

AP Biology Summer Assignment: 2018-2019 School Year

Welcome to AP Biology at Collins Hill High School! This year we will be exploring the intricacies of the study of living organisms at the molecular, cellular, organismal, and ecological levels. In preparation for this year's content, I am asking you to complete a summer assignment with several components. The list of components is given below with supplemental directions and an expected time commitment. If you have questions, please email me at danielle_wilcher@gwinnett.k12.ga.us

Assignment Components:

Component Name	*Page in Packet*	*Directions*	*Teachers' Reason for Including the Component*	*Expected Time Commitment*
"How do we DO science?"		-Read each section (there are 3 parts) -Complete the Questions that accompany each section.	- To form a baseline understanding of Experimental Design, a fundamental component of AP Bio - To practice Hypothesis writing	1.5 hours
Evolution Online Case Study Questions		-Use the link given below to access the online case study -Answer all questions thoroughly and accurately on a separate sheet of paper	-To develop content reading and analysis skills -To further explore Evolution by Natural Selection	1 hour
Chemistry of Water Video and Questions		-Read the info about the chemistry of water -Use the link given below to access the Bozeman Video (Water – A Polar Molecule) -Answer all questions thoroughly and accurately on a separate sheet of paper	-To explore the topics of our first unit, Chemistry of Life	1 hour
How Acidic and basic conditions of water affect living organisms		-Read each section -Complete the Questions that accompany each section. -Design your own experiment at the end	-To extend the topic of our first unit, Chemistry of Life -To integrate content knowledge with scientific investigation/experimental design practice	2 hours

Case Study Link:

- Evolution Case Study – http://evolution.berkeley.edu/evolibrary/article/0_0_0/biowarfare_01

Bozeman Video: Water – A Polar Molecule

- http://www.bozemanscience.com/water-a-polar-molecule

How do we DO science?

Part 1 – Hypothesis Writing

Asking questions

Scientists are characteristically curious and creative individuals whose curiosity is directed toward understanding the natural world. They use their study of previous research or personal observations of natural phenomena as a basis for asking questions about the underlying causes or reasons for these phenomena. For a question to be pursued by scientists, the phenomenon must be well defined and testable. The elements must be measurable and controllable.

There are limits to the ability of science to answer questions. Consider this question: Do excessively high temperatures cause people to behave immorally? Can a scientist investigate this question? Temperature is certainly a well-defined, measurable, and controllable factor, but morality of behavior is not scientifically measurable. We probably could not even reach a consensus on the definition. Thus, there is no scientific experiment that can be performed to test the question.

Which of the following questions can be answered scientifically? Why?

1. Do cactus spines reduce herbivory?
2. Should human embryonic stem cells be used to treat Parkinson's disease?

Developing Hypotheses

As questions are asked, scientists attempt to answer them by proposing possible explanations. Those proposed explanations are called hypotheses. A hypothesis tentatively explains something observed. Consider question 2 from above. One hypothesis based on this question might be "Spines on cacti reduce herbivory." The hypothesis has suggested a possible explanation for the observed spines.

A scientifically useful hypothesis must be testable and falsifiable (able to be "proved" false). To satisfy the requirement that a hypothesis be falsifiable, it must be possible that the test results do not support the explanation. In our example, if spines are removed from test cacti and the plants are NOT eaten by animals, then the hypothesis has been falsified. Even though the hypothesis can be falsified, it can NEVER be proved true. Hypothesis do NOT have to be written in an "If, then" statement (what this statement is and WHEN to use it will come later).

Before scientific questions can be answered, they must first be converted to hypotheses, which can be tested.

Write a hypothesis for each of the following questions.

1. Does cell phone usage reduce auditory function?
2. Do offspring of mothers who jog each day have a mental advantage over offspring of sedentary mothers?

Part 2 – Experimental Design

Identifying Variables

The most creative aspect of science is designing a test of our hypothesis that will provide unambiguous evidence to falsify or support a particular explanation. An experiment involves defining variables, outlining a procedure, and determining controls to be used as the experiment is performed.

Independent – Variable that is independent from all other variables. In other words, it is the variable that YOU change.

Dependent – Variable that is ***dependent*** on the Independent variable. This variable changes in response to the independent variable; it is the variable that is MEASURED.

Constant/Controlled – Variables that remain the same.

Read the following description of a scientific investigation of the effects of sulfur dioxide on soybean reproduction.

INVESTIGATION OF THE EFFECT OF SULFUR DIOXIDE ON SOYBEAN REPRODUCTION

Agricultural scientists were concerned about the effect of air pollution, sulfur dioxide in particular, on soybean production in fields adjacent to coal-powered power plants. Based on initial investigations, they proposed that sulfur dioxide in high concentrations would reduce reproduction in soybeans. They designed an experiment to test this hypothesis (Figure 1.1). In this experiment, 48 soybean plants, just beginning to produce flowers, were divided into two groups, treatment and no treatment. The 24 treated plants were divided into four groups of 6. One group of 6 treated plants was placed in a fumigation chamber and exposed to 0.6ppm of sulfur dioxide for 4 hours to simulate sulfur dioxide emissions from a power plant. The experiment was repeated on the remaining three treated groups. The no-treatment plants were divided similarly into four groups of 6. Each group in turn was placed in a second fumigation chamber and exposed to filtered air for 4 hours. Following the experiment, all plants were returned to the greenhouse. When the beans matured, the number of bean pods, the number of seeds per pod, and the weight of the pods were determined for each plant.

Answer the following questions.

1. For the soybeans, several dependent variables are measured, all of which provide information about reproduction. What are they?

2. What was the independent variable in the investigation of the effect of sulfur dioxide on soybean reproduction?

3. Can you suggest other variables that the investigator might have changed that would have had an effect on the dependent variables?

4. Although other factors, such as light, temperature, time, and fertilizer, might affect the dependent variables, only one independent variable is usually chosen. Why is it important to have only one independent variable?

5. Why is it acceptable to have more than one dependent variable?

6. What are the controlled/constant variables in this experiment?

The Controlled Experiment

The experimental design includes an experimental group AND a **control group** in which the independent variable is held at an established level or is omitted. The control or control treatment serves as a benchmark that allows the scientist to decide whether the predicted effect is really due to the independent variable. Basically the controlled experiment removes the independent variable from the experiment.

For example, if you wanted to know if watering plants increases the growth rate then the experimental group would have plants receiving different amounts of water and the plant height would be measured. Independent variable would be the amount of water each plant receives. Dependent variable would be the height of each plant. The controlled experiment or control group would be a plant that received no water but height was still measured. If the plant still grew (had a high growth rate) then we could NOT conclude that the amount of water influences/affects plant growth.

We use a control group in order to determine if CORRELATION equals CAUSATION.

Answer the following questions.

1. In the case of the soybean experiment, what was the control treatment/group?

2. What is the difference between the controlled experiment and the controlled variables discussed previously?

Part 3 – Making Predictions

If, then statements

The investigator never begins an experiment without a **prediction** of its outcome. *The prediction is always based on the particular experiment designed to test a specific hypothesis.* **Predictions are written in the form of if/then statements**: "If the hypothesis is true, then the results of the experiment will be…"; for example, "If cactus spines reduce herbivory, then removal of the spines will result in greater surface area removed by herbivores." Making a prediction provides a critical analysis of the experimental design.

The if/then statement: **If** *hypothesis,* **then** *prediction*.

Where the prediction is a statement that is specific to YOUR experiment. If you think that cactus spines reduce herbivory and you design an experiment that measures herbivory by removing spines and measuring how much of the cactus is eaten without spines then your prediction needs to be about how much of the cactus you predict will be eaten if you remove the spines (or if you add them).

Answer the following questions.

1. For the soybean experiment, the hypothesis was: "Exposure to sulfur dioxide reduces reproduction." What should the prediction be (remember, the prediction needs to be specific to the experiment)?

2. Now consider an experiment you might design to test the following hypothesis: Offspring of mother's who jog each day have a mental advantage over offspring of sedentary mothers. State a prediction for this hypothesis and experiment. Use the if/then format.

Biological Warfare and the Coevolutionary Arms Race – Case Study Questions

1. What do the Rough-Skinned newts do when they are disturbed? Why?
2. Why were poisonous newts favored by natural selection?
3. Describe an example of an organism who has adapted to its abiotic environment. Do all organisms evolve in response to their abiotic environment?
4. Why did Butch need to test the hypothesis that the newts were poisonous?
5. Why would newt populations evolve to be toxic?
6. Why would making LARGE amounts of TTX neurotoxin **not** be beneficial to a newt?
7. Describe how natural selection would cause newts to evolve TTX levels that were just high enough to protect them from predators.
8. Why did Butch offer newts to garter snakes in a laboratory investigation?
9. Why do newts make such large amounts of TTX?
10. What is coevolution? How are garter snakes and newts an example of coevolution?
11. What are the three requirements of natural selection?
12. Why do you think Butch and his son needed to show that natural selection could operate on both newt toxicity and snake resistance?
13. What is the evolutionary tradeoff newts face? Snakes face?
14. What were the Brodie's predictions if the snakes and newts were actually coevolving?
15. What was the evidence that supported their prediction?
16. How do evolutionary trade-offs restrict adaptation?

The Chemistry of Water

Intro

Water makes up 70% to 95% of the cell content of living organisms and covers 75% of Earth's surface. It's unique properties make the external environment fit for life and the internal environments of organisms fit for the chemical and physical processes of life.

Hydrogen bonding between polar water molecules creates a cohesive liquid with a high specific head and high heat of vaporization, both of which help to regulate environmental temperature. Ice floats and protects oceans and lakes from freezing. The polarity of water makes it a versatile solvent. The $[H^+]$ in a solution is expressed as pH.

The polarity of water molecules results in hydrogen bonding

A water molecule consists of two hydrogen atoms each covalently bonded to a more electronegative oxygen atom. This polar molecule has a shape like a wide V with a slight positive charge on each hydrogen atom (+) and a slight negative charge (-) associated with the oxygen. Hydrogen bonds, electrical attractions between the hydrogen atom of one water molecule and the oxygen atom of a nearby water molecule, create a structural organization that leads to the emergent properties of water.

Four emergent properties of water contribute to Earth's fitness for life

Cohesion - Liquid water is unusually cohesive due to the constant forming and reforming of hydrogen bonds that hold the molecules close together. This cohesion creates a more structurally organized liquid and helps water to be pulled upward in plants. The adhesion of water molecules to the walls of plant vessels also contributes to water transport. Hydrogen bonding between water molecules produces a high surface tension at the interface between water and air.

Moderation of Temperature - In a body of matter, heat is a measure of the total quantity of kinetic energy, the energy associated with the movement of atoms and molecules. Temperature measures the average kinetic energy of the molecules in a substance. Temperature is measured using a Celsius scale. Water at sea level freezes at 0 ºC and boils at 100 ºC. A calorie (cal) is the amount of heat energy it takes to raise 1 g of water 1 ºC. A kilocalorie (kcal) is 1,000 calories, the amount of heat required to raise 1 kg of water 1 ºC.

Specific heat is the amount of heat absorbed or lost when 1 g of a substance changes its temperature by 1 ºC. Water's specific heat of 1 cal/g/ ºC is unusually high compared with other common substances. Why does water absorb or release a relatively large quantity of heat as its temperature changes? Heat must be absorbed to break hydrogen bonds BEFORE water molecules can move faster and the temperature can rise, and conversely, heat is released when hydrogen bonds form as the temperature of water drops. The high proportion of water in the environment and within organisms keeps temperature fluctuations within limits that permit life.

Vaporization or evaporation occurs when molecules of a liquid with sufficient kinetic energy overcome their attraction to other molecules and escape into the air as a gas. Water has a ***high heat of vaporization*** (580 cal/g at 25 ºC) because a large amount of heat is needed to break the hydrogen bonds holding water molecules together. This property of waster helps moderate the climate on Earth as solar heat is dissipated from tropical seas during evaporation and heat is released when moist tropical air condenses to form rain.

As a liquid vaporizes, the surface left behind loses the kinetic energy of the escaping molecules and cools down. ***Evaporative cooling*** helps to protect terrestrial organisms from overheating and contributes to the stability of temperatures in lakes and ponds.

Insulation of water bodies by floating ice – as water cools below 4 ºC, it expands. By 0 ºC, each water molecule becomes hydrogen-bonded to four other molecules, creating a crystalline lattice that spaces the molecules apart. Ice is thus less dense than liquid water; therefore, it floats.

The solvent of life – a solution is a liquid homogeneous mixture of two or more substances; the dissolving agent is called the solvent and the substance that is dissolved is the solute Water is the solvent in an aqueous solution. The positive and negative regions of water molecules are attracted to oppositely charged ions or partially charged regions of

polar molecules. Thus, solute molecules become surrounded by water molecules (a hydration shell) and dissolve into solution.

Ionic and polar substances are hydrophilic; they have an affinity for water due to electrical attractions and hydrogen bonding. Large hydrophilic substances may not dissolve but become suspended in an aqueous solution, forming a mixture called a colloid. Nonpolar molecules are hydrophobic; they will not easily mix with or dissolve in water.

The polarity of water molecules and the emergent properties of water and how they contribute to Earth's fitness for life will be further discussed via a Bozeman Biology video: Water - A Polar Molecule. Watch the video and fill out the accompanying question guide using info from the video and the reading.

Bozeman Biology Video: Water – A Polar Molecule
Video and Reading Questions

1. What type of molecule is water?
2. Oxygen is highly electronegative, what does that mean?
3. Why does electronegativity not increase as you go down the periodic table?
4. Oxygen, because of electronegativity, has what charge? Hydrogen?
5. Draw how you would NOT find water molecules together.
6. Draw how you WOULD find water molecules together.
7. Describe the Hydrogen Bond.
8. What is the maximum number of hydrogen bonds ONE water molecule can participate in?
9. What does not dissolve in water? Why?

Property	**Explanation of Property**	**Example of Benefit to Life**
a. (2 properties)	Hydrogen bonds hold molecules together and adheres them to hydrophilic surface.	b.
High specific heat	c.	Temperature changes in environment and organisms are moderated.
d.	Hydrogen bonds must be broken for water to evaporate.	e.
f.	Water molecules with high kinetic energy evaporate; remaining molecules are cooler.	g.
Less dense as solid.	h.	i.
j.	k.	Most chemical reactions in life involve solutes dissolved in water.

Acidic and basic conditions of water affect living organisms

A water molecule can dissociate into a hydrogen ion, H^+ (which can bind to another water molecule to for a hydronium ion, H_3O^+) and a hydroxide ion, OH^-. In pure water at 25ºC, the concentrations of H^+ and OH^- ions are the same; both equal to 10^{-7}M.

Effects of Changes in pH - When acids or bases dissolve in water, the H^+ and OH^- balance shifts. An acid adds H^+ to a solution, whereas a base reduces H^+ in a solution by accepting hydrogen ions or by adding hydroxide ions (which then combine with H+ and thus remove hydrogen ions). A strong acid or strong base may dissociate completely when mixed with water. A weak acid or base reversibly dissociates, either releasing or binding H^+.

In an aqueous solution, the product of the $[H^+]$ and $[OH^-]$ is constant at 10^{-14}. Brackets, [ ], indicate molar concentration. If the $[H^+]$ is higher, then the $[OH^-]$ is lower, because the excess hydrogen ions combine with the hydroxide ions in solution and form water. Likewise, an increase in $[OH^-]$ causes an equivalent decrease in $[H^+]$.

The pH of a solution is defined as the negative log (base 10) of the $[H^+]$: $pH = -\log[H^+]$. For a neutral aqueous solution, $[H^+]$ is 10^{-7}M, and the pH equals 7. As the $[H^+]$ increases in an acidic solution, the pH value decreases. The difference between each unit of the pH scale represents a tenfold difference in the concentration of $[H^+]$ and $[OH^-]$. Most cells have an internal pH of 7.

pH: Acid/Base Chemistry Questions

1. Complete the following table to review your understanding of pH.

[H+]	**[OH-]**	**pH**	**Acidic, Basic, or Neutral?**
	10^{-11}	3	acidic
10^{-8}			
	10^{-7}		
		1	

2. Adding a base to a solution would
    a. Raise the pH
    b. Lower the pH
    c. Decrease $[H^+]$
    d. Both a and c
    e. Both b and c

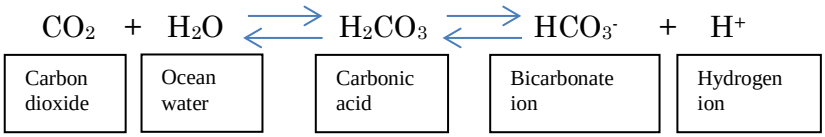
3. Comparing the $[H^+]$ of orange juice (pH 3) and coffee (pH 5), the $[H^+]$ of
    a. Orange juice is higher
    b. Orange juice is lower

4. Some archaea are able to live in lakes with pH values of 11. How does pH 11 compare with the pH 7 typical of your body cells?
    a. It is four times more basic than pH 7
    b. It is a thousand times more acidic than pH 7
    c. It is a thousand times more basic than pH 7
    d. It is ten thousand times more acidic than pH 7
    e. It is ten thousand times more basic than pH 7

Threats to Water Quality on Earth

Acid precipitation, rain, snow, or fog with a pH lower than normal (pH 5.6), is due to the reaction of water in the atmosphere with the sulfur oxides and nitrogen oxides released by the combustion of fossil fuels. Aquatic life is damaged by acid precipitation, and lowering the pH of the soil solution affects the solubility of minerals needed by plants.

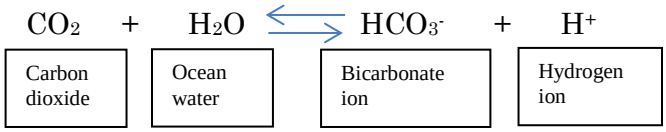
The burning of fossil fuels increases the release of CO_2 to the atmosphere, contributing to the "green house" effect and increasing the absorption of CO_2 by the oceans. Below is the formula to help explain why increasing [CO^2] in water (because of an increase in atmospheric CO_2) leads to a lower/more acidic pH.



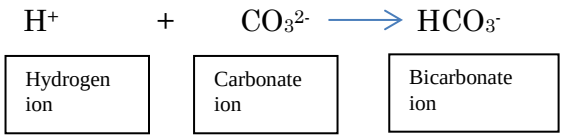
Increasing [CO_2] will drive these reactions to the right, increasing [H+] in the ocean and making the seawater more acidic.

What effects can decreasing the ocean pH have on ocean life? Well, the lower the pH of seawater the lower the concentrations of a molecule called Carbonate (CO_3^{2-}). Carbonate is a very important ion needed for coral reef calcification. Calcification is the process by which coral produce calcium carbonate ($CaCO_3$). Such decreases in calcification would cause the loss of reefs because construction rates would fall below natural destruction rates. Below is the formula to help explain how decreasing ocean pH leads to a loss of Carbonate ions.

Basically (from above)…



Some of these H^+ will combine with the Carbonate ion CO_3^{2-} that is already present in the seawater.



While this reaction can increase the pH of the ocean this reaction ultimately decreases the carbonate ions available for coral reefs to use to form/build their structures. **This is why the coral reefs are dying ☹**

Threats to Water Quality on Earth Questions

1. Researchers are interested in how levels of atmospheric CO_2 can affect Coral Reef calcification. You are tasked with ***designing an experiment*** that investigates this relationship between CO_2 levels and the rate of calcification of a coral reef habitat.

What to include:
A description of the experiment you have designed
Identify your variables (independent, dependent, constants)
Identify your control group
What are the expected results from your experiment
Write out an appropriate Hypothesis AND an If, then statement for your experiment