizons in biology and the associated ethics
Lecture 1 – (June 5) Ethics and biology/synthetic biology and other fun topics

Guest lecturer: Mylae Jackson, New York U

In class EXAM 2 (June 7)


**FINAL ORAL EXAM (June 8, 13 or 14)**
RECITATION SYLLABUS

**Week 1** – How to read an article from the primary literature
Assignment for recitation: Read Finkel and Kolter and prepare to discuss

**Week 2** – Scientific revolutions

**Week 3** – Networks and circuits: how biology can inform engineering challenges

**Week 4** – Assessing the metabolic potential of Caltech’s microbial community (part I)

*mini-lab* sample bacteria from Beckman Behavioral and Baxter Ponds

**Week 5** – Assessing the metabolic potential of Caltech’s microbial community (part II)
Homework: no homework this week
*mini-lab* metabolic microarrays of communities and isolates from Beckman and Baxter Ponds

**Week 6** – The central dogma and beyond

**Week 7** – Reproduction and the advantages of fluorescent microscopy

**Week 8** – Who’s in our backyard? 16S rRNA phylogeny of Caltech’s microbial community

*mini-lab* Phylogenetic analysis of the 16S rRNA sequences from the ponds

**Week 9** – Global warming and the effect on the biosphere

**Week 10** – Pandemics and Ethics

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*Volta Flame Experiment*

**Thurs. 7pm – BBB Baxter**
**WRITING ASSIGNMENT**

**Motivation:** regardless of what field of science or engineering you ultimately pursue, being able to articulate your ideas cogently is crucial for professional success. To help you build the skills needed to achieve this, we have designed a progressive writing assignment. You will have the opportunity to develop an original research proposal in consultation with the S11 staff. This proposal is limited to 4 pages, double spaced (font Arial 11 points, 1 inch borders) not including figures or references.

We encourage you to write about any biological problem that interests you, as long as you can formulate a hypothesis and a reasonable means to test it. One way to take advantage of being at Caltech is to propose something that relates to the research of one of our faculty. You are welcome to write about any of the following 5 topics (and associated hypotheses); alternatively, you can develop one of your own. For the topics/hypotheses given below, we have provided the names and websites of the Caltech faculty doing research in these areas to guide your search for information.

**TOPIC: BIOMECHANICS**
Hypothesis: Significant savings to the operational costs of running a submarine can come from applying design principles from aquatic organisms.

- Profs. John Dabiri (MechE): http://dabiri.caltech.edu/
- Profs. Mary Gharib (MechE): http://www.gharib.caltech.edu/

**TOPIC: ENERGY**
Hypothesis: Viable alternate energy solutions can be found by mining the enzymatic potential of biological systems in an engineered context.

- Profs. Frances Arnold (ChemE): http://shomo.cho.caltech.edu/groups/haf/
- Profs. Jared Leadbetter (Env. Eng): http://www.its.caltech.edu/~jared/
- Profs. Nate Lewis (Chemistry): http://nsob.caltech.edu/research

**TOPIC: NETWORK DESIGN**
Hypotheses: Feedback networks in biological systems provide important mechanisms for providing robustness, but also introduce fragilities.

- Profs. Michael Elowitz (Biology & BioEng): http://elizwitz.caltech.edu/
- Profs. Richard Murray (CDS and BioEng): http://www.cds.caltech.edu/~murraywiki/Main_Page

Hypothesis: Networks of biomolecular reactions can be used to implement computations and functions that provide insight into biological systems and new approaches to nanoscale engineering.

- Profs. Richard Murray (CDS and BioEng): http://www.cds.caltech.edu/~murraywiki/Main_Page
- Prof. Miles Pierce (BioEng and App. Math): http://piercellab.caltech.edu/

**TOPIC: ECOLOGY/MICROBIOLOGY**
Hypothesis: Carriage of specific microbes alters the complexity of the immune system.

- Profs. Sarkis Mazmanian: http://biology.caltech.edu/Members/Mazmanian
- Prof. Margaret McFall-Ngai: http://www.medmicro.wisc.edu/labs/mcfall-nga/index.html
TOPIC: EVOLUTION
Hypothesis: Microbial metabolisms directly changed the geological landscape of the early Earth.

Prof. Wooya Fischer (GPS): http://www.gps.caltech.edu/~wfischer/
Prof. Jiri Kirschvink (GPS): http://www.gps.caltech.edu/~jkirschvink/
Prof. Dianna Newman (BIO and GPS): http://dnlab.caltech.edu/Newman_Lab.html
Prof. Victoria Orphan (GPS): http://www.gps.caltech.edu/people/orphan/profile
Prof. Alex Sessions (GPS): http://www.gps.caltech.edu/~als/

To provide each of you with effective feedback on your writing assignment, we will be collecting and reviewing each stage of your progress. These assignments are due at the beginning of Tuesday lecture and should be typewritten. The stage, due dates and the grading scheme are listed below. Note that your final grade will be derived from the three major assignments in bold (Weeks 4, 6 and 8), so it is important to stay on track throughout the term. More details about our expectations for each step will be provided during the introduction to the assignment in the first week of class.

Week 1: Introduction to assignment (no work due this week)
Week 2: Define interests (multiple ideas) due April 10
Week 3: Refine ideas due April 17
Week 4: Hypotheses/aims (ONE idea) due April 24 -- worth 20% of writing assignment total
Week 5: Methodology/Approach due May 1
Week 6: Rough draft due May 8 -- worth 30%
Week 7: Revision of corrected rough draft (no work due this week)
Week 8: Final draft due May 22 -- worth 50%
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