

Dear \_\_\_\_\_,

You have signed up to take AP Biology next year and I am looking forward to teaching you! (Or possibly teaching you again) This packet includes information about the class and our summer assignment. The summer assignment is a major grade that is due the first day of school. It is possible to get the summer assignment completed in one day, so it is not something that will drag on all summer. It is meant to give you a taste of the expectations and types of assignments you will work through next school year. Please read all the information and instructions, and do not lose this packet.

All of the summer assignment will be on paper this year, that way if you do not have internet at home, you can still do the work at home. At one point, you will need the internet to access the online textbook. (instructions later in this packet) If you do not have internet access, the library will be open this summer and you can come and print the 2 chapters from our online textbook pdf if needed. Or, before school lets out, I can print them for you if you stop by and request it.

If you have decided to not take AP Biology next school year, talk to the counselor before school lets out so you can choose another science to take. I had a mass exodus of students last school year on the first day, and we want to avoid this so you can get into a science class that you want instead of whatever one is offered the same class period because of a schedule change after school has already started.

Have a wonderful summer! Please email me if you have any questions. During the summer, I don't check my email every day but I usually do every 3 or 4 days.

Thanks,

Mrs. Henderson  
hendersons@woisd.net

If you lose this, you will  
have to print it from my  
blog over the summer!



## AP Biology 2023-2024

**This has a lot of information about the AP Biology program sponsored by the College Board Organization and about the AP expectations at White Oak High School. Please read it and initial after each section that you have read and understand.**

Welcome to AP Biology, for the 2023-2024 school year. If you have enrolled in this class, it means you want to take a college level Biology class and I am excited to teach you! This class is intended to be taught at a **college level** and will help prepare you for the AP Biology Exam in May 2024. Most four-year colleges in the United States and colleges in more than 60 other countries give students credit, advanced placement or both on the basis of AP Exam scores. You can find out what score you need to get credit for college Biology courses by looking on your university of choice's website. For example, Baylor University requires a score of a 5 for credit for the first two semesters of Biology for majors or a 4 for the one semester Biology for non-majors. Texas A&M requires a 4 for credit for the first two semesters of Biology for majors and a 3 for credit for two semesters of Biology for non-majors. SFA requires a score of a 3 for credit for one semester of Biology. Texas Tech requires a 5 for 2 semesters of Biology for majors, and a 3 for Biology for non-majors. (These are subject to change!) By entering college with AP credits, you'll have the time to move into upper level courses, pursue a double-major or study abroad. **Initial:** \_\_\_\_\_

Here is information about the AP Biology curriculum adopted in Fall 2012:

*Given the speed with which scientific discoveries and research continuously expand scientific knowledge, many students are faced with the challenge of balancing breadth of content with depth of understanding.*

*The revised AP Biology course addresses this challenge by shifting from a traditional "content coverage" model of instruction to one that focuses on enduring, conceptual understandings and the content that supports them. This approach will enable students to spend less time on factual recall and more time on inquiry-based learning of essential concepts, and will help them develop the reasoning skills necessary to engage in the science practices used throughout their study of AP Biology.*

*To foster this deeper level of learning, the breadth of content coverage in AP Biology is defined in a way that distinguishes content essential to support the enduring understandings from the many examples or applications that can overburden the course. Illustrative examples are provided that offer teachers a variety of optional instructional contexts to help their students achieve deeper understanding. Additionally, content that is outside the scope of the course and exam is also identified.*

Students who take an AP Biology course designed using this curriculum framework as its foundation will also develop advanced inquiry and reasoning skills, such as designing a plan for collecting data, analyzing data, applying mathematical routines, and connecting concepts in and across domains. The result will be readiness for the study of advanced topics in subsequent college courses—a goal of every AP course.

The revised AP Biology course has been endorsed enthusiastically by higher education officials.

AP Biology requires independent study outside of school hours. We will not be able to cover all of the material in class, you will have to devote your own time to learn all the material. This will require watching video clips, reading online text, and/or working on assignments. We will also use many supplemental materials that I will copy for you from some recently published AP Biology workbooks, lab tech materials, and scientific magazines/journals. I do not give busy work, every assignment I give you will help you learn about the world we live in and prepare you for the AP test. ***If you are not willing to do independent work at home, then this may not be the class for you this year.*** It will not be 2 hours every day or anything like that, but you have to be willing to do your own homework and study to be successful. **Initial:** \_\_\_\_\_

Attendance to class is important. Missing AP labs and class discussions will hinder your ability to succeed in the class and on the AP Exam. If you know you will have to miss class a lot, then it will be harder for you just because our time together is precious and will help you prepare for the AP exam. **Initial:** \_\_\_\_\_

We will use an online textbook found at <https://openstax.org/details/books/biology-ap-courses>. This text is sponsored by Rice University, and edited by numerous Biology professors from around the nation (including two of my former professors at Baylor at one point). This text is available by web access and can also be downloaded as a high or low resolution pdf document. If you download the pdf and place it in your google drive folder, you can have access to it with or without WIFI. We will not cover every chapter in the text, not all of them are included as part of the AP Biology curriculum. You may purchase a paper copy or print pdf's of the chapters if you prefer paper textbooks. **Initial:** \_\_\_\_\_

There is a summer assignment that is mandatory and for a **major grade**. Doing this assignment in the summer will enable you to experience the text and the rigor of the course. The summer assignment will also give you a taste of what will be expected of you throughout the course. You have only two weeks at the beginning of school to change your schedule if you decide AP Biology is not in your plan. **Initial:** \_\_\_\_\_

By signing up and taking this course, you are agreeing to take the AP exam in the Spring of 2024. With the development of the College Board online component, students who use their resources are supposed to take the test. You will have to pay for all AP exams for the classes you are enrolled in sometime in the first couple of months of school. Students with free/reduced lunch can get a discount. If your family is struggling right now, please stay signed up for the course and we will help you figure it out. I don't want students to drop out who have the chance of being very successful in AP Biology. Everyone who wants to take the test and puts forth the effort will be able to, our great WO community takes care of each other!

**Initial:** \_\_\_\_\_ (by signing this you are just telling me that you are aware, you're not obligated to pay if you initial here but decide to change your schedule)

The new AP Biology course is divided into 4 Big Ideas and 7 Best Practices. Below are the 4 Big Ideas.

**Big Idea 1: The process of evolution drives the diversity and unity of life.**

**Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce, and to maintain dynamic homeostasis.**

**Big Idea 3: Living systems store, retrieve, transmit, and respond to information essential to life processes.**

**Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties.**

Best Practices

1. **The student can use representations and models to communicate scientific phenomena and solve scientific problems**
2. **The student can use mathematics appropriately**
3. **The student can engage in scientific questioning to extend thinking or to guide investigations within the context of the AP course**
4. **The student can plan and implement data collections strategies appropriate to a particular scientific question**
5. **The student can perform data analysis and evaluation of evidence**
6. **The student can work with scientific explanations and theories**
7. **The student is able to connect and relate knowledge across various scales, concepts and representations in and across domains**

Initial: \_\_\_\_\_

## **THE EXAM**

I will teach this class under the expectation that you will take the AP Biology Examination. It will be during the month of May, 2024. This past year it was scheduled for Wednesday, May 10th at noon. They have not released next year's schedule yet.

The AP Biology Exam consists of two sections: multiple choice and free response. Both sections include questions that assess students' understanding of the big ideas, enduring understandings, and essential knowledge and the ways in which this understanding can be applied through the science practices. These may include questions on the following:

- the use of modeling to explain biological principles;
- the use of mathematical processes to explain concepts;
- the making of predictions and the justification of phenomena;
- the implementation of experimental design; and
- the manipulation and interpretation of data.

The exam is 3 hours long and includes both a 90-minute multiple choice and a 90-minute free-response section that begins with a 10-minute reading period. The multiple-choice section accounts for half of the student's exam grade, and the free-response section accounts for the other half.

**Section I – 90 minutes**

**60 Multiple Choice questions**

**Section II - 90 minutes**

**2 Long Free Response**

**4 Short Free Response**

**Initial:** \_\_\_\_\_

Due to the increased emphasis on quantitative skills and application of mathematical methods in the questions on both sections, students will be allowed to use calculators (either graphing or regular) on the entire exam. Students will also be supplied with a formula list as part of their testing materials.

Beginning with the May 2013 administration of the AP Biology Exam, multiple-choice questions contain four answer options, rather than five. This change saves students valuable time without altering the rigor of the exam in any way. A student's total score on the multiple-choice section is based on the number of questions answered correctly. Points are not deducted for incorrect answers or unanswered questions. **Initial:** \_\_\_\_\_

**How the Curriculum Framework Is Assessed**

- All big ideas, enduring understandings, and essential knowledge components are required and therefore must be learned in the AP Biology course. The learning objectives should be used to guide learning.
- The exam will assess the application of the science practices.
- Questions on the AP Biology Exam will require a combination of specific knowledge from the concept outline as well as its application through the science practices.
- In order to answer multiple-choice questions correctly, students will not be required to recall specific illustrative examples. However, an illustrative example may appear on the exam provided that the question includes sufficient information to enable students to answer the question.

For the free-response questions, students will be expected to provide appropriate scientific evidence and reasoning to support their responses. Students can draw upon the illustrative examples or any other appropriate, relevant examples in order to assist in answering the questions.

- For those more quantitative questions throughout the AP Biology Exam, students will be allowed to use calculators.

• As the emphasis of quantitative questions is on the application of quantitative skills and mathematical reasoning, students will not be required to recall specific formulas. A formula list will be provided within the exam materials. **Initial:** \_\_\_\_\_

## **THE LABORATORY**

A more student-directed, inquiry-based lab experience supports the AP Biology course and AP Course Audit Curricular Requirements, as it provides opportunities for students to design experiments, collect data, apply mathematical routines and methods, and refine testable explanations and predictions. The 2012 lab manual, AP Biology Investigative Labs: An Inquiry-Based Approach, supports the recommendation by the National Science Foundation (NSF) that science teachers build into their curriculum opportunities for students to develop skills in communication, teamwork, critical thinking, and commitment to lifelong learning. Students are expected to devote 25 percent of class time to lab investigations and conduct at least two investigations per big idea (last school year we did 10 out of the 13 labs, above the required 8). In conducting lab investigations, students will be encouraged to engage in the following:

- Generate questions for investigation
- Choose which variables to investigate
- Design and conduct experiments
- Design their own experimental procedures
- Collect, analyze, interpret, and display data
- Determine how to present their conclusions

There are five essential responsibilities of learners conducting inquiry-based labs:

1. Engaging in scientifically oriented questions
2. Giving priority to evidence in responding to questions
3. Formulating explanations from evidence
4. Connecting explanations to scientific knowledge
5. Communicating and justifying explanations

There will also be supplemental labs to build your skills and increase your knowledge in areas not covered by these labs. **Initial:** \_\_\_\_\_

**Resources for AP Biology:**

<https://openstaxcollege.org/> --Online text sponsored by Rice University  
Bozeman AP Biology video clips: <http://www.bozemanscience.com/ap-biology>  
Digital Escape Rooms by HeyNowScience  
AP Biology Biozone workbook and POGIL resources (I will copy for you)  
AP Biology Test Practice by Pearson Publishing  
Scientific American articles  
Howard Hughes Medical Institute Biointeractive website  
Many others, I can and will find anything possible that might help you out!

**Materials you will need:**

3 ring binder to keep your Topic Review Guide Question Sets (notes)  
Folder to keep handouts and homework  
Pens and pencils (black or blue pen is needed for free response)  
School-issued Chromebook (or another computer equivalent)-preferably not a tablet  
(the AP classroom website works better on a computer)  
Classroom supply to donate: Paper Towels

**Initial:** \_\_\_\_\_

**Most importantly, I am very excited you decided to take this class! I have had a great nine years teaching this subject, and I feel like the program will continue to improve.**

My Contact Information:  
Staci Henderson  
hendersons@woisd.net

Please email me if you have any questions!



## Summer Assignment Requirements

1. Read through the information and initial each section.
2. Chapter 1 Topic Review Guide: Topic Review guides are basically guided readings that become notes for you to use to study for our tests. The more time you invest independently answering these questions, the better you will understand the information and the better your study materials will be. If you answer a question incompletely, then when you study you won't have much information to study. These are sometimes used on quizzes and sometimes I just check them for completion. At any time, you are welcome to ask for help on these questions. We will often discuss the concepts in class, but we usually don't go over the topics in every question due to time.
3. Analyzing Graphs assignment
4. Chapter 2 Topic Review Guide
5. Hold on for Your Life Scientific Method and Experiment Practice
6. Take a look at the example AP Test questions and the formula chart. I want you to answer the multiple choice questions the best you can. You will not be graded for accuracy. I want you to take a look at the type of questions you will be doing on the AP exam so you know what to expect. The questions will seem easier and easier as you go through the AP Bio school year! Just skim through the free response (open-ended question) so you know what you will prepare to do throughout the year. The good thing is that the Free Response on the AP Biology test is not like English. You don't have to write essays with intros and conclusions. You will directly answer the questions in a sentence or paragraph format. For example: 1b on a Free Response question may simply ask....."What is the dependent variable in the experiment described above?" And you would just have to answer: "The dependent variable is.....".
7. Look over the formula chart so you know the math that we will practice throughout the year in AP Bio. You are not expected to already know everything on it.

You will keep all your summer assignment materials and bring them with you to the first day of class. **They are DUE the first day of school!** (Tuesday, August 15th) The summer assignment components count as a major grade so it is very important that you complete these. You could complete these all in one day if you wanted, or you can spread it out over the summer.

AND... please enjoy your summer!!!





## Topic Review Guide for Chapter 1: "The Study of Life"

Topics Review Guides are questions that will help lead you through the text and help you analyze and think about it critically. It is recommended that you read the whole text, not just skim it and hunt for answers. I will never have you read a section or chapter that is not needed for our curriculum. I know this is not your only class! Keep in mind, you will have more than just one day to complete these....you will not have one every night for homework.

Answering these questions is your way of taking notes over the information. Answer them completely, so that you can study them in the future. I will try to leave enough space for you to write a complete answer. These are yours, so complete sentences aren't necessary...but make sure they are complete answers. Sometimes I may give quizzes in which you can use these assignments. If there is any question that you do not understand, write the part of the answer you know and make sure you ask me about it in class. During class discussion time, you are welcome to add to it to make your answers even better.

Read Chapter 1 from OpenStax Biology, "**The Study of Life**". To get to the text, go to <https://openstax.org/details/books/biology-ap-courses>. You can go to "View Online" or download a pdf. At times, there might be a page that comes up to ask for a donation, don't worry about it....no money is required. Answer the following questions.

1. Contrast a hypothesis and theory. How does a hypothesis become a theory?
2. Describe inductive reasoning and give an example.
3. Describe deductive reasoning and give an example.
4. Describe some characteristics of valid hypotheses.

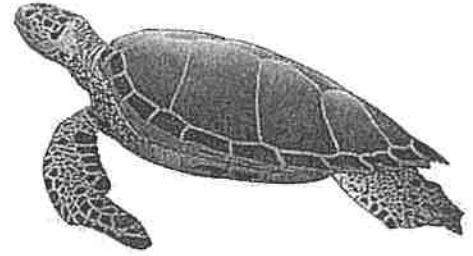
5. After Figure 1.6 there is a scenario with a toaster. Write the 6 steps of the scientific method, and then after each step write the lettered statement that represents that step. (there are instructions there as well)
6. While research efforts are usually carefully planned, some discoveries are made by serendipity. Describe what that means and a quick description of Alexander Fleming's discovery.
7. List and describe each of the seven Properties of Life.





## Analyzing Graphs from Primary Research

Graphs are a way for scientists to communicate data about research they have conducted. Examine the graph below. You may not understand everything about it, and might at first dismiss it as something way too complicated for you to follow. Standardized tests, like the SAT, will often incorporate data tables to assess a student's ability to understand information.



### Title: Telomeres, Age and Reproduction in Long Lived Reptiles

Without reading the article, see what you can learn by just analyzing the data presented in the bar graph.

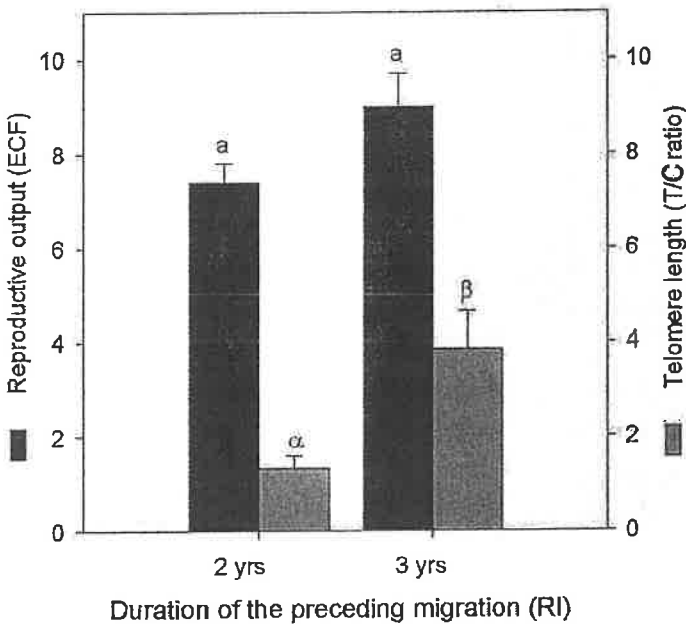


Figure 1. Estimated Clutch Frequency (ECF, the estimated number of clutches laid during the considered nesting season) and blood telomere length in relation to the duration of the migration preceding the considered nesting season (RI, the remigration interval) in leatherback turtles nesting in French Guiana in 2005 or 2006.

This graph was taken from a PLOS ONE.  
<https://doi.org/10.1371/journal.pone.0040855>

1. Read the title and figure description. What animal is being studied?

2. Examine the X axis. The label bar provides information on what the bars represent. What is the X axis label?

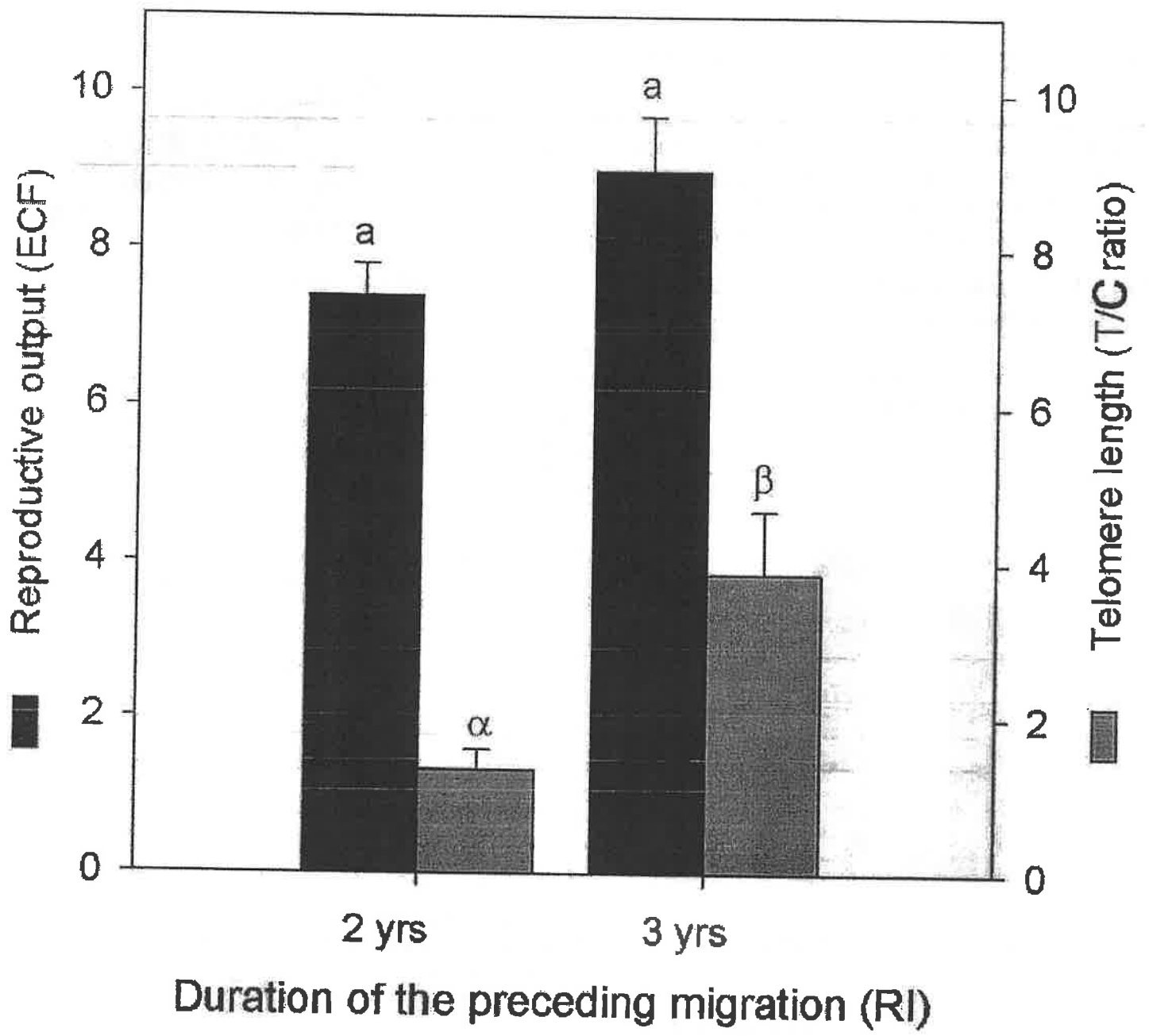
Explain what you think this means.

3. There are two labels on the Y axis. What does the black bar represent?

What does the gray bar represent?

4. Reproductive output refers to the number of eggs laid. Sea turtles migrate for a period of years where they restore their body reserves then lay their eggs on land. Which group (2 year or 3 year) has the greater reproductive output?

5. To understand more of the graph, you need to know what a "telomere" is. Telomeres are structures found at the ends of our chromosomes, they can vary in length. Summarize the relationship between telomere length and reproductive output.





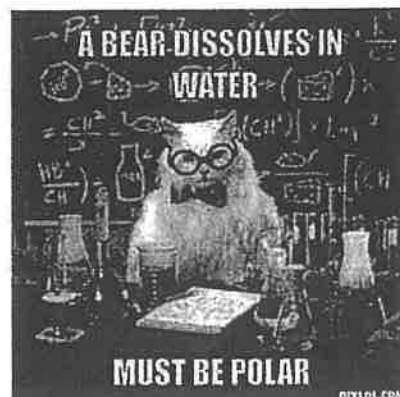
## Topic Review Guide---Water

Three quarters of Earth's surface is covered by water. The abundance of water is a major reason why Earth is habitable. 70-95% of cells are made of water. What properties of water make it so indispensable to life on Earth?

Go to <http://www.bozemanscience.com/water-a-polar-molecule> and watch the podcast about Water and/or read Chapter 2, sections 1 and 2 in your Open Stax Biology book. (Section 1 is a review of Chemistry, Section 2 is about Water).

Answer the following questions completely. Remember to write your answers in a way that will help you when you study this TRG in the future.

1. **Compare and contrast** ionic and covalent bonds in terms of electrons and strength.
2. **Contrast** polar covalent bonds and nonpolar covalent bonds.
3. Examine Figure 2.9 in the Open Stax online book. **Draw** a water molecule and indicate its polarity. Underneath your picture, **describe** what a polar covalent bond is.
4. How are multiple water molecules held together? **Name** the bond and **describe** how it works in water. (end of Section 1)



5. **Contrast** hydrophilic and hydrophobic and give an example of a material that has each property.

6. **Explain** how the structure of water molecules account for each of the following properties **and describe** how that property is useful to living things:

a. Cohesion

b. Adhesion

c. High Specific Heat

d. Floating Ice

e. Good Solvent Properties

f. Evaporative cooling (High heat of vaporization)

7. **Contrast** acids and bases. (in no more than 4-6 sentences...just general info)

8. **Describe** what a buffer is and how it is useful for living organisms relating to their pH.



# Hold on for Your Life!

This assignment will help you use your science skills to interpret data and figure out the results of an experiment. Feel free to look back at your topic review guide or any other resource you can find to help you do this. I want to see your own work and I want you to try your best. Write in complete sentences! On the AP exam, there is always some type of graph/data table with similar questions you'll have to answer about an experiment, so this is a great way to start getting ready. Keep in mind, with the nature of interpretation and open-ended questions, some questions may have different ways of answering them and both be correct.

... \* Indicates required question

1. Enter your name below please! \*

This assignment was originally a pdf produced by an organization made up of college professors and teachers. I just took snapshots of each section to include in a google form. Please read all the information before moving on.

## Hold on for your life! Part I

Featured scientist: Colin Donihue from Harvard University  
Written with: Bob Kuhn and Elizabeth Schultheis

### Research Background:

On the Caribbean islands of Turks and Caicos, there lives a small brown anole lizard named *Anolis scriptus*. The populations on two small islands, called Pine Cay and Water Cay, have been studied by researchers from Harvard University and the Paris Natural History Museum for many years. In 2017, Colin, one of the scientists, went to these islands to set up a long-term study on the effect of rats on anoles and other lizards on the islands.



*Anolis scriptus*, the Turks and Caicos anole, on Pine Cay.

Unbeknownst to him, though, a storm was brewing to the south of the islands, and it was about to change the entire trajectory of his research.

While he was collecting data, Hurricane Irma was developing into a massive category 5 hurricane. Eventually it became clear that it would travel straight over these small islands. Colin knew that this might be the last time he would see the two small populations of lizards ever again because they could get wiped out in the storm. It dawned on him that this might be a serendipitous moment. After the storm, he could evaluate whether lizards could possibly survive a severe hurricane. He was also interested in whether certain traits could increase survival. Colin and his colleagues measured the lizards and vowed to come back after the hurricane to see if they were still there. They measured both male and female lizards and recorded trait values including their body size, femur length, and the toepad area on their forelimbs and hindlimbs.

2. Describe how Colin's research changed and why. \*

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Colin was not sure whether the lizards would survive. If they did, Colin formed two alternative hypotheses about what he might see. First, he thought lizards that survived would just be a random subset of the population and simply those that got lucky and survived by chance. Alternatively, he thought that survival might not be random, and

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*Data Nuggets developed by Michigan State University fellows in the NSF BEACON and GK-12 programs*

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Name \_\_\_\_\_

some lizards might be better suited to hanging on for their lives in high winds. There might be traits that help lizards survive hurricanes, called **adaptations**. He made predictions off this second hypothesis and expected that survivors would be those individuals with large adhesive pads on their fingers and toes and extra-long legs – both traits that would help them grab tight to a branch and make it through the storm. This would mean the hurricanes could be agents of natural selection.

3. Define adaptation. \*

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In the last paragraph, it says to underline hypotheses. You will answer the question after this instead.

Not only did Hurricane Irma ravage the islands that year, but weeks later Hurricane Maria also paid a visit. Upon his return to Pine Cay and Water Cay after the hurricanes, Colin was shocked to see there were still anoles on the islands! He took the measurements a second time. He then compared his two datasets from before and after the hurricanes to see if the average trait values changed.

**Scientific Question:** Is there evidence that anoles have adaptations allowing them to survive better in hurricanes?

**What is the hypothesis?** Find the two hypotheses in the Research Background and underline them. A hypothesis is a proposed explanation for an observation, which can then be tested with experimentation or other types of studies. Having two alternative hypotheses means that more than one mechanism may explain a given observation. Experimentation can determine if one, both, or neither hypotheses are supported.

4. Write the two hypotheses in the section below. Feel free to look back at the information in the text. \*

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Use the data below to answer the scientific question:

	Before Hurricane				After Hurricane			
	Male (n = 39)	SE	Female (n = 39)	SE	Male (n = 61)	SE	Female (n = 52)	SE
Average Body Size (mm)	56.91	0.89	44.11	0.40	53.68	0.75	43.52	0.49
Average Femur Length (mm)	12.99	0.21	9.9	0.19	11.81	0.19	9.31	0.12
Average Forelimb Toepad Area (mm <sup>2</sup> )	1.93	0.06	0.93	0.03	2.03	0.07	1.13	0.05
Average Hindlimb Toepad Area (mm <sup>2</sup> )	3.05	0.09	1.44	0.05	3.1	0.1	1.76	0.07

\*Standard error (SE) tells us how confident we are in our estimate of the mean, and depends on the number of replicates in an experiment and the amount of variation in the data. A large SE means we are not very confident, while a small SE means we are more confident.

5. If you were to graph this, what would the independent variable in this experiment be? \*

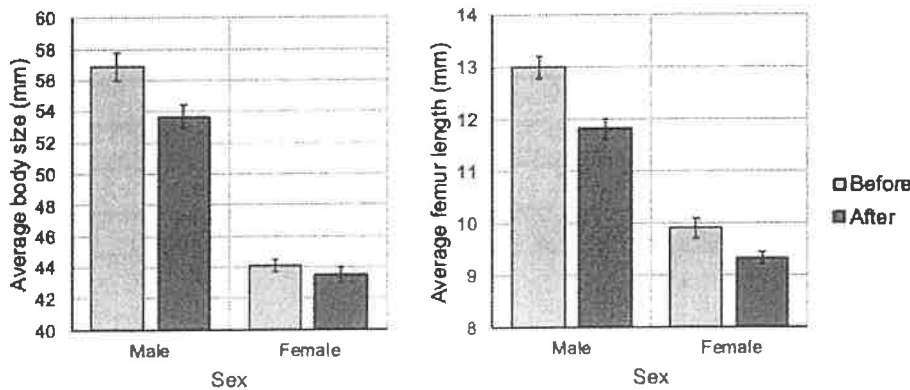
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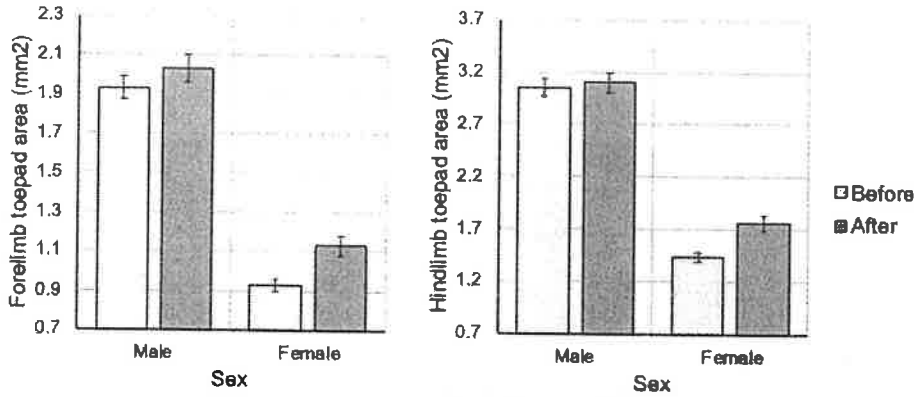
6. What would the dependent variable be? \*

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These graphs show the information in a way that is easier you to compare.

Below are graphs of the data: Identify any changes, trends, or differences you see in your graphs. Draw arrows pointing out what you see, and write one sentence describing what you see next to each arrow.





7. Make a claim that answers the scientific question for Colin's research. In science, a claim is just a statement that answers the question. \*

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8. What evidence was used to write your claim? Reference specific parts of the data table/graphs. In science, evidence is specific things found in the experiment or observations that support your claim. Often times it includes qualitative or quantitative data. \*

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9. Explain your reasoning and why the evidence supports your claim. Connect the data back to what you learned about how traits may be adaptive and help anoles better hold on tight during hurricane winds. \*

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10. Did the data support one, both, or neither of Colin's two hypotheses? Use evidence to explain why or why not. If \* you feel the data were inconclusive, explain why.

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11. Your next steps as a scientist: Science is an ongoing process. What new question(s) should be investigated to \* build on Colin's research? How would your questions build on the research that has already been done?

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# AP<sup>®</sup> Biology Exam

## SECTION I: Multiple Choice

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO.

### At a Glance

<b>Total Time</b>	1 hour and 30 minutes
<b>Number of Questions</b>	60
<b>Percent of Total Score</b>	50%
<b>Writing Instrument</b>	Pencil required
<b>Electronic Device</b>	Calculator allowed

### Instructions

Section I of this exam contains 60 multiple-choice questions. Indicate all of your answers to the Section I questions on the answer sheet. No credit will be given for anything written in this exam booklet, but you may use the booklet for notes or scratch work.

Use your time effectively, working as quickly as you can without losing accuracy. Do not spend too much time on any one question. Go on to other questions and come back to the ones you have not answered if you have time. It is not expected that everyone will know the answers to all of the multiple-choice questions.

Your total score on Section I is based only on the number of questions answered correctly. Points are not deducted for incorrect answers or unanswered questions.

# AP<sup>®</sup> BIOLOGY EQUATIONS AND FORMULAS

## Statistical Analysis and Probability

### Mean

$$\bar{x} = \frac{1}{n} \sum_{i=1}^n x_i$$

### Standard Deviation

$$s = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n - 1}}$$

### Standard Error of the Mean

$$SE_{\bar{x}} = \frac{s}{\sqrt{n}}$$

### Chi-Square

$$\chi^2 = \sum \frac{(o - e)^2}{e}$$

### Chi-Square Table

p value	Degrees of Freedom							
	1	2	3	4	5	6	7	8
0.05	3.84	5.99	7.81	9.49	11.07	12.59	14.07	15.51
0.01	6.63	9.21	11.34	13.28	15.09	16.81	18.48	20.09

### Laws of Probability

If A and B are mutually exclusive, then:

$$P(A \text{ or } B) = P(A) + P(B)$$

If A and B are independent, then:

$$P(A \text{ and } B) = P(A) \times P(B)$$

### Hardy-Weinberg Equations

$$p^2 + 2pq + q^2 = 1 \quad p = \text{frequency of allele 1 in a population}$$

$$p + q = 1$$

$$q = \text{frequency of allele 2 in a population}$$

$\bar{x}$  = sample mean

$n$  = sample size

$s$  = sample standard deviation (i.e., the sample-based estimate of the standard deviation of the population)

$o$  = observed results

$e$  = expected results

$\Sigma$  = sum of all

Degrees of freedom are equal to the number of distinct possible outcomes minus one.

### Metric Prefixes

<u>Factor</u>	<u>Prefix</u>	<u>Symbol</u>
$10^9$	giga	G
$10^6$	mega	M
$10^3$	kilo	k
$10^{-1}$	deci	d
$10^{-2}$	centi	c
$10^{-3}$	milli	m
$10^{-6}$	micro	$\mu$
$10^{-9}$	nano	n
$10^{-12}$	pico	p

Mode = value that occurs most frequently in a data set

Median = middle value that separates the greater and lesser halves of a data set

Mean = sum of all data points divided by number of data points

Range = value obtained by subtracting the smallest observation (sample minimum) from the greatest (sample maximum)

We will learn these throughout  
the school year!

And you get a calculator on the test.

### Rate and Growth

#### Rate

$$\frac{dY}{dt}$$

$dY$  = amount of change

$dt$  = change in time

$B$  = birth rate

#### Population Growth

$$\frac{dN}{dt} = B - D$$

$D$  = death rate

$N$  = population size

$K$  = carrying capacity

#### Exponential Growth

$$\frac{dN}{dt} = r_{\max} N$$

$r_{\max}$  = maximum per capita growth rate of population

#### Logistic Growth

$$\frac{dN}{dt} = r_{\max} N \left( \frac{K - N}{K} \right)$$

#### Simpson's Diversity Index

$$\text{Diversity Index} = 1 - \sum \left( \frac{n}{N} \right)^2$$

$n$  = total number of organisms of a particular species

$N$  = total number of organisms of all species

### Water Potential ( $\Psi$ )

$$\Psi = \Psi_p + \Psi_s$$

$\Psi_p$  = pressure potential

$\Psi_s$  = solute potential

The water potential will be equal to the solute potential of a solution in an open container because the pressure potential of the solution in an open container is zero.

### The Solute Potential of a Solution

$$\Psi_s = -iCRT$$

$i$  = ionization constant (1.0 for sucrose because sucrose does not ionize in water)

$C$  = molar concentration

$R$  = pressure constant  
( $R = 0.0831$  liter bars/mole K)

$T$  = temperature in Kelvin ( $^{\circ}\text{C} + 273$ )

$$\text{pH} = -\log[\text{H}^+]$$

### Surface Area and Volume

#### Surface Area of a Sphere

$$SA = 4\pi r^2$$

#### Volume of a Sphere

$$V = \frac{4}{3}\pi r^3$$

$r$  = radius

$l$  = length

#### Surface Area of a Rectangular Solid

$$SA = 2lh + 2lw + 2wh$$

#### Volume of a Rectangular Solid

$$V = lwh$$

$h$  = height

$w$  = width

#### Surface Area of a Cylinder

$$SA = 2\pi rh + 2\pi r^2$$

#### Volume of a Cylinder

$$V = \pi r^2 h$$

$s$  = length of one side of a cube

#### Surface Area of a Cube

$$SA = 6s^2$$

#### Volume of a Cube

$$V = s^3$$

$SA$  = surface area

$V$  = volume

BIOLOGY

SECTION I

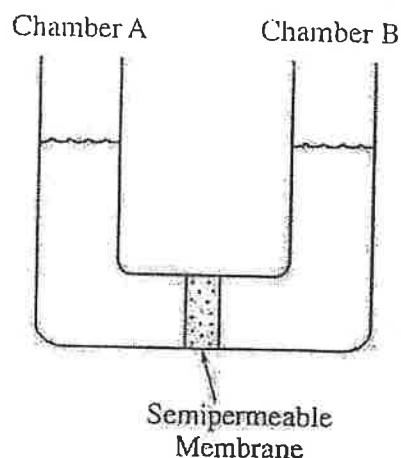
Time—1 hour and 30 minutes

60 Questions

**Directions:** Each of the questions or incomplete statements below is followed by four suggested answers or completions. Select the one that is best in each case and then enter the letter in the corresponding space on the answer sheet.

1. Humans produce sweat as a cooling mechanism to maintain a stable internal temperature. Which of the following best explains how the properties of water contribute to this physiological process?

- (A) The high specific heat capacity of water allows the body to absorb a large amount of excess heat energy.
- (B) The high heat of vaporization of water allows the body to remove excess heat through a phase change of water from liquid to gas.
- (C) The high surface tension of water contributes to the physical process by which water leaves the body.
- (D) The high melting temperature of water allows the body to remove excess heat through a phase change of water from solid to liquid.



2. A student placed a semipermeable membrane inside a U-shaped channel with two chambers, as shown. The membrane permits the movement of water but not salt. The student wants to vary the rate of osmosis that occurs across the membrane. Which of the following experimental designs will result in the fastest net rate of water movement into chamber A?

- (A) Placing salt water in chamber A and distilled water in chamber B
- (B) Placing distilled water in both chambers
- (C) Placing distilled water in chamber A and salt water in chamber B
- (D) Placing salt water in both chambers

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3. Which of the following best describes the role of water in photosynthesis?

- (A) Water is the only source of protons for the formation of a proton gradient.
- (B) Water molecules donate electrons to the electron transport chain.
- (C) Water molecules combine with stored carbon molecules to produce glucose.
- (D) Water is the terminal electron acceptor for electrons that pass through the electron transport chain.

4. What evolutionary advantage does compartmentalization of core metabolic processes offer eukaryotes?

- (A) Evolution of the mitochondria allowed eukaryotes to perform respiration.
- (B) With the evolution of mitochondria in eukaryotes, the Krebs cycle and electron transport chain also evolved.
- (C) Evolution of a nucleus in eukaryotes separates the processes of transcription and translation and they can be regulated separately.
- (D) A nucleus in bacteria provides separation of respiration from transcription.

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Questions 12 - 17

Certain reef-building corals contain photosynthetic, symbiotic algae that have the ability to make dimethylsulphoniopropionate (DMSP), a chemical involved in the marine sulfur cycle. DMSP is released into the surrounding water, where it is converted to the gas dimethyl sulfide (DMS) by microorganisms and enters the atmosphere. Once in the atmosphere, it triggers the formation of sulfate aerosols, which induce cloud formation and block sunlight from heating up the water.

The symbiotic algae produce DMSP when they are stressed by a high water temperature. If water temperature is too high, corals will expel the symbiotic algae that produce DMSP. Researchers measured the amount of DMSP produced by juvenile and adult coral and their symbionts under normal and thermally stressed conditions. The data are shown in the graphs in Figure 1.

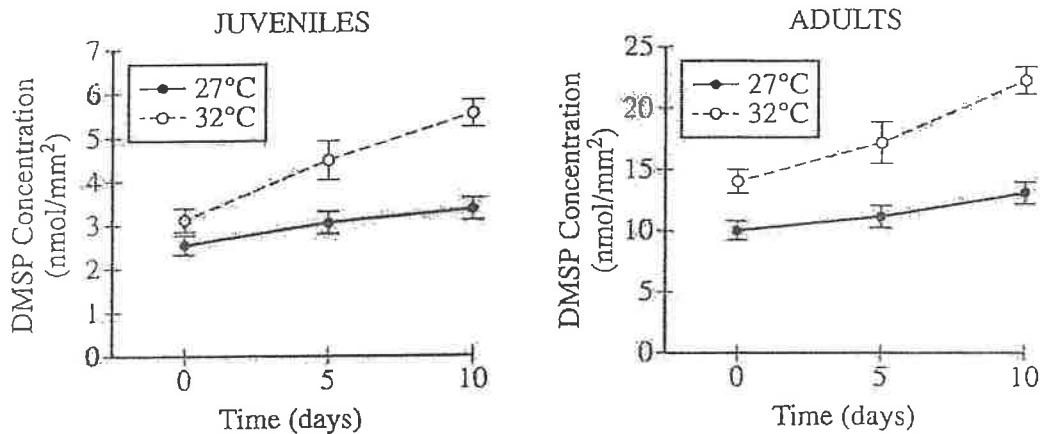


Figure 1: DMSP concentration in juvenile and adult corals and their symbionts in normal and thermally-stressed conditions. Error bars represent  $\pm 2SE_{\bar{x}}$ .

The researchers also measured the density of the symbiont as well as the photosynthetic yield in adult corals at the two temperatures. Photosynthetic yield is an index measure of energy output compared to sunlight energy input in which larger photosynthetic yield values represent photosynthetic organisms producing more energy.

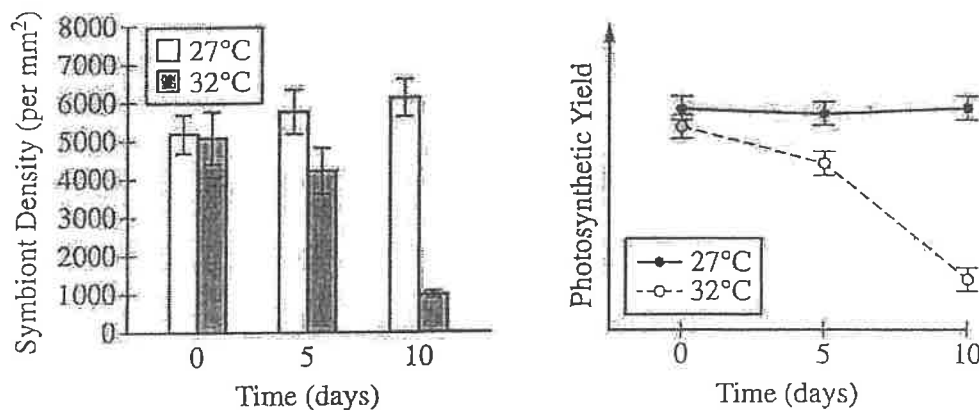


Figure 2: Variation in symbiont density and photosynthetic yield in adult corals grown in normal and thermally-stressed conditions. Error bars represent  $\pm 2SE_{\bar{x}}$ .

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12. Which of the following best describes the production of DMSP by coral and coral symbionts?
- (A) A negative feedback mechanism that increases the environmental change
  - (B) A negative feedback mechanism that reverses the environmental change
  - (C) A positive feedback mechanism that increases the environmental change
  - (D) A positive feedback mechanism that reverses the environmental change
13. Which of the following best describes the effect of temperature on corals' ability to produce DMSP as shown in Figure 1 ?
- (A) Both juvenile and adult corals produce less DMSP at 27°C than at 32°C.
  - (B) Both juvenile and adult corals produce less DMSP at 32°C than at 27°C.
  - (C) The amount of DMSP produced over time increases at 32°C in juveniles only.
  - (D) The amount of DMSP produced over time increases at 32°C in adults only.
14. Which of the following best describes the difference between the total amount of DMSP produced by adults compared to juveniles at the start of the 32°C trial?
- (A) Adult corals produced 3 times more DMSP than juveniles produced.
  - (B) Adult corals produced 3 times less DMSP than juveniles produced.
  - (C) Adult corals produced 5 times more DMSP than juveniles produced.
  - (D) Adult corals produced 5 times less DMSP than juveniles produced.
15. In addition to the effect of temperature on DMSP produced by corals and their symbionts, which of the following relationships is also being considered in this experiment?
- (A) Effect of varying light levels and coral species
  - (B) Effect of additional DMSP produced by symbionts and the corals' age
  - (C) Effect of age and varying light levels
  - (D) Effect of coral species and additional DMSP produced by symbionts
16. Which of the following best describes the scientists' findings concerning the density of symbionts presented in Figure 2 ?
- (A) The symbiont density at 32°C on day 5 was less than the density on day 0 of the experiment.
  - (B) The symbiont density at 27°C on day 0 was less than the density on day 5 of the experiment.
  - (C) The symbiont density at 32°C was different from the density at 27°C on days 5 and 10 of the experiment.
  - (D) The symbiont density at 27°C was higher than the density at 32°C for the entire length of the experiment.

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17. Which of the following best explains the result of adult corals being exposed to elevated temperatures for extended periods?

- (A) They are able to obtain more energy from their symbionts because the algae are receiving more light.
- (B) They are able to obtain more energy from their symbionts because the efficiency increases slightly over time.
- (C) They are able to obtain less energy from their symbionts because the algae have been expelled.
- (D) They are able to obtain less energy from their symbionts because more DMSP is being produced at lower temperatures.

18. A particular gene has two alleles, a dominant allele *A* and a recessive allele *a*. The frequency of allele *A* is 0.55. If the population is in Hardy-Weinberg equilibrium with respect to the gene, then what is the expected frequency of genotype *Aa* ?

- (A) 0.203
- (B) 0.303
- (C) 0.405
- (D) 0.495

19. A particular genetic disorder results from a single change in the amino acid sequence coded for in a gene. Parts of the sequence in normal and mutated genes are shown below.

Normal: TAC CTC GTG GAC TGA GGT CTC

Mutated: TAC CTC GTG GAC TGA GGT CAC

		Second Base				
		U	C	A	G	
First Base	U	Phe	Ser	Tyr	Cys	U
		Phe	Ser	Tyr	Cys	C
		Leu	Ser	Stop	Stop	A
		Leu	Ser	Stop	Trp	G
C	Leu	Pro	His	Arg	U	
	Leu	Pro	His	Arg	C	
	Leu	Pro	Gln	Arg	A	
	Leu	Pro	Gln	Arg	G	
A	Ile	Thr	Asn	Ser	U	
	Ile	Thr	Asn	Ser	C	
	Ile	Thr	Lys	Arg	A	
	Met	Thr	Lys	Arg	G	
G	Val	Ala	Asp	Gly	U	
	Val	Ala	Asp	Gly	C	
	Val	Ala	Glu	Gly	A	
	Val	Ala	Glu	Gly	G	

Based on the codon chart above, which of the following amino acid changes is most likely found in the mutated protein?

- (A) Glu → Val
- (B) Val → Glu
- (C) Glu → Pro
- (D) Pro → Val

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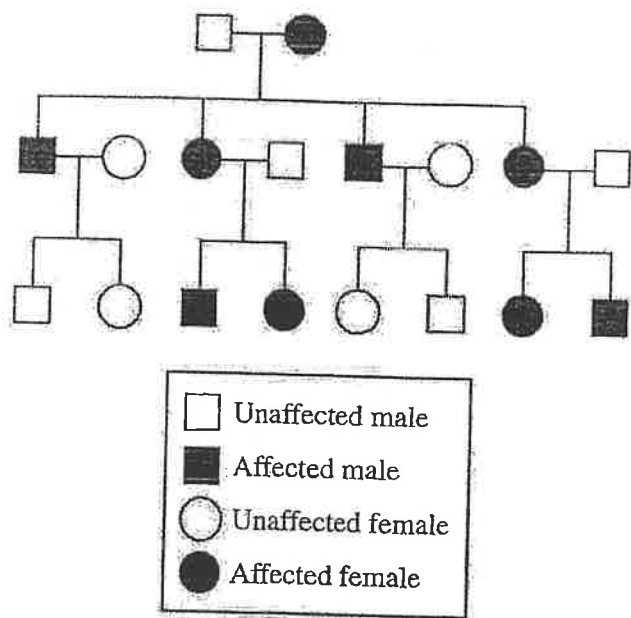


Figure 1. A pedigree of three generations of a family that have a high frequency of a particular genetic condition

20. Figure 1 shows the inheritance of a particular genetic condition in three generations of one family. Which of the following best explains the observed pattern of inheritance?

- (A) The condition is passed randomly because of the independent assortment of chromosomes.
- (B) The condition is passed from fathers to sons via a Y-linked gene.
- (C) The condition is passed from mothers to sons via an X-linked gene.
- (D) The condition is passed from mothers to offspring via a mitochondrial gene.

21. Oncogenes are genes that can cause tumor formation as a result of a particular mutation. Which of the following potential therapies would be most effective at preventing the expression of an oncogene?

- (A) Reducing the number of ribosomes in the cell to prevent the creation of the oncogene's proteins
- (B) Blocking membrane-bound receptors of transcription factors
- (C) Introducing a chemical that binds to transcription factors associated with the oncogene's promoter
- (D) Producing additional transcription factors for tumor suppressor genes in the cell

22. Ultraviolet (UV) radiation can damage DNA by breaking weak bonds. Which of the following best explains how this occurs?

- (A) UV radiation disrupts the double helix structure by breaking the covalent bonds between the nitrogenous base pairs.
- (B) UV radiation disrupts the double helix structure by breaking the hydrogen bonds between the nitrogenous base pairs.
- (C) UV radiation is able to break DNA strands in two by breaking covalent bonds between the sugar-phosphate backbone molecules.
- (D) UV radiation is able to break DNA strands in two by breaking hydrogen bonds between the sugar-phosphate backbone molecules.

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2. Atherosclerosis is a disease that results when certain cells and proteins of an individual's body adhere to and damage blood vessels, especially those around the heart. Researchers continue to look for improved ways to treat individuals with the disease. Data obtained from earlier experiments suggested that it might be possible to reduce damage to the blood vessels by increasing the expression of FXR1, an RNA-binding protein in the muscle cells that form the outer surface of the blood vessels. Additional data suggested that IL-19, a protein secreted by certain white blood cells, might regulate expression of the *FXR1* gene.

To investigate the regulation of the *FXR1* gene by IL-19, a researcher added IL-19 to vessel-lining muscle cells growing in the lab. The researcher measured the amount of FXR1 protein produced by the cells over a period of 48 hours in the presence of IL-19. The researcher then calculated the relative amount of FXR1 present at each time point compared with the amount of FXR1 at Time 0, when IL-19 was first added to the cells. Data from three replicate experiments are shown in Table 1.

TABLE 1. RELATIVE AMOUNT OF FXR1 PRODUCED BY CELLS  
IN RESPONSE TO IL-19

Time in the Presence of IL-19 (h)	Relative Amount of FXR1 Protein $\pm 2SE_{\bar{x}}$
0	0.98 $\pm$ 0.070
4	1.70 $\pm$ 0.220
8	1.60 $\pm$ 0.275
16	3.10 $\pm$ 0.800
24	2.15 $\pm$ 0.405
48	1.60 $\pm$ 0.520

- (a) **Describe** how amino acids are categorized by their chemical properties. **Explain** how a change in the amino acid sequence of the FXR1 protein could decrease the ability of the protein to bind to RNA.
- (b) Using the template in the space provided for your response, **construct** an appropriately labeled graph that represents the data shown in Table 1. **Determine** whether there is a statistical difference in the amount of FXR1 protein produced by the cells after 16 and 24 hours in the presence of IL-19.

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(c) Based on the data for the 48-hour period, **describe** the effect of IL-19 on *FXR1* gene expression.

(d) The researcher hypothesizes that the *FXR1* gene codes for a protein that binds to mRNAs that encode some of the proteins that damage arteries. Individuals with a particular mutation of the *FXR1* gene tend to have high levels of these proteins. Based on this information, **predict** how the FXR1 protein most likely interacts with the mRNAs.

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**THIS PAGE MAY BE USED FOR TAKING NOTES AND PLANNING YOUR ANSWERS.**

**NOTES WRITTEN ON THIS PAGE WILL NOT BE SCORED.**

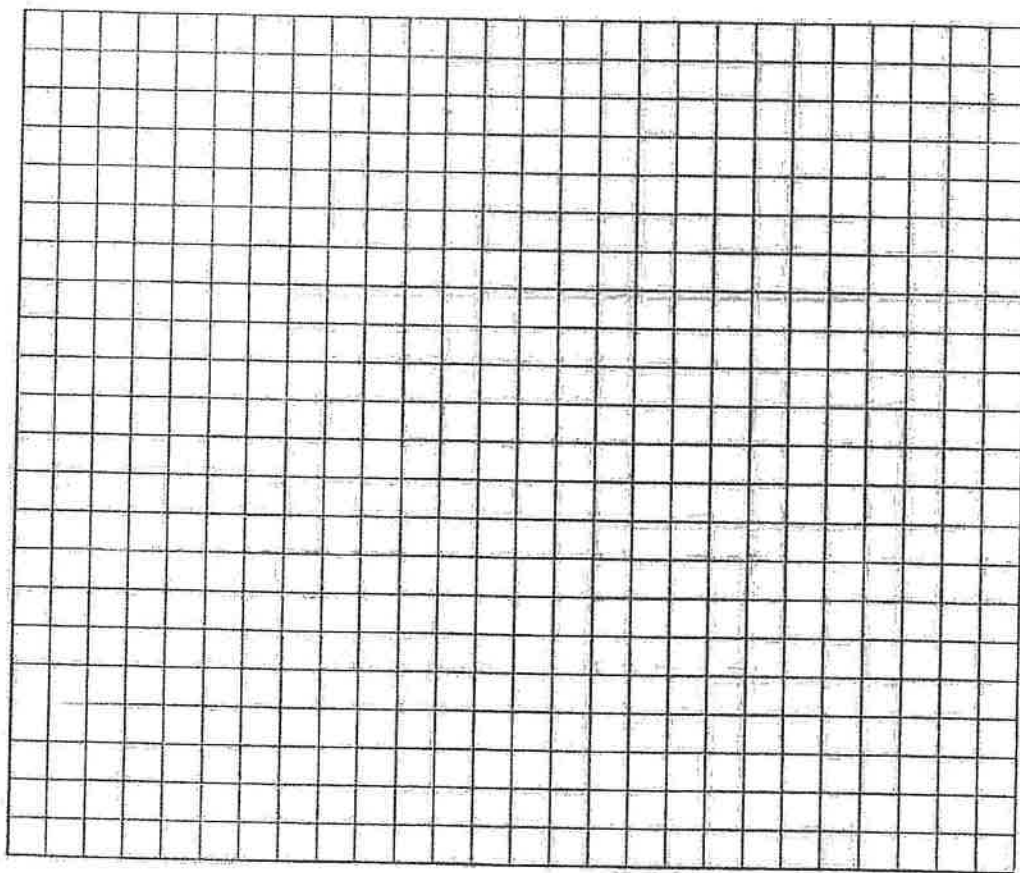
**WRITE ALL YOUR RESPONSES ON THE LINED PAGES.**

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(data table reprinted for reference)

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