AP® BIOLOGY

About the Advanced Placement Program® (AP®)

The Advanced Placement Program® has enabled millions of students to take college-level courses and earn college credit, advanced placement, or both, while still in high school. AP Exams are given each year in May. Students who earn a qualifying score on an AP Exam are typically eligible to receive college credit and/or placement into advanced courses in college. Every aspect of AP course and exam development is the result of collaboration between AP teachers and college faculty. They work together to develop AP courses and exams, set scoring standards, and score the exams. College faculty review every AP teacher's course syllabus.

AP Biology Course Overview

AP Biology is an introductory college-level biology course. Students cultivate their understanding of biology through inquiry-based investigations as they explore the following topics: evolution, cellular processes — energy and communication, genetics, information transfer, ecology, and interactions.

LABORATORY REQUIREMENT

This course requires that 25 percent of the instructional time will be spent in hands-on laboratory work, with an emphasis on inquiry-based investigations that provide students with opportunities to apply the science practices.

PREREQUISITE

Students should have successfully completed high school courses in biology and chemistry.

AP Biology Course Content

The course is based on four Big Ideas, which encompass core scientific principles, theories, and processes that cut across traditional boundaries and provide a broad way of thinking about living organisms and biological systems. The following are Big Ideas:

- The process of evolution explains the diversity and unity of life.
- Biological systems utilize free energy and molecular building blocks to grow, to reproduce, and to maintain dynamic homeostasis.
- Living systems store, retrieve, transmit, and respond to information essential to life processes.
- Biological systems interact, and these systems and their interactions possess complex properties.

Science Practices

Students establish lines of evidence and use them to develop and refine testable explanations and predictions of natural phenomena. Focusing on these disciplinary practices enables teachers to use the principles of scientific inquiry to promote a more engaging and rigorous experience for AP Biology students. Such practices require that students:

- Use representations and models to communicate scientific phenomena and solve scientific problems;
- Use mathematics appropriately;
- Engage in scientific questioning to extend thinking or to guide investigations within the context of the AP course;
- Plan and implement data collection strategies in relation to a particular scientific question;
- Perform data analysis and evaluation of evidence;
- Work with scientific explanations and theories; and
- Connect and relate knowledge across various scales, concepts, and representations in and across domains.

Inquiry-Based Investigations

Twenty-five percent of instructional time is devoted to hands-on laboratory work with an emphasis on inquiry-based investigations. Investigations require students to ask questions, make observations and predictions, design experiments, analyze data, and construct arguments in a collaborative setting, where they direct and monitor their progress.

AP Biology Exam Structure

AP BIOLOGY EXAM: 3 HOURS

Assessment Overview

Exam questions are based on learning objectives, which combine science practices with specific content. Students learn to

- Solve problems mathematically — including symbolically
- Design and describe experiments and analyze data and sources of error
- Explain, reason, or justify answers with emphasis on deeper, conceptual understanding
- Interpret and develop conceptual models

Due to the increased emphasis on quantitative skills and application of mathematical methods in the questions, students are allowed to use simple four-function calculators (with square root) on the entire exam. Students also receive a formula list as part of their testing materials.

Format of Assessment

Section I: Multiple Choice | 69 Questions | 1 Hour, 30 Minutes | 50% of Exam Score

Multiple-Choice: 63 Questions

- Discrete Questions
- Questions in sets

Grid-In: 6 Questions

- Discrete Questions
- Questions integrate biology and mathematical skills

Section II: Free Response | 8 Questions | 1 Hour, 30 Minutes (includes 10-minute reading period) | 50% of Exam Score

- Long Free Response (2 questions, one of which is lab or data-based)
- Short Free Response (6 questions, each requiring a paragraph-length argument/response)

AP BIOLOGY SAMPLE EXAM QUESTIONS

Sample Multiple-Choice Question

Two flasks with identical medium containing nutrients and glucose are inoculated with yeast cells that are capable of both anaerobic and aerobic respiration. Culture 1 is then sealed to prevent fresh air from reaching the culture; culture 2 is loosely capped to permit air to reach the culture. Both flasks are periodically shaken.

*Which of the following best **predicts** which culture will contain more yeast cells after one week, and most accurately **justifies** that prediction?*

A. Culture 1, because fresh air is toxic to yeast cells and will inhibit their growth

B. Culture 1, because fermentation is a more efficient metabolic process than cellular respiration

C. Culture 2, because fresh air provides essential nitrogen nutrients to the culture

D. Culture 2, because oxidative cellular respiration is a more efficient metabolic process than fermentation.

Correct Answer: D

Sample Grid-In Question

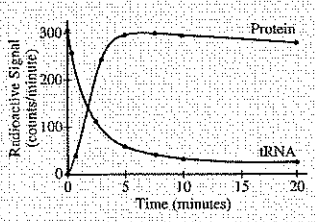
The data below demonstrate the frequency of tasters and non-tasters in an isolated population at Hardy-Weinberg equilibrium. The allele for non-tasters is recessive.

How many of the tasters in the population are heterozygous for tasting?

Tasters	Non-Tasters
8235	4328

Sample Short Free-Response Question

The role of tRNA in the process of translation was investigated by the addition of tRNA with attached radioactive leucine to an in vitro translation system that included mRNA and ribosomes. The results are shown by the graph.



*In a **short paragraph**, describe how this figure justifies the claim that the role of tRNA is to carry amino acids that are then transferred from the tRNA to growing polypeptide chains.*

Educators: apcentral.collegeboard.org/apbiology

Students: apstudent.collegeboard.org/apbiology

CollegeBoard

00558-020 (Updated January 2017)

Using and Interpreting AP Scores

The extensive work done by college faculty and AP teachers in the development of the course and the exam and throughout the scoring process ensures that AP Exam scores accurately represent students' achievement in the equivalent college course. While colleges and universities are responsible for setting their own credit and placement policies, AP scores signify how qualified students are to receive college credit or placement:

AP Score	Recommendation
5	Extremely well qualified
4	Well qualified
3	Qualified
2	Possibly qualified
1	No recommendation

Additional Resources

Visit apcentral.collegeboard.org for more information about the AP Program.

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Science Practices for AP Biology

Science Practice 1: The student can use representations and models to communicate scientific phenomena and solve scientific problems.

Visual representations and models are indispensable tools for learning and exploring scientific concepts and ideas. The student is able to create representations and models using verbal or written explanations that describe biological processes. The student also can use representations and models to illustrate biological processes and concepts; communicate information; make predictions; and describe systems to promote and document understanding. Illustrative examples of representations and models are diagrams describing the relationship between photosynthesis and cellular respiration; the structure and functional relationships of membranes; and diagrams that illustrate chromosome movement in mitosis and meiosis. Using model kits, the student can build three-dimensional representations of organic functional groups, carbohydrates, lipids, proteins and nucleic acids. The student is able to demonstrate how chemical structures, such as the Watson and Crick model for DNA, link structure to function at the molecular level and can relate key elements of a process or structure across multiple representations, such as a schematic two-dimensional diagram and a space-filling model of DNA. The student can refine and/or revise visual representations of biological processes, including energy flow through ecosystems; immunological processes; movement of molecules in and out of cells; and graphs or other visual data representations of experimental results. The student can use/apply representations and models to make predictions and address scientific questions as well as interpret and create graphs drawn from experimental data.

1.1 The student can *create representations and models* of natural or man-made phenomena and systems in the domain.

1.2 The student can *describe representations and models* of natural or man-made phenomena and systems in the domain.

1.3 The student can *refine representations and models* of natural or man-made phenomena and systems in the domain.

1.4 The student can *use representations and models* to analyze situations or solve problems qualitatively and quantitatively.

1.5 The student can *reexpress key elements* of natural phenomena across multiple representations in the domain.

Science Practice 2: The student can use mathematics appropriately.

The student can routinely use mathematics to solve problems, analyze experimental data, describe natural phenomena, make predictions, and describe processes symbolically. The student also can justify the selection of a particular mathematical routine and apply the routine to describe natural phenomena. The student is able to estimate the answers to quantitative questions using simplifying assumptions and to use this information to help describe and understand natural phenomena. Examples of the use of mathematics in biology include, but are not limited to, the use of Chi-square in analyzing observed versus predicted inherited patterns; determination of mean and median; use of the Hardy-Weinberg equation to predict changes in gene frequencies in a population; measurements of concentration gradients and osmotic potential; and determination of the rates of chemical reactions, processes and solute concentrations. The student is able to measure and collect experimental data with respect to volume, size, mass, temperature, pH, etc. In addition, the student can estimate energy procurement and utilization in biological systems, including ecosystems.

2.1 The student can *justify the selection of a mathematical routine* to solve problems.

2.2 The student can *apply mathematical routines* to quantities that describe natural phenomena.

2.3 The student can *estimate numerically* quantities that describe natural phenomena.

Science Practice 3: The student can engage in scientific questioning to extend thinking or to guide investigations within the context of the AP course.

As scientists and students, how do we know what we know? Facts, concepts and theories fill biology textbooks, but how did scientists discover facts, concepts and theories that make up modern science, such as that cells produce carbon dioxide as a by-product of respiration or that the details for copying the two strands of DNA differ during replication? What historical experiments provided evidence that DNA, not protein, was *the* hereditary material for living organisms? What scientific evidence supports evolution by natural selection, and how is this different than alternative ideas with respect to evolution and origin of life? To provide deeper understanding of the concepts, the student must be able to answer,

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"How do we know what we know?" with, "This is why we know what we know." The student is able to pose, refine and evaluate scientific questions about natural phenomena and investigate answers through experimentation, research, and information gathering and discussion. For example, if the student poses the question: "What happens to photosynthesis at very high, nonbiological temperatures?" he or she can address this question in a variety of means: literature searches, fact finding and/or designing an experiment to investigate the effect of temperature on chloroplast function, including collecting data, making predictions, drawing conclusions and refining the original question or approaches. The student is able to formulate good scientific questions — ones that are amenable to experimental approaches and addressable through evidence — and can distinguish them from other questions that are ethical, social or teleological in nature. The student can pose and rationally discuss questions that address ethical and civic issues that surround the development and application of scientific knowledge, and controversial issues such as stem cells, cloning, genetically modified organisms, and who should decide what types of biological research are acceptable and which are not.

3.1 The student can *pose scientific questions.*

3.2 The student can *refine scientific questions.*

3.3 The student can *evaluate scientific questions.*

Science Practice 4: The student can plan and implement data collection strategies appropriate to a particular scientific question.

Experimentation and the collection and analysis of scientific evidence are at the heart of biology. Data can be collected from many different sources: experimental investigation, scientific observation, the findings of others, historic reconstruction and archival records. After the student poses a question about biology, he or she is able to investigate and arrive at answers through experimentation and reasoning. In this coupled process, the student can justify the selection of the kind of data needed to answer a question. For example, if the question is about how temperature affects enzymatic activity, the student should be able to collect data about temperature while controlling other variables, such as pH and solute concentration. To test a hypothesis about an observation, the student is able to design an experiment; identify needed controls; identify needed supplies and equipment from a given list of resources; develop or follow an experimental protocol to collect data; analyze data and draw conclusions from the results; and describe the limitations of the experiment and conclusions. In addition, the student can draw conclusions from experimental results of other scientists, e.g., the historical experiments of

Fredrick Griffith, Calvin and Krebs, Hershey and Chase, and Watson and Crick.

4.1 The student can *justify the selection of the kind of data* needed to answer a particular scientific question.

4.2 The student can *design a plan* for collecting data to answer a particular scientific question.

4.3 The student can *collect data* to answer a particular scientific question.

4.4 The student can *evaluate sources of data* to answer a particular scientific question.

Science Practice 5: The student can perform data analysis and evaluation of evidence.

The student can analyze data collected from an experimental procedure or from a given source to determine whether the data support or does not support a conclusion or hypothesis. For example, if the student conducts an experiment to determine if light intensity affects the rate of photosynthesis, he or she can construct a graph based on the collected data and use the graph to formulate statements, conclusions, and possibly a hypothesis. Alternatively, the student can draw conclusions from a provided data set. For example, given a graph depicting the percent change in the mass of potato cores after exposure to different concentrations of sucrose, the student is able to estimate the concentration of sucrose within the potato core. The student also is able to assess the validity of experimental evidence. Using the same example, if given hypothetical data showing that potato cores *increase* in mass when placed in solutions with lower water potential (a hypertonic solution), the student is able to explain why the data (evidence) are likely invalid: Since potatoes contain sucrose, they should increase in mass only when placed in solutions with higher water potential (hypotonic). After identifying possible sources of error in an experimental procedure or data set, the student can then revise the protocol to obtain more valid results. When presented with a range of data, the student is able to identify outliers and propose an explanation for them as well as a rationale for how they should be dealt with.

5.1 The student can *analyze data* to identify patterns or relationships.

5.2 The student can *refine observations and measurements* based on data analysis.

5.3 The student can *evaluate the evidence provided by data sets* in relation to a particular scientific question.

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Science Practice 6: The student can work with scientific explanations and theories.

The student can work with scientific descriptions, explanations and theories that describe biological phenomena and processes. In efforts to answer, "How do we know what we know?" the student can call upon current knowledge and historical experiments, and draw inferences from his or her explorations to justify claims with evidence. For example, the student is able to cite evidence drawn from the different scientific disciplines that supports natural selection and evolution, such as the geological record, antibiotic-resistance in bacteria, herbicide resistance in plants or how a population bottleneck changes Hardy-Weinberg Equilibrium. The student can articulate through narrative or annotated visual representation how scientific explanations are refined or revised with the acquisition of new information based on experimentation; for example, the student can describe/explain how advances in molecular genetics made possible a deeper understanding of how genes are carried in DNA and of how genes are expressed to determine phenotypes. The student understands that new scientific discoveries often depend on advances in technology; for example, only when microscopy was sufficiently advanced could the linkage between chromosomes and the transmission of genetic traits be clearly established. Likewise, the ability to sequence whole genomes allows comparisons between the entire genetic information in different species, and technology is revealing the existence of many previously unknown genes and evolutionary relationships. In addition, the student can use existing knowledge and models to make predictions. For example, when provided a sequence of DNA containing a designated mutational change, the student can predict the effect of the mutation on the encoded polypeptide and propose a possible resulting phenotype. The student also can evaluate the merits of alternative scientific explanations or conclusions.

6.1 The student can *justify claims with evidence.*

6.2 The student can *construct explanations of phenomena based on evidence* produced through scientific practices.

6.3 The student can *articulate the reasons that scientific explanations and theories are refined or replaced.*

6.4 The student can *make claims and predictions about natural phenomena* based on scientific theories and models.

6.5 The student can *evaluate alternative scientific explanations.*

Science Practice 7: The student is able to connect and relate knowledge across various scales, concepts and representations in and across domains.

The student is able to describe through narrative and/or annotated visual representation how biological processes are connected across various scales such as time, size and complexity. For example, DNA sequences, metabolic processes and morphological structures that arise through evolution connect the organisms that compose the tree of life, and the student should be able to use various types of phylogenetic trees/cladograms to show connections and ancestry, and to describe how natural selection explains biodiversity. Examples of other connections are photosynthesis at the cellular level and environmental carbon cycling; biomass generation and climate change; molecular and macroevolution; the relation of genotype to phenotype and natural selection; cell signaling pathways and embryonic development; bioenergetics and microbial ecology; and competition and cooperation from molecules to populations. The student is able to describe how enduring understandings are connected to other enduring understandings, to a big idea, and how the big ideas in biology connect to one another and to other disciplines. The student draws on information from other sciences to explain biological processes; examples include how the conservation of energy affects biological systems; why lipids are nonpolar and insoluble in water; why water exhibits cohesion and adhesion, and why molecules spontaneously move from high concentration to areas of lower concentration, but not *vice versa*.

7.1 The student can *connect phenomena and models* across spatial and temporal scales.

7.2 The student can *connect concepts* in and across domain(s) to generalize or extrapolate in and/or across enduring understandings and/or big ideas.

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AP Biology Practice 1 – Models and Representations
Video Review Sheets
www.bozemanscience.com/apb-practice-1-models-representations

A. What is a model?.....A visual representation of

B. A _____ of how it works is a "Conceptual Model".

C. What are the four Big Ideas we will be discussing in AP Biology? List below along with associated example:

1. _____ - example shows natural _____

2. Free _____ - example:

3. _____ - genetics and cell

4. _____ - pyramid of

C. What are the 5 things you will need to be able to do using models and visual representations? [Please keep in mind, some of the examples that he uses may be unknown to you at this time, focus on the "practice" not the content.]

1. _____
   a. Relating to beetles, draw/label the final graph he created below:

   b. Why do you think there were fewer light colored beetles when the trees became darker?

2. _____ What was is going to move in his example? _____

3. _____ They will give you a model and then _____ based on that.

4. _____ Means that you are _____ your knowledge to a visual representation

5. _____ Asking you to _____ the knowledge that you have.

D. Models allow us to make _____ of a _____ model.

E. What is the most famous model of all? _____ That was created by _____

AP Biology Practice 2 – Using Mathematics
Video Review Sheet
www.bozemanscience.com/apb-practice-2-using-mathematics

NEED YOUR CALCULATOR!!!

A. All sciences have what at their core?

B. What is "Mathematical Biology" driven by:

1. _____: sequencing DNA – what is the trend?
2. _____ Theory: being used to predict
3. Computing _____: computers are getting
4. Laboratory experiments in silico:
    a. In vitro:
    b. In vivo:
    c. In silico: simulating

C. Four equations in the four big ideas: want to be familiar with these

1. Evolution:
2. Free energy:
3. Information:
4. Systems:

D. Understandings in Using Mathematics:

1. _____ the _____ of a Mathematical Routine: Pause video, try and do it and then check it. You should do this one no problem. Show your work below
2. Apply _____ Routines: Again, try this problem, showing your work below. I think you can do this one based on common sense!
3. _____ quantities that _____ natural phenomena.
    a. You can absolutely do this, show work.
    b. Potatoes: you can do this too! _____M Sucrose

AP Biology Practice 3 – Scientific Questioning
Video Review Sheet

www.bozemanscience.com/apb-practice-3-scientific-questioning

1. I should be able to ask you, "How do we....
2. Students should be able to answer, "This is how....
3. What is a good example of how you ask questions all the time?
4. What is the problem with:
    a. Smallest bird question?

    b. Universe question?

    c. Genetically modified food question?

5. Why is the plant growth question more scientific?....but what is a problem with it too?

6. Why is the CO_2 question a good scientific question?

7. A good question is going to lead to: (2x)

8. What are the three things you have to be able to do during the practice of "Scientific Questioning"?

9. Write out one of the three questions he "posed" concerning the phylogenetic tree. (You are just asking, not answering.)

10. When you "refine" a question, you are taking it to another _____
11. What is the third part of scientific questioning?

12. What can you then do if you are good at scientific questioning?

AP Biology Practice 4 – Data Collection Strategies
Video Review Sheet
www.bozemanscience.com/apb-practice-4-data-collection-strategies

1. What is science? Diagram his flow chart (you can do it left to right): The belief that:

2. In addition to collecting data you have to be able to:

3. Questions in four areas:
   a. To _____ Data Collection Strategies. See if you can guess the right answer to the photosynthesis question BEFORE he explains it. You can see how he *justified* his answer. Did you get it right? _____

   b. To _____ a plan for _____ Data of your own
      i. First you would need to:

      ii. Then: _____ an experiment that

      What would a good essay contain?:

   c. To _____ to

   d. To _____ _____ of Data.

4. What makes science, science?

AP Biology Practice 5 – Analysis and Evaluation of Evidence Video Review Sheet

www.bozemanscience.com/apb-practice-5-analysis-evaluation-of-evidence

1. One of the first things you want to do with data is:

2. When you look at data, see if there are patterns that you can

3. You will be asked:
   a. To _____ data to Identify
   b. To _____ Observations and
   c. To _____ Evidence

4. We collect data. First we have to _____ it and then we have to

AP Biology Practice 6 – Scientific Explanations and Theories
Video Review Sheet

www.bozemanscience.com/apb-practice-6-scientific-explanations-theories

A. Diagram the process of developing a theory; be sure to include the feedback loops.

B. The five ways to deal with theories and scientific explanations:
   1. Justify claims with
   2. Construct explanations based on
   3. _____ the Reasons that Explanations and Theories are
   4. Make _____ and predictions about
   5. Evaluate

C. Theories get better and better over _____ and on the test they want you to be able to

AP Biology Practice 7 – Scales, Concepts and Representations
Video Review Sheet

www.bozemanscience.com/apb-practice-7-scales-concepts-representations

1. This practice is about _____ knowledge. Bringing together different disciplines.
2. Scale: draw and label intersecting diagram and use one of his examples:

3. Domains: _____ of biology.
    a. Thermodynamics (Physics) Example:

    b. Biochemistry Example:

    c. Chemistry Example:

4. Big Idea examples: elaborate on
    a. Evolution example: peppered moth, what happens over _____

    b. Free Energy: Feedback loops and how they allow organisms to survive in…

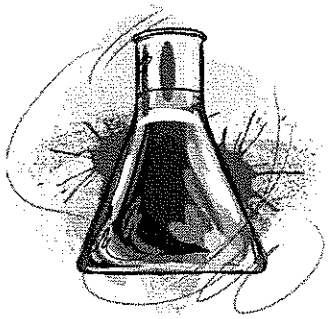
    c. Information: Himalayan rabbit ex, expressing different genes depending on

    d. Systems: Cotton ex sugar able to create

5. Two goals:
    a. Connect Phenomenon and Models Across _____ and _____ scales. Try answering the question before he does. ____

    b. Connect Concepts _____ and _____ Domains. Try ___

Are you going to try his Wiki game?



Part 2: Chemistry & Biochemistry Review

1. All matter is composed of atoms . What are atoms composed of?

2. Explain how atoms, which are made up of charged particles, can have no overall charge.

3. What are the six (6) most common elements that make up living things?

4. Can you name the major categories of organic compounds and list the elements (from the above list) which comprise each?

1 H 1.0079																	2 He 4.003
3 Li 6.941	4 Be 9.012	Chemical symbol Atomic number Atomic mass (average of all isotopes)										5 B 10.81	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.179
11 Na 22.990	12 Mg 24.305											13 Al 26.982	14 Si 28.086	15 P 30.974	16 S 32.06	17 Cl 35.453	18 Ar 39.948
19 K 39.098	20 Ca 40.08	21 Sc 44.956	22 Ti 47.86	23 V 50.942	24 Cr 51.996	25 Mn 54.938	26 Fe 55.847	27 Co 58.933	28 Ni 58.69	29 Cu 63.546	30 Zn 65.38	31 Ga 69.72	32 Ge 72.59	33 As 74.922	34 Se 78.96	35 Br 79.909	36 Kr 83.80
37 Rb 85.4678	38 Sr 87.62	39 Y 88.906	40 Zr 91.22	41 Nb 92.906	42 Mo 95.94	43 Tc (99)	44 Ru 101.07	45 Rh 102.906	46 Pd 106.4	47 Ag 107.870	48 Cd 112.41	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.904	54 Xe 131.30
55	56	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86

Cs	Ba	Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
132.905	137.34	174.97	178.49	180.948	183.85	186.207	190.2	192.2	195.08	196.967	200.59	204.37	207.19	208.980	(209)	(210)	(222)
87	88	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118
Fr	Ra	Lr	Rf	Db	Sg	Bh	Hs	Mt									
(223)	226.025	(260)	(261)	(262)	(266)	(264)	(269)	(268)	(269)	(272)	(277)		(285)	(289)			(293)

	57	58	59	60	61	62	63	64	65	66	67	68	69	70
Lanthanide series	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb
	138.906	140.12	140.9077	144.24	(145)	150.36	151.96	157.25	158.924	162.50	164.930	167.26	168.934	173.04
	89	90	91	92	93	94	95	96	97	98	99	100	101	102
Actinide series	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No
	227.028	232.038	231.0359	238.02	237.0482	(244)	(243)	(247)	(247)	(251)	(252)	(257)	(258)	(259)

5. Differentiate between atomic number, mass number and atomic mass.

6. Define "isotope." Istopes of which element were important in the discovery that DNA replicates semi-conservatively?

7. Define "radioisotope." Radioistopes of which element were important in the discovery that bacteriophages inject DNA, not proteins, into a bacterium?

8. Electrons are found in energy levels/orbitals. What is the maximum number of electrons found in:

   a. the first energy level? _____

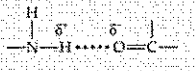
   b. the second energy level? _____

   c. the third energy level? _____

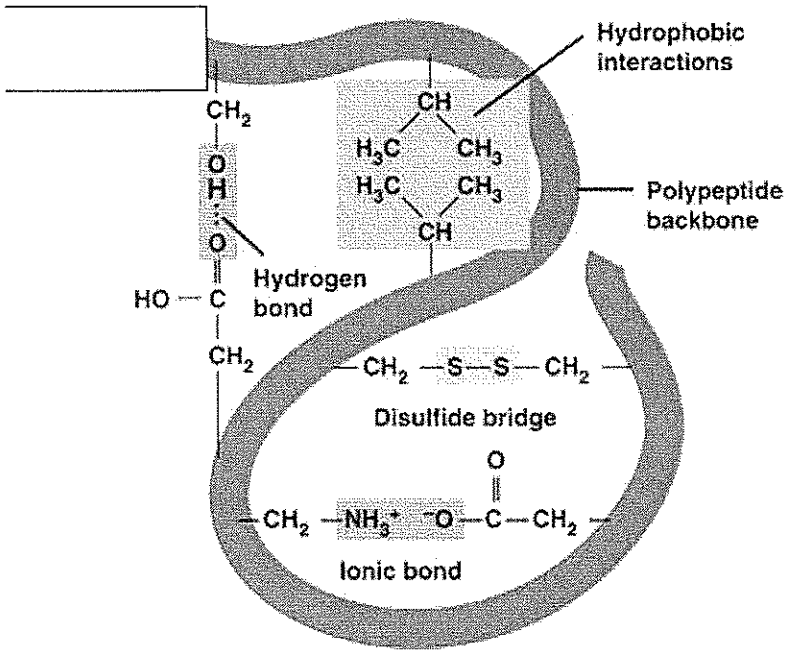
9. Differentiate between an atom being <u>stable</u> and atom being <u>neutral</u>. Using a specific element, give an example of each.

10. Differentiate between covalent, ionic, and hydrogen bonds. Using the chart below, explain the significance of the bond energy of each.

2.1 Chemical Bonds and Interactions

NAME	BASIS OF INTERACTION	STRUCTURE	BOND ENERGY* (KCAL/MOL)
Covalent bond	Sharing of electron pairs		50–110
Hydrogen bond	Sharing of H atom		3–7
Ionic interaction	Attraction of opposite		3–7

11. In the following diagram, show where you would find a covalent bond, an ionic interaction, a hydropobic interaction, and a hydrogen bond.



12. What determines what type of bond (nonpolar covalent, polar covalent, or ionic) will form between two atoms?

13. Differntiate between cations and anions. List at least three of each type that are of biological importance.

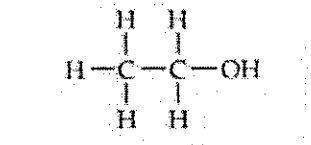
14. Differentiate between exergonic and endergonic reactions. Give a biological example of each.

15. The most important INORGANIC compound on Earth is _____. List and define several of this molecule's extraordinary properties.

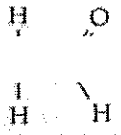
16. What determines the pH of a solution?

17. Why is the control of pH so important in living systems? What buffering system is important in human blood ?

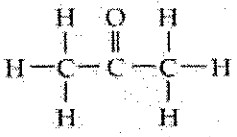
18. Identify the functional groups in the molecules below. What properties do each exhibit?



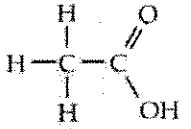
Ethanol



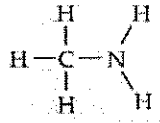
Acetaldehyde



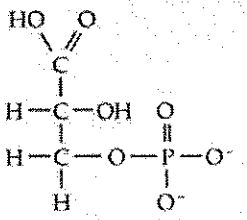
Acetone



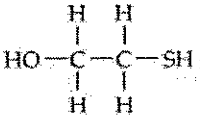
Acetic acid



Methylamine

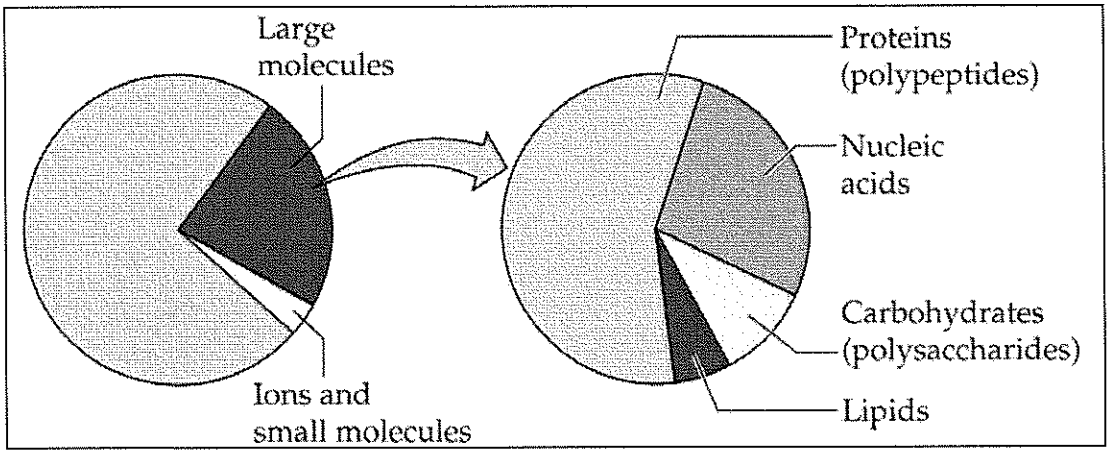


3-Phosphoglyceric acid



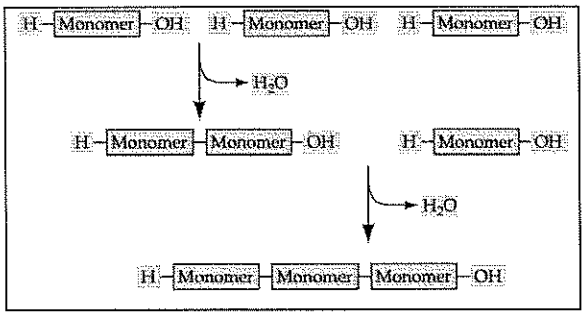
Mercaptoethanol

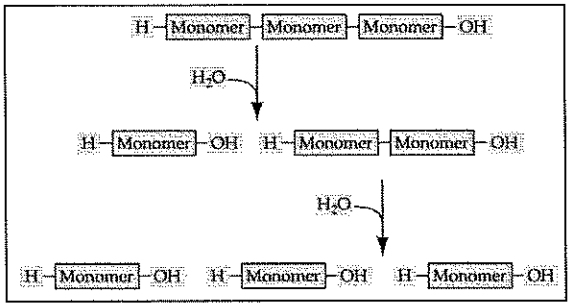
19. Examine the diagram below. What does the largest portion of the circle on the left represent?



20. Complete the following chart.

21. What types of reactions are depicted below?





22. Monosaccharides are named according to the number of carbons they contain. For example, a three carbon monosaccharide is called a triose. Two importants trioses are phosphoglyceraldehde (PGAL) and dihydroxyacetone (DHAP).

A five carbon monosaccharide is called a _____. Name two common five carbon sugars and state their formulas

a. _____ ; chemical formula is _____

POLYMER	POLYMER EXAMPLE	MONOMER	NAME OF BOND BETWEEN MONOMERS	MONOMER EXAMPLE
POLYSACCAHRIDE (complex carb)				
POLYPEPTIDE (protein)				
NUCLEIC ACID				
LIPID				

b. _____ ; chemical formula is _____

A six carbon monosaccharide is called a _____. Name three common six carbon sugars and state their formulas

a. _____ ; chemical formula is _____

b. _____ ; chemical formula is _____

c. _____; chemical formula is _____

23. Draw the structural formula for an amino acid. Label all 5 parts.

24. Describe the four levels of protein structure. What types of bonds are important at each level?

a. primary - _____

_____

b. secondary - _____

_____

c. tertiary - _____

_____

d. quaternary - _____

_____

25. What are three parts common to all nucleotides?

a.

b.

c.

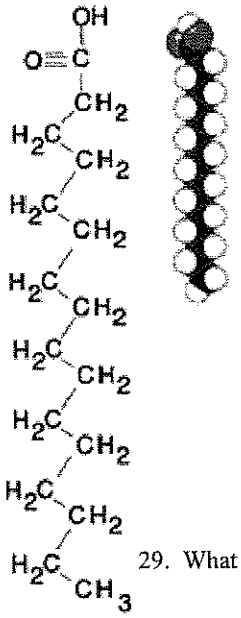
26. Complete the chart below.

27.

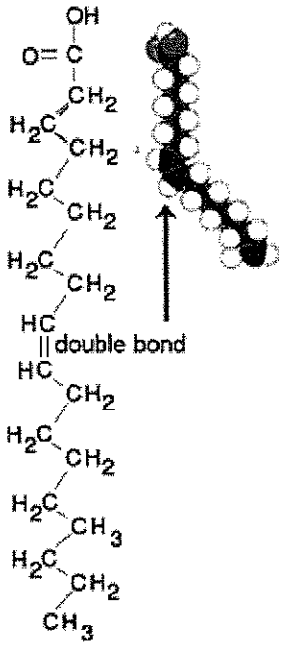
DNA		RNA
	Sugar	
	Nitrogen Bases	
	#of nucleotide strands	
	Location in the cell	
	Types or Forms	

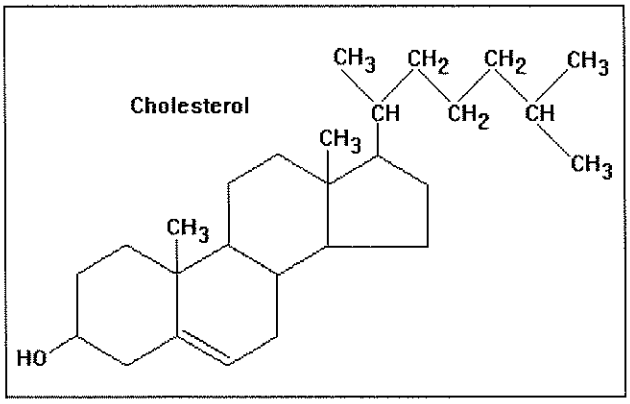
Distinguish between purines and pyrimidines. State which bases are purines and which are pyrimidines.

28. Three of the molecules shown to the left below are bonded to glycerol, what type of molecule is produced? Three of the molecules shown to the right below are bonded to glycerol, what type of molecule is produced?



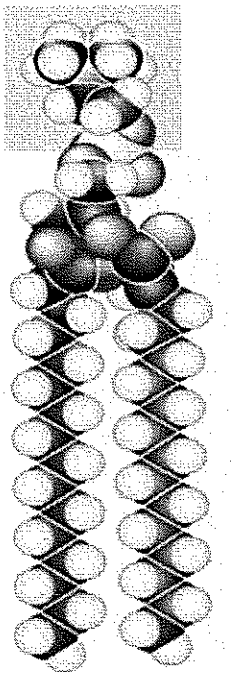
29. What type of molecule is shown below?

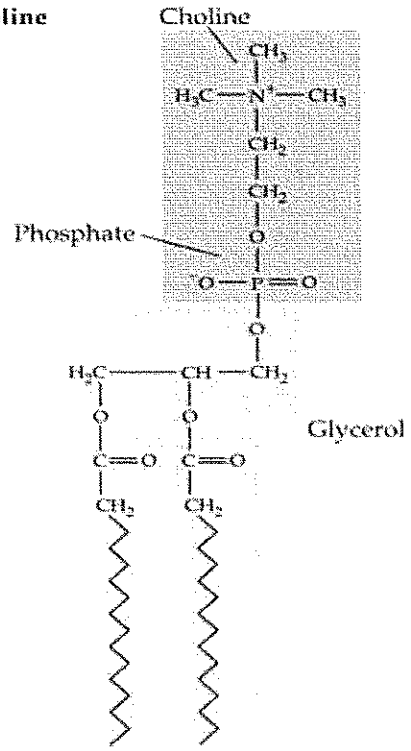




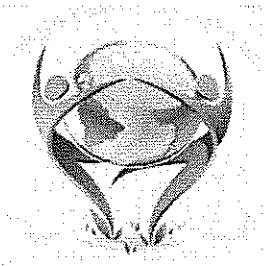
30. What type of molecule is shown below? Where in the cell is it found? Label the hydrophobic and hydrophilic portions of the molecule.

(a) **Phosphatidyl choline**





Part 3: Ecology & Population Biology



1.A.2: Natural selection acts upon phenotypic variations in populations.

1. Go to the following link: http://www.ncbi.nlm.nih.gov/pubmed/18409423 and read the abstract. Write a brief summary on flowering time in Concord, MA.

1.C.1: Speciation and extinction have occurred throughout Earth's history.

2. Go to the following link: http://www.guardian.co.uk/environment/2010/mar/07/extinction-species-evolve and read the article (if it doesn't open, search for "why do scientists think that we are in the midst of a mass extinction" and answer the questions below based upon the site you selected).

a. Why are scientists stating we may be in our 6th major mass extinction?

b. How many species are currently being threatened? What ratios did you see (mammals, amphibians…*etc…..if you used another link than the one above, list the numbers threatened per group – mammals, amphibians, insects, reptiles…*)?

2.C.2: Organisms respond to changes in their external environments.

3. *Click on or paste this link into your URL bar and a Power Point will download. Answer the next 3 questions based on the Power Point.*
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=10&ved=0CFsQFjAJ&url=http%3A%2F%2Fwww.saburchill.com%2FIBbiology%2Fchapters05%2Fimages%2FPHOTOPERIODISM.ppt&ei=PDONUYD6JPKq4APznIDoBA&usg=AFQjCNG35hXOWCYElTQzvwxZhuCVDooKTQ&bvm=bv.46340616,d.dmg

a. What is photoperiodism? What organisms does it affect?

b. Which latitude lines does photoperiodism have the greatest affect? Why?

c. List the 3 types of plants considered to be affected by photoperiodism, and give the day, length and examples of each.

2.D.1: All biological systems from cells and organisms to populations, communities and ecosystems are affected biotic and abiotic interactions involving exchange of matter and free energy.

4. *Use the following link to answer the next set of questions.*
http://www.mdsg.umd.edu/programs/education/interactive_lessons/biofilm/

a. Click on "*Introduction*". Based up on the information and descriptions, what are biofilms?

b. Click on "*How to Calculate Biodiversity*"
   1. What is "Species Richness"?

   2. What is the "Simpson's Index"?

c. Click on "*Biodiversity and Depth*"
   1. Which level has the most richness?
   2. What can you conclude about the relationship between richness and the environmental conditions (salinity, pH, temp, dissolved O_2)? What's the proof?

5. You are given the following organisms from the Chesapeake Bay: (*NOTE: This question does NOT pertain to the link on the previous page.)*

1. Osprey
2. Herbivorous Ducks
3. Vegetation
4. Phytoplankton
5. Zooplankton
6. Tundra Swan
7. Bivalves
8. Striped Bass
9. Great Blue Heron
10. Menhaden (fish)

Create a food web below of these 10 organisms; remember the arrow points towards what is eating it. Look up the organisms if you are not sure what they eat, or what the organism is.

2.D.3: Biological systems are affected by disruptions to their dynamic homeostasis.

6. *Use the following link to answer the next question.*
http://onlinelibrary.wiley.com/doi/10.1111/plb.12337/abstract

Read over the salinity abstract and summarize the experimental findings.

2.E.2: Timing and coordination of physiological events are regulated by multiple mechanisms.

7. *Use this link to answer the next 2 questions:* http://www.scientificamerican.com/article.cfm?id=how-to-prevent-jet-lag

a. What is circadian rhythms?

b. How can you "reset" or change your circadian rhythm to lessen the effects of jet lag?

Use the following link to answer the next 2 questions. You may be surprised from what you read about bears and hibernation..... http://www.nhfishandwildlife.com/seven.php

c. Which of the 7 organisms are "true hibernators"? Why are they considered this?

d. Why are the other organisms not considered "true hibernators"?

Find a link to answer the next two questions: http://www._____

e. What is symbiosis? What are the five types of symbiosis?

f. Give an example of each type of symbiosis (be sure to talk about both organisms).

3.E.1: Individuals can act on information and communicate it to others.

8. *Use the following link to answer the next question:*
http://www.sciencedaily.com/releases/2009/06/090619171244.htm

a. What does this article seem to suggest?

Find a link to answer the next 2 questions: http://www._____

b. What does norepinephrine and epinephrine do?

c. Imagine someone under constant severe stress all the time. What would stage three look like?

Find a link to answer the next question: http://www.

d. Read an article on schooling fish, list and explain three reasons why fish school the way they do.

4.A.5: Communities are composed of populations of organisms that interact in complex ways.

9. *Use the following link to answer the next 2 questions.*
http://onlinelibrary.wiley.com/doi/10.1111/j.1466-8238.2008.00390.x/pdf

a. Population is a group of individuals of a single species living in the same general area. What is *population density* and why is it difficult to measure?

b. Do population density studies take into effect water bodies for terrestrial organisms? Why do you think this might cause mistakes in calculations?

4.A.6: Interactions among living systems and with their environment result in the movement of matter and energy.

10. *Use the following link to answer the next 3 questions:*
http://www.sciencedaily.com/releases/2011/03/110331104003.htm

a. The researchers have identified a range of historical and ongoing human activities that have damaged or restructured food webs in the Southern Ocean over recent decades. List the 5 activities they mention in the article.

b. The Antarctic Treaty and other conventions cannot address Global-scale threats. Pick two of the four bullets/points that are listed you think are the most important, explain why you feel this way.

c. What will the increasing amounts of CO_2 do to the oceans besides warm up the planet? Do a little search online to see why excess CO_2 in the atmosphere is not good for the oceans, and explain what happens to at least two groups of organisms.

Use the following link to answer the next 4 questions: http://www.ramp-alberta.org/river/ecology/life+in+aquatic+ecosystems/food+chains+and+food+webs.aspx

d. What is a food chain? Draw a food chain.

e. What is a food web? Draw a food web.

f. What are cascade interactions? Give an example of this.

g. *Click on the bottom "Next Page".* What is primary and secondary production? Given an example of each.

4.B.3: Interactions between and within populations influence patterns of species distribution and abundance.

4.C.4: The diversity of species within an ecosystem may influence the stability of an ecosystem.

11. *Use the following link/pdf presentation to answer the following 4 questions:*

Zach Gregory The Effects of the Wolves and Snowpack on Ravens (This link is safe)

a. What is a keystone species? Why are they important?

b. Wolfs are just another animal .....why do they support SO MANY other species? Give one good example of how wolves support a species.

c. So we pretty much eliminated wolves from the Continental United States prior to 1995 (they were re-introduced then into Yellowstone National Park). So what? Why are they important to the environment?

d. What are steps that can be taken to preserve the wolf's habitat?

4.B.4: Distribution of local and global ecosystems over time.

12. *Find a link to answer the next 4 questions:* http://www.

a. What are invasive species, and why do they survive so well in their new habitats?

b. Why is it a big deal for invasive species to be controlled or handled?

c. What are 3 current invasive species in the United States, and what is being done about them?

d. Name at least 3 invasive species here in Connecticut (not listed in the previous question.). What is being done to the native species....AND are there any control measures currently in place and explain.

Part 4: Personal Diet Analysis

DIET ANALYSIS
A closer look at your eating habits

For this project, you will submit:

- **Your 3 days' worth of foods and beverages, with motivation codes and physical/mental/emotional states, IN MENU FORMAT**
- **Your Nutrient Intake Report from SuperTracker**
- **Your typed essay, answering all questions assigned**

Preparation for the 3-Day Diet Analysis Project

- **STEP #1: Food Log**

Record everything that you eat and drink for 3 days. (See Instructions for Completing Food Log handout). The most accurate picture of your eating habits is achieved when the three days include two weekdays and one weekend day. Try to pick a time when you think your intake will be representative of your normal eating habits (e.g., no major celebrations, vacations, or unusual events planned). Do not consciously alter your normal eating pattern.

Record the **amount** of each food eaten. Also record the quantity of **all beverages including water** that you consumed. DO NOT include vitamin or mineral supplements in your analysis.

Describe each food as completely as possible including the brand name of commercial products and the ingredients of homemade items. For example, if you ate a Big Mac record 1 Big Mac, but if you ate a homemade stir-fry record the amount of each ingredient in the portion you ate.

FOR THIS ASSIGNMENT, PLEASE RECORD YOUR PHYSICAL AND MENTAL/EMOTIONAL STATES BEFORE AND AFTER EACH MEAL/SNACK. This information will factor into your analysis in the essay portion.

- **STEP #2: Menu Format**

Write out the day's food and beverages in menu form: breakfast, snack, lunch, etc. (See below for a sample menu with the expected format). Include all the food and beverages, even if that means listing few meals and lots of snacks. (Please type this information out as you will be handing it in.) **Label each item on your menu with the code or codes that indicate why you chose to eat that food or drink that beverage. Also, be sure to include the physical and mental/emotional states you recorded in your food log. Include this menu in your project submission.**

Code	Motivation
A	Personal Preference (I like it.)
B	Habit or tradition (It's familiar; I always eat it.)
C	Social pressure (It was offered; I couldn't refuse.)
D	Availability (I was hungry and it was nearby.)
E	Convenience (I was too rushed to prepare anything else.)
F	Economy (It was a food I could afford.)
G	Health value (I think it is healthy for me to eat.)
H	Advertising.
I	Other (explain).

- **STEP #3: SuperTracker**

We will again use USDA's SuperTracker (https://www.supertracker.usda.gov). This website will calculate your estimated nutrient needs and compare them with the totals from your 3-day intake. You will use this information to analyze your intake. **Below is a review of the instructions on creating a profile, just in case you need to do so again (if you lost your log-in information, for example), as well as instructions on generating the Nutrient Intake Report. If you still have your log-in info, just log in to your existing profile—there is no need to create a new one.**

1. Create a profile on the website. This only takes a couple of minutes, and you will answer questions that the website uses to calculate an estimate of your energy and nutrient needs.

2. Log into your profile.

3. Once logged in, click on the Food Tracker link. Once in Food Tracker, you can search for foods and beverages and add them to your day. Be sure to adjust for the correct quantity of each food before adding.

3. Once you've added all your food and beverages, click on the link titled Nutrient Intake Report. This link is in very small, blue type underneath bar graph on the right.

4. In the upper right corner of the screen, there is the option to export the report to a variety of formats. Export the report to Word. Save the file and submit it with your project.

5. Once you create a profile in SuperTracker, the website will save your data, and you can access your input by the date you entered it. Just log back in and click on Food Tracker, where you can use the calendar tool access a particular day's data.

- **STEP #4: Essay**

Please be sure to use single spacing and 12 point Times New Roman. Also, please remember to include your intake for the day in menu format, as well as the Nutrient Report from SuperTracker. You do not need a cover page.

To answer the questions thoroughly, you should need about 2 pages (though you're welcome to write more). Be sure to complete the assignment in continuous essay format. Do not write the question and then the answer…and use full paragraphs! A well-written paragraph contains an introduction, supporting sentences that elaborate on the topic at hand, and a strong conclusion. The 2 pages do not include your menu and SuperTracker chart.

1. List any vitamins and minerals that averaged less than 100% of the recommended amount.

2. For each vitamin or mineral that averaged less then 100% of the recommendation, suggest one food that would increase the amount of that nutrient in your diet.
    a. Why did you pick the food? Is realistic to YOUR diet?
    b. Suggest a way you would incorporate the food directly into your diet.

3. How many grams of fiber did you consume per day?
    a. What is the recommended intake per day?
    b. If you ate less than the recommended daily intake, how could you **realistically** increase your fiber?
    c. What foods in your 3-day intake are highest in fiber? (Next to each nutrient listed in the Nutrient Intake Report, there is a plus sign (+). You can click on the "+" to see a list of foods providing that particular nutrient, and these foods are listed in order from greatest to lowest contribution.)

4. Take a look at your essential fatty acid intakes: linoleic acid, alpha-linolenic acid, omega-3 EPA, and omega-3 DHA.
    a. How did your intakes of linoleic and alpha-linolenic acids compare to your recommendations?
    b. Current recommended intake for the sum of EPA+DHA is around 500-1000 milligrams per day for healthy adults (but not more than 3000 mg/d, due to increased risk of bleeding). What was your sum of EPA+DHA?
    c. What foods were the major contributors of these nutrients during your 3-day intake? If your intakes were low, what foods could you include to boost the numbers?

5. What have you learned about your eating habits?
    a. Note the physical and mental/emotional states before and after meals/snacks.
    b. Offer observations: did you notice any patterns with respect to the above states and your food choices/eating habits? Did you notice any influence that your food choices/eating habits had on your physical/mental/emotional states? Please describe.

6. As a conclusion, summarize what you have learned from this exercise. Include here any thoughts on modifications you might make to your eating habits or behaviors. Be sure to **list at least one specific change you would make** (for example: I would incorporate a baked sweet potato with dinner to increase my vitamin A intake).

Sample Menu

After you record your intake for the day, organize it as follows in menu format. In parentheses following each item is the motivation code for that item, as described above. In brackets are the physical and mental/emotional states that you may have logged for extra credit. Please note that, where possible, foods are grouped according to the dishes to which they belong (e.g., Tacos: 4 corn tortillas, 6 ounces beef, ½ cup tomato salsa, ¼ cup cilantro).

Monday, 11/28/11

Breakfast (7:00am):
[Before: hungry, tired]
8 fluid ounces water (B, G)
1 slice sprouted grain bread (G)
1 tablespoon unsalted almond butter (A, G)
1 apple (A, G, D)
16 fluid ounces green tea (A, G, B, I: caffeine to help wake me up)
[After: satiated, energized]

Morning Snack (10:15am):
[Before: stressed, hungry, empty stomach]
1 hard-boiled egg (D, G, F)
¼ teaspoon salt (A)
1 pear (D, G)
12 fluid ounces water (B, G)
[After: partially satiated, focused]

Lunch (12:30pm):
[Before: energized, happy, hungry]
12 fluid ounces water (G)
Salad:
2 cups mixed baby lettuces (A, G)
1/3 cup marinated artichoke hearts (A, G)
¼ cup sliced black olives (A)
¼ cup grated carrot (A, G)
½ cup raw broccoli (G)
1 tablespoon balsamic vinegar (A, B)
2 tablespoons extra-virgin olive oil (A, G)
¼ teaspoon salt (A)
6 ounces grilled chicken breast (B, D)
Soup:
1 cup butternut squash (A, G)
¼ cup chopped onions (A)
¼ teaspoon salt (A)
2 teaspoons extra-virgin olive oil (A, G)

½ cup chicken broth (A)
[After: happy, satiated, tired]

Afternoon Snack (2:45pm):
[Before: tired]
2 ounces dark chocolate (A, I: helps perk me up when I'm tired)
1/4 cup raw walnuts (G)
1 tangerine (A, D, G)
16 fluid ounces green tea (B, G, I: caffeine)
[After: more alert, but still tired]

Between snack and dinner:
16 fluid ounces water (G)
8 fluid ounces English breakfast tea (I: caffeine)

Dinner (8:30pm):
[Before: very hungry, stressed]
5 fluid ounces red wine (A, I: helps me relax)
12 fluid ounces water (B, G)
Tacos (from taco truck): (E)
4 corn tortillas (A, G)
6 ounces beef (flank steak) (A)
½ cup tomato salsa (A)
¼ cup cilantro (A, G)
Rice:
2 teaspoons extra-virgin olive oil (A, G)
1 cup cooked brown rice (A, G)
1 teaspoon tomato paste (A)
1 clove garlic (A, G)
1/8 teaspoon salt (A)
Slaw:
1½ cups sliced red cabbage (A, D, G)
½ cup grated carrot (A, G)
½ cup grated beet (A, G)
1 tablespoon extra-virgin olive oil (A, G)
2 tablespoons lime juice (A)
1/8 teaspoon salt (A)
Dessert:
1 cup Coconut Bliss ice cream (Hazelnut Fudge) (A)
[After: relaxed, full, sleepy]