1. Homeostasis, a steady-state physiological condition characteristic of living organisms, is maintained via feedback mechanisms. Select **three** of the following physiological conditions and explain how feedback mechanisms are used to maintain homeostasis.
    a. blood glucose concentration
    b. body temperature in birds
    c. calcium ion concentration in blood
    d. pulse rate in mammals

2. A scientist working with *Bursatella leachii*, a sea slug that lives in an intertidal habitat in the coastal waters of Puerto Rico, gathered the following information about the distribution of the sea slugs within a ten-meter square plot over a ten day period.
    a. graph the data
    b. Identify three physiological or environmental variables that could cause the distribution patterns noted.
    c. Explain how each variable could influence the observed distribution pattern.
    d. Choose 1 of the variables that you identified and design a controlled experiment to test your hypothetical explanation.
    e. Describe results that would support or refute your hypothesis.

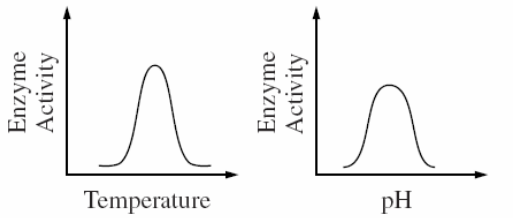
Distribution of Slugs within a $10m^2$ area	
Time of Day	Average Distance (cm)
midnight	8.0
4 a.m.	8.9
8 a.m.	44.8
noon	174.0
4 p.m.	350.5
8 p. m	60.5
midnight	8.0

2. Water has several unique properties that make life possible on Earth. Select three properties of water and, for each property,
    a. Identify and define the property and explain it in terms of the physical/chemical nature of water.
    b. Describe one example of how the property affects the functioning of living organisms.

3. Water is fundamental to life processes and its functions are related to its physical properties.
    a. Explain how the properties aid in two of the following processes:
        - transpiration in plants
        - thermoregulation in animals
        - structure of the plasma membrane
    b. Describe the role of water in the carbon cycle
    c. Discuss how human activity has an impact on the water cycle.

4. The storage and transfer of energy are essential activities for all living organisms.
    a. Explain why living organisms require a continuous intake of energy.
    b. Describe how ATP powers cellular work via coupling reactions.
    c. Describe the energy transformations involved in two of the following processes:
        - energy flow in an ecosystem
        - glycolysis
        - photosynthesis
        - digestion of starch

5. The effects of pH and temperature were studied for an enzyme-catalyzed reaction. The results are plotted in the graph below.
    a. Explain how temperature and pH affect the activity of this enzyme. Be sure to include details about the relationship between the structure and the function of the enzyme and how temperature and pH affect the function of enzymes.
    b. Design a controlled experiment, for either temperature or pH that might have produced the results shown in the graph.



6. Cells transport substances across their membranes. For each of the processes listed below
        - osmosis
        - active transport
        - facilitated diffusion
        - endocytosis/exocytosis
    a. Describe each process
    b. Explain how the organization of cell membranes functions in the movement of specific molecules across the membrane.
    c. Explain the significance of each type of transport to a specific cell

7. Maintaining an oxygen-carbon dioxide balance in internal tissues is crucial for multicellular organisms.
    a. What processes produce oxygen and carbon dioxide?
    b. What processes use oxygen and carbon dioxide?
    c. Describe characteristics of gas exchange surfaces in multicellular organisms.
    d. Describe how gas exchange takes place in each of the following organisms:
        - earthworm
        - fish
        - mammal
        - multicellular plant

8. A biologist tested the effects of different NaCl concentrations on diffusion rate. In the experiment, four solutions of NaCl (0%, 1.0%, 5.0%, and 10.0%) were tested under identical conditions. Twenty mL of each solution were placed in bags made of dialysis tubing and submerged in separate beakers containing 500 mL distilled water. The dialysis tubing was permeable to Na^+ ions, Cl^- ions, and water. The concentration of NaCl in the water outside the each bag was measured at 30 second intervals. The data chart below shows the results from the bag containing 5.0% NaCl.

NaCl concentration (mg/mL) outside 5.0% NaCl Bag

Time (s)	NaCl (mg/mL)
0	0
30	125
60	215
90	320
120	405
150	475

   a. Graph the data for the 5% NaCl solution.
   b. On the same graph, draw and label three additional lines representing your predictions for the 0%, 1.0%, and 10.0% NaCl solutions.
   c. Explain your predictions.
   d. Apply the results of your experiment to a scenario about farmlands near coastal regions being threatened by increasing salinity in the soil.

9. When a population of cells is examined with a microscope, the percentage of cells in the M phase is called the mitotic index. The greater the proportion of cells that are dividing, the higher the mitotic index is. In a particular study, cells from a cell culture are spread on a slide, preserved and stained, and then inspected in the microscope. A hundred cells are examined and the results recorded in Table A. Consider that the cell cycle for these cells lasts 15 hours.

   a. Determine the percent of cells in each state and the time spent in each cell phase.

Table A: Percentage of Cells in Cell Cycle Stages			
Phase	Number of Cells	Percent of Total Cells	Time In Cell Phase (minutes)
Interphase	80		
Prophase	8		
Metaphase	6		
Anaphase	2		
Telophase	4		

   b. Interphase cells were further analyzed for average DNA content. The results are presented in Table B: Based on the data, determine the duration in minutes of G_1, S, and G_2 phases. Remember, the cell cycle for these cells is 15 hours.

Table B: Average Content of DNA in Interphase Cells			
DNA Content	10 ng	10~20 ng	20 ng
Percent of Cells	50 %	30%	20%

10. Regulation of biochemical and physiological activities is a key theme throughout the living world. Describe three of the following regulatory processes, including details about the controlling process, its effects, and an example.
    a. regulation of RNA transcription in a eukaryotic cell
    b. regulation of cell activities by a steroid hormone
    c. regulation of embryonic development by induction
    d. regulation of a biochemical pathway ay an allosteric inhibitor
    e. regulation of population growth by density-dependent factors

11. The Roman emperor Claudius Caesar (10 BC~AD42) had an appetite for the delicate taste of mushrooms. Historians believe that Caesar's wife, Agrippina, wanted to poison him. She mixed into Caesar's favorite dish of mushrooms a few of the poisonous species *Amanita caesarea*. These poisonous mushrooms contain a substance that blocks the activity of an enzyme required for the cells to transcribe messenger RNA from DNA. For the first 10 hours after Caesar ate the mushrooms, all seemed well. But as the poisonous mushrooms were digested, poisons entered the blood stream and were absorbed by the liver and kidneys. About 15 hours after eating the mushrooms, Caesar's liver cells (hepatocytes) stopped functioning. Nausea, diarrhea, and delirium affected him as his liver and kidneys could no longer filter and detoxify wastes and other harmful substances from the blood. He died two days later from liver failure.
    a. What are the functions of mRNA?
    b. What are the functions of the proteins that mRNA helps to produce?
    c. How could a substance that stops the synthesis of mRNA cause the liver to stop functioning (cause the death of liver cells?)
    d. Identify types of liver cells and describe their functions
    e. Why do you suppose that it took 2 days for Caesar to die?

12. The following are the results of a series of *Drosophila* gene mapping experiments determined the frequency of recombination of four different linked genes on chromosome 2. The results are as follows:

Recombination Frequencies	Key to Symbols
vg-b = 19.5 cn-vg = 9.5 rb-cn = 6.5 b-rb = 3.5 b-cn = 9.0	b = black body cn = cinnabar ey es rb = reduced bristles vg = vestigal wings

    a. Arrange these genes sequentially along the chromosome using this data. (you may want to use labeled diagram that indicates the gene distances)
    b. Describe the process in cell division that could create recombination of these genes with the wild genotypes
    c. Design a series of *Drosophila* crosses to determine whether or not the locus for a fictitious gene for a recessive trait for blue wings is on the same chromosome as the recessive trait for vestigial wings.

13. The complimentarily of structure and function is an important theme in biology. Select four structure—process relationships listed below and describe two ways in which each structure is adapted to carry out the function.
    a. leaf—photosynthesis
    b. mitochondrion—Krebs cycle
    c. cell membrane—transport of molecules
    d. mammalian intestine—digestion
    e. gas exchange—insect tracheal system

14. Evolution is a fundamental characteristic of populations of living organisms.
    a. Describe, with an example, how each of the following processes are related to population changes
        - crossing over
        - independent assortment
        - mutation
        - natural selection
        - genetic drift
    b. Explain how antibiotic resistant strains of bacteria appear.

15. Prokaryotes and eukaryotes differ in the organization of their genetic material.
    a. Compare and contrast the organization of genetic material in prokaryotic and eukaryotic organisms. Be sure to include specific examples.
    b. Describe how the following activities are carried out in prokaryotes and eukaryotes:
        - DNA replication
        - Transcription and translation of the genome
        - Gene regulation
    c. Cell division

17. The rate of photosynthesis may vary with changes that occur in environmental temperature, wavelength of light and light intensity. Using a photosynthetic organism of your choice, choose only **1** of the three variables (temperature, wavelength of light, or light intensity) and for this variable
    a. Design a scientific experiment to determine the effect of the variable on the rate of photosynthesis for the organism
    b. Explain how you would measure the rate of photosynthesis in your experiment.
    c. Describe the results you would expect.
    d. Explain why you would expect these results.

18. Photosynthesis and cellular respiration recycle oxygen in ecosystems.
    a. Explain how the metabolic processes of cellular respiration and photosynthesis recycle oxygen.
    b. Discuss the structural adaptations that function in oxygen exchange between each of the following organisms and its environment: a plant; an insect; a fish.
    c. Trace a molecule of O_2 from the environment to a muscle cell in a vertebrate of your choice.

19. A student counts 1920 kernels of corn from the F_2 progeny of a dihybrid cross. The observed number of progeny in each phenotypic class was 998 purple wrinkled; 410 purple smooth; 376 yellow wrinkled; and 136 yellow smooth. Use the table below to determine the expected number, the X^2 value, and the probability of the observed values not differing significantly from the expected 9:3:3:1 ratio. Do the data fit the model?

Analysis Corn Ears (dihybrid cross)

$$X^2 = \frac{(a_1-e_1)^2}{e_1} + \frac{(a_2-e_2)^2}{e_2} + \frac{(a_3-e_3)^2}{e_3} + \frac{(a_4-e_4)^2}{e_4}$$

	Purple~Wrinkled	Purple~Smooth	Yellow~Wrinkled	Yellow~smooth	Total
Actual Number	a_1	a_2	a_3	a_4	
Expected Number	e_1	e_2	e_3	e_4	

You are given an ear of corn from the F_2 generation from the same cross above. You count a total of 420 kernels - 242 purple wrinkled, 84 purple smooth, 70 yellow wrinkled, and 24 yellow smooth. Do these data reflect a 9:3:3:1 ratio?

Analysis Corn Ears (dihybrid cross)

$$X^2 = \frac{(a_1-e_1)^2}{e_1} + \frac{(a_2-e_2)^2}{e_2} + \frac{(a_3-e_3)^2}{e_3} + \frac{(a_4-e_4)^2}{e_4}$$

	Purple~Wrinkled	Purple~Smooth	Yellow~Wrinkled	Yellow~smooth	Total
Actual Number	a_1	a_2	a_3	a_4	
Expected Number	e_1	e_2	e_3	e_4	

Table 6: X^2 Values

	P (probability)								
d. f. *	.95	.90	.80	.70	.50	.30	.10	.05	.01
1	.004	.016	.064	.148	.455	1/03	2.71	3.84	6.64
2	.103	.211	.446	.713	1.38	2.41	4.60	5.99	9.20
3	.352	.584	1.00	1.42	2.37	3.66	6.25	7.82	11.30

*degrees of freedom = 1 for monohybrid cross
= 3 for dihybrid cross

X^2 Data from http://www.richland.cc.il.us/james/lecture/m170/tbl-chi.html
X^2 calculator: http://www.physics.csbsju.edu/stats/chi-square_form.html

You are looking for the difference to be INSIGNIFICANT!
P values above .05 are INSIGNIFICANT (not significant)
This means that actual values DO NOT differ from expected values.

20. The Okapi, a medium-sized relative of the giraffe, lives in isolated parts of the jungles in Zaire. They either have a plain rear, striped, or a densely striped *white* appearance. In the early 1900's, zoologists began recording the appearance of a herd of Okapi (Table A). During this time, no predators of the Okapi had been identified and the population appeared to be stable. In 1923, leopards were spotted in this region for the first time and were found to be feeding on Okapis. Studies of leopards preying on Okapis showed that they had the greatest success capturing Okapis with plain rears, or with a large number of stripes (thus making the rear appear almost all white). Table B shows statistics on Okapi stripes in the 1940's after many years of leopard predation. Corresponding genotypes are included from genetic studies. Note that the stripes trait appears to be show a co-dominant inheritance pattern

Table A: Okapi Appearance—1905	
Stripes	# of 0kapi
Plain (PP)	52
Striped (Pp)	35
White (pp)	5

Table B: Okapi Appearance—1945	
Stripes	# of Okapi
Plain (PP)	23
Striped (Pp)	46
White (pp)	23

d. Construct a bar graph for the data (see below)
e. Describe the change in the Okapi population since their discovery in the 1800's.
f. Identify the type of selection process demonstrated by the data.
g. Identify the selective force in the environment.
h. The "Giraffe" family originated in the plains of Africa, and then moved into the forest. Describe a scenario to explain how the neck length may have shortened in the Okapi population?