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Impact Project

Chapter 1:

"Agriculture Biology Curriculum Student Workbook" is the product created for the benefit of ease during student use, as well as for teachers in the role of instructing an Agriculture Biology course. The purpose of this project is to compile available information and resources within the topic of Ag Biology, along with resources I created the past year all into one spot to help encourage student retention and organization. The goal of the student workbook is to not only help students better understand the content by having everything they need to succeed in one convenient spot, but to also make it easier on the teacher. Currently, there are little to no complete curriculum courses available for an Ag Biology class, so this led me to create a semester-long high school curriculum. This past year, as my first time teaching the course I was always in search of how to link Agriculture and Biology to not only meet all of the State requirements and standards, but to make the class as hands-on as possible.

Chapter 2:

"Our lives are completely dependent on agriculture, from the clothes we wear, to the food we eat, to the roof over our heads; we simply cannot survive without it. Having, at least, a rudimentary understanding of agriculture provides us with a minimum level of knowledge to help us make decisions which impact our lives and those of our loved ones." (Swafford, 2019, 10). This statement is widely known throughout the agriculture community, but is not always evident to those who either don't have an agricultural background or have the opportunity to learn about agriculture in school. With every course I teach, I like to break down the words to their origins to help my students understand. So with biology, the term means the study of living organisms. In my opinion, biology and agriculture go hand in hand with each other. If we are teaching about life in a biology course, why not do it in a way that students can have experiential learning opportunities? Agriculture offers many avenues to accomplish this goal, including the Broiler contest. There is often the idea that combining agriculture and biology is a challenge in that it is difficult to remain relevant in larger schools, but many solutions to this include using experiments to connect standards and principles (Osborne et al., 2019, 13). It's possible that many Biology teachers are already incorporating agriculture into their curriculum without even realizing it. "As I walked by the science classroom I heard the biology teacher presenting a lesson on genetics. I thought proudly to myself , I just taught that very same lesson in my animal science class last week." (Myers, 2018, 6).

Another challenge from teaching Ag Biology is the student pushback, as not all students like the idea of incorporating agriculture into their curriculum. There are many stereotypes regarding agriculture and what it really means, and to a teenager, even these little details can push them in the wrong direction into not liking the course. However, once students fully understand the concept of agriculture they seem to really appreciate it. “For many students, agricultural education provides an avenue where science education is applied in meaningful ways.” (Barrick et al., 2018). This is definitely true when it comes to students with an agricultural background as it makes them feel seen and valued for the hard work they put into their lives outside of school.

To create a successful Ag Biology course, a few things need to be in order: curriculum needs to be readily available and accessible, and both students and teachers need to have an open mind of combining the ideas that agriculture and biology go hand in hand with each other. “Throughout humanity, learning how to sustainably produce food, shelter, and clothing, and increasing human understanding of natural phenomena have been essential outcomes of any successful education system. In fact, one could argue an interdisciplinary understanding of AFNR and science as essential for the establishment, sustainability, and progress of any society.” (McKim et al., 2018).

Chapter 3:
The start of this project began with creating a list of all the items I desired in the student workbook. The majority of these items are assignments and activities that I used my first year teaching the course which was stored in a Google Drive. From here, the best method to organize the information for each student workbook is to include a title page of that chapter, a table of contents for ease of finding materials, book notes based off of Miller and Levine Biology 2017, notes that correspond to Edpuzzle videos by the Amoeba sisters, doodle notes that bring visual aspects to the topic, other various activity worksheets, student labs, project outlines, lesson review questions, and quiz/test review materials. Since most of the items have been used to some degree before, much of the project was spent assembling the workbook. However, there are also items that have been swapped or recreated. Some chapters, given the complexity of the content, have more activities than others, but all chapters follow the same guidelines. The idea of creating said chapters for a student workbook is for the teacher to be able to pick and choose which topics that you would like to focus on in your classroom, or to move items into a different order. Once all items have been inputted into the correct chapter in the correct format, I reviewed each one for final edits.

Chapter 4:
The following Chapter workbooks: 8, 9, 10, 11, 12, and 13 begin below.

Chapter 5:
This resource is important as it was specifically created and designed to make both the teachers and students life easier. Many students struggle with more than just class content; class

preparation and organization being at the forefront. By offering students a workbook with all the materials they need for the selected chapter at one time, the goal is to bring a sense of relief but more importantly the expectation of what the student needs to learn in order to be successful for this chapter. After creating the project, I plan to put it to use this year in my classroom and will reassess at the end of the school year if it turned out as expected. If all goes accordingly, I hope to create workbooks for other classes that I teach. This resource is offered to Michigan agriculture, food and natural resources educators looking for a curriculum for their Ag Biology course.This workbook in particular is made for the second semester of a year long Ag Biology course, as many of the topics build upon the semester one information. Since this workbook includes book notes based off of Miller and Levine Biology 2017, if educators do not have this specific book it may not line up exactly. However, that does not mean that it can't be adapted to accommodate other Biology textbooks. There is also the option to pick and choose items as you please, or add additional items that you like to use in your classroom.

Potential extensions of this project would include the written state standards for both AFNR and State Science, student learning objectives/outcomes, and areas of inquiry or research. But the most important extension that I plan to include in the coming year is additional connections to agriculture. Since this workbook is designed to be used during the second semester, many agricultural connections are lost since the Broiler Contest is completed during the first semester. I would love to include more opportunities like the Broiler chickens into the curriculum workbook for the second semester, with one potential idea being Salmon in the Classroom.

Reviewing the project, there is nothing that stands out that I would have done differently. Granted, if I had more time then the extensions are what I would have liked to include. Overall, I am happy with the turnout of the project and believe that it will be put to good use in my years as an Ag Biology teacher.

References:

Barrick, R. K., Heinert, S. B., Myers, B. E., Thoron, A. C., & Stofer, K. (2018, May). Integrating Disciplinary Core Ideas, the Agriculture, Food and Natural Resources Career Pathways and Next Generation Science Standards. *Career and Technical Education Research*, *43*(1), 41-56. 10.5328/cter43.1.41

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Swafford, M. (2019, May/June). STEM and Agricultural Education: Manure, Lowell Catlett and Three Circles. *The Agricultural Education Magazine*, *91*(6), 10-12. https://www.naae.org/profdevelopment/magazine/archive_issues/Volume91/2019%2005%20--%20May%20June.pdf

Thoron, A. C., & Osborne, E. W. (2019, May/June). Agriculture IS the Integrated Science: Consider the Context. *The Agricultural Education Magazine*, *91*(6), 13. https://www.naae.org/profdevelopment/magazine/archive_issues/Volume91/2019%2005%20--%20May%20June.pdf.

In addition to crediting Miller and Levine Biology 2017 for various materials pulled from the textbook, credit is also deserved to the following: Amoeba Sisters, Doodle Notes, Givens Mister Science 2013, US Biology Teaching, Purdue University, Pedersen Science, Mainely Science, Keystone Science, BioInteractive, etc.

Ag Biology

Semester 2

Chapter 8 Workbook: Photosynthesis

Name: _____ Date: _____

Class Period: _____ Teacher: _____

Table of Contents

Chapter 8: Photosynthesis

8.1 Energy and Life

Lesson Objectives

- Describe the role of ATP in cellular activities.
- Explain where plants get the energy they need to produce food.

Lesson Summary

Chemical Energy and ATP Energy is the ability to do work. Organisms need energy to stay alive.

- **Adenosine triphosphate (ATP)** is a chemical compound cells use to store and release energy.
  - An ATP molecule consists of adenine, the sugar ribose, and three phosphate groups.
  - Cells store energy by adding a phosphate group to adenosine diphosphate (ADP) molecules.
  - Cells release energy from ATP molecules by subtracting a phosphate group.
- Energy provided by ATP is used in active transport, to contract muscles, to make proteins, and in many other ways.
- Cells contain only a small amount of ATP at any one time. They regenerate it from ADP as they need it, using energy stored in food.

Heterotrophs and Autotrophs The energy to make ATP from ADP comes from food. Organisms get food in one of two ways.

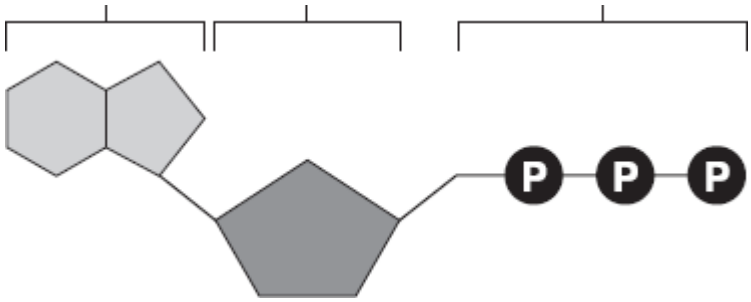
- **Heterotrophs** get food by consuming (eating) other organisms.
- **Autotrophs** use the energy in sunlight to make their own food.
- **Photosynthesis** is the process that uses light energy to produce food molecules.

Chemical Energy and ATP

For Questions 1–6, complete each statement by writing the correct word or words.

1. _____ is the ability to do work.
2. The main chemical compound cells use for energy is _____ (ATP).
3. _____ is a 5-carbon sugar molecule that is part of an ATP molecule.
4. The _____ of ATP are the key to its ability to store and supply energy.
5. ATP releases energy when it _____ bonds between its phosphate groups.
6. Most cells only store enough ATP for _____ of activity.

7. Label each part of the diagram of an ATP molecule below.



For Questions 8–10, refer to the Visual Analogy comparing ATP to a charged battery.

8. In the visual analogy, what chemical is represented by the low battery?

_____

_____

9. What are two ways in which the diagram shows an increase in energy?

_____

_____

10. Describe the concepts shown in the diagram.

_____

_____

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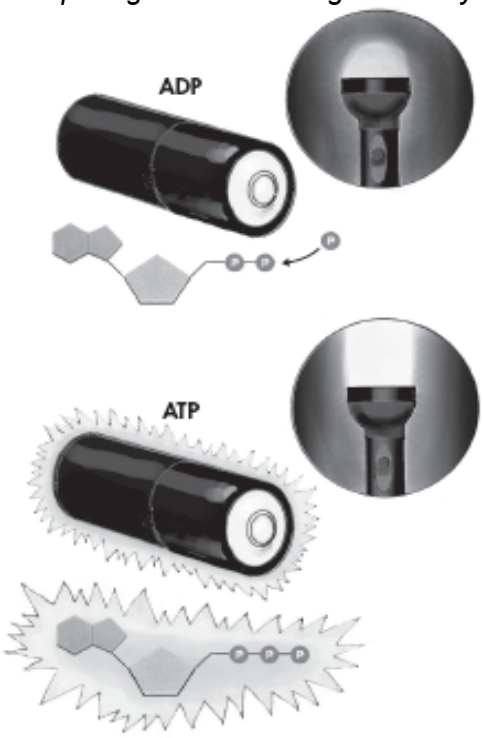


11. What are two ways in which cells use the energy temporarily stored in ATP?

_____

_____

12. Energy is needed to add a third phosphate group to ADP to make ATP. What is a cell's source of this energy?

_____

_____

Heterotrophs and Autotrophs

For Questions 13–17, write True if the statement is true. If the statement is false, change the underlined word or words to make the statement true.

_____ **13.** All heterotrophs must <u>eat food</u> to get energy.

_____ **14.** <u>Autotrophs</u> do not need to eat food because they make food.

_____ **15.** The energy in food originally came from <u>ATP</u>.

_____ **16.** The term photosynthesis means "<u>pulling apart</u> with light" in Greek.

_____ **17.** The energy of sunlight is stored in the chemical bonds of <u>carbohydrates</u>.

18. Complete the table comparing two types of organisms.

Autotrophs and Heterotrophs		
Type	**Description**	**Examples**
Autotrophs		
Heterotrophs		

Apply the Big idea

19. Suppose that you ate a hamburger on a wheat roll with lettuce, tomatoes, and onions for lunch. As you ate, you took in food molecules from plants and animals. Explain why all the energy in the food molecules of this hamburger could be traced back to the sun.

8.2 Photosynthesis: An Overview

Lesson Objectives

- Explain the role of light and pigments in photosynthesis.
- Explain the role of electron carrier molecules in photosynthesis.
- State the overall equation for photosynthesis.

Lesson Summary

Chlorophyll and Chloroplasts In eukaryotes, photosynthesis occurs in organelles called chloroplasts. Chloroplasts house light-absorbing chemicals.

- Light is a form of energy. Sunlight is a mixture of all the different colors of visible light.
- Light-absorbing molecules called **pigments** capture the sun's energy.
- **Chlorophyll** is the principal pigment in photosynthetic organisms. Chlorophyll absorbs blue-violet and red light but reflects green light.
- Chloroplasts have a complex internal structure that includes:
  - **thylakoids**: saclike photosynthetic membranes that contain chlorophyll and other pigments and are arranged in stacks called grana.
  - **stroma:** the fluid portion outside of the thylakoids.

High-Energy Electrons The energy in light raises some of the electrons in chlorophyll to higher energy levels. These high-energy electrons are used in photosynthesis.

- Electron carriers are used to transport the electrons from chlorophyll to other molecules during photosynthesis.
- **$NADP^+$** is a compound that can accept and hold 2 high-energy electrons and 1 hydrogen ion. This process converts $NADP^+$ into NADPH.

An Overview of Photosynthesis Usually summarized by a simple chemical reaction, photosynthesis is a complex process that involves two interdependent sets of reactions.

- The **light-dependent reactions** require light, light-absorbing pigments, and water to form NADPH, ATP, and oxygen.
- The **light-independent reactions** do not use light energy. They use carbon dioxide from the atmosphere, NADPH, and ATP to make energy-rich carbon compounds.

Chlorophyll and Chloroplasts

For Questions 1–6, complete each statement by writing the correct word or words.

1. The _____ of light determines its color.

2. Chemicals that absorb light are called _____.

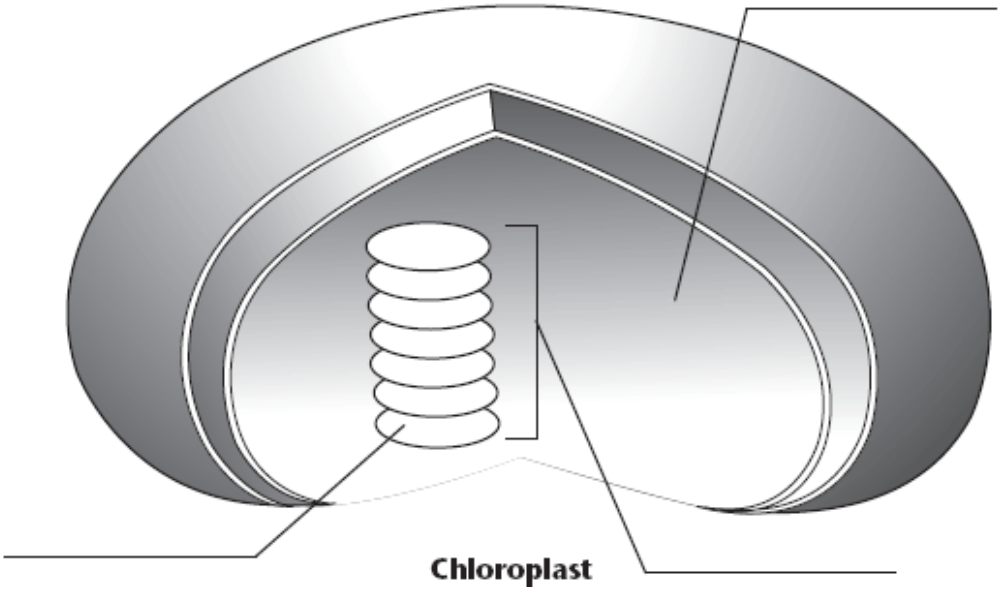
3. Chlorophyll makes plants look green because it _____ green light.

4. Chloroplasts contain an abundance of saclike photosynthetic membranes called _____.

5. The _____ is the fluid portion of the chloroplast located outside the thylakoids.

6. The visible light absorbed by chlorophyll _____ the energy level of the chlorophyll's electrons.

7. Label the internal parts of the chloroplast below.



High-Energy Electrons

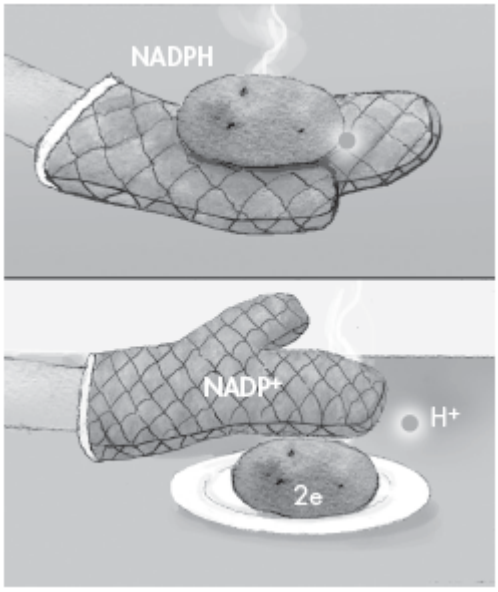
For Questions 8–9, refer to the Visual Analogy comparing electron carriers to oven mitts.

8. In the visual analogy of carrying electrons, what represents the high-energy electrons?

_____

_____

_____



9. Write another analogy that describes the process of electron carriers.

_____

_____

_____

_____

_____

_____

10. Where do the high-energy electrons carried by NADPH come from?

_____

An Overview of Photosynthesis

For Questions 11–13, write the letter of the correct answer on the line at the left.

_____**11.** What are the reactants of the photosynthesis reaction?

A. chlorophyll and light
C. carbohydrates and oxygen
B. carbon dioxide and water
D. high-energy electrons and air

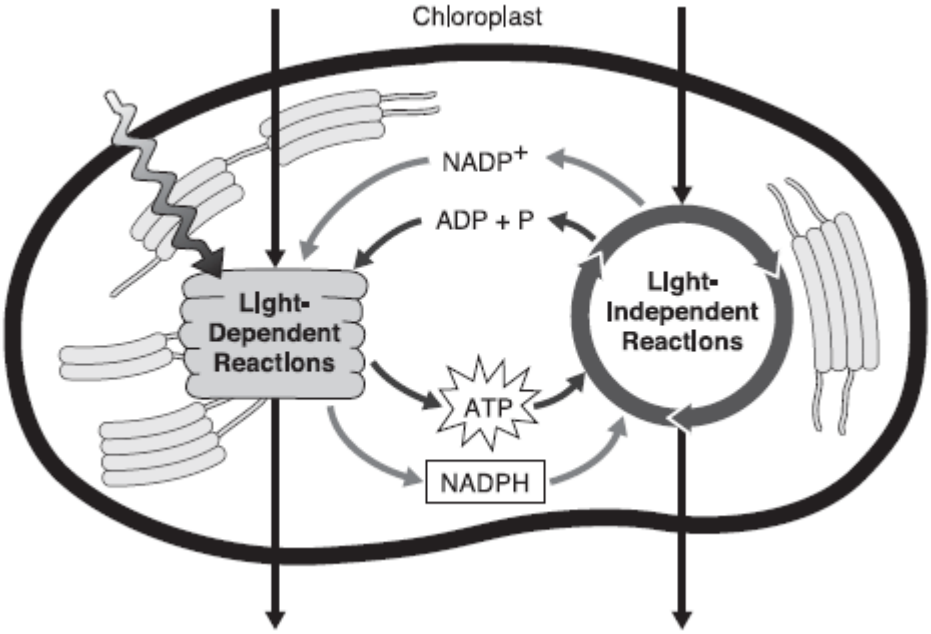
_____**12.** What are the products of the light-dependent reactions?

A. chloroplasts and light
C. oxygen and ATP
B. proteins and lipids
D. water and sugars

_____**13.** Where do the light-independent reactions occur?

A. stroma
C. chlorophyll
B. thylakoids
D. mitochondria

14. Complete the illustration by writing the reactants and products of the light-dependent and light-independent reactions. Also, fill in the energy source that excites the electrons.



15. Solar power uses cells or panels to absorb the sun's energy. That energy is then used to create electricity. How does this compare to the light dependent reactions of photosynthesis?

_____

_____

_____

_____

_____

8.3 The Process of Photosynthesis

Lesson Objectives

- Describe what happens during the light-dependent reactions.
- Describe what happens during the light-independent reactions.
- Identify factors that affect the rate at which photosynthesis occurs.

Lesson Summary

The Light-Dependent Reactions: Generating ATP and NADPH

Photosynthesis begins with these reactions, which occur in thylakoid membranes.

- **Photosystems** are clusters of proteins and chlorophyll in thylakoid membranes.
- High-energy electrons form when pigments in photosystem II absorb light. The electrons pass through **electron transport chains**, a series of electron carrier proteins.
  - The movement of electrons through an electron transport chain causes a thylakoid to fill up with hydrogen ions and generates ATP and NADPH.
  - **ATP synthase** is a membrane protein through which excess hydrogen ions escape a thylakoid in a process that makes ATP.

The Light-Independent Reactions: Producing Sugars They occur in the stroma of thylakoids and are commonly called the **Calvin cycle.**

- Six carbon dioxide molecules from the atmosphere enter the Calvin cycle and combine with 5-carbon compounds already present. They produce twelve 3-carbon molecules.
- Two 3-carbon molecules are removed from the cycle. They are used by the plant to build sugars, lipids, amino acids, and other compounds.
- The remaining ten 3-carbon molecules are converted back to 5-carbon molecules and begin a new cycle.

Factors Affecting Photosynthesis Many factors influence the rate of photosynthesis.

- Temperature, light intensity, and availability of water affect photosynthesis.
- C4 and CAM plants have a modified type of photosynthesis that enables the plants to conserve water in dry climates.

The Light-Dependent Reactions: Generating ATP and NADPH

For Questions 1–5, write True if the statement is true. If the statement is false, change the underlined word or words to make the statement true.

_____ **1.** Photosystems are clusters of chlorophyll and <u>proteins</u>.

_____ **2.** The light-dependent reactions begin when <u>photosystem I</u> absorbs light.

_____ **3.** Electrons from <u>water</u> molecules replace the ones lost by photosystem II.

_____ **4.** <u>ATP</u> is the product of photosystem I.

_____ **5.** ATP and NADPH are two types of <u>protein</u> carriers

6. How does ATP synthase produce ATP? _____

_____

_____

7. When sunlight excites electrons in chlorophyll, how do the electrons change?

_____

_____

8. Where do the light-dependent reactions take place? _____

_____

9. Complete the table by summarizing what happens in each phase of the light-dependent reactions of photosynthesis.

Light-Dependent Reactions	Summary
Photosystem II	
Electron Transport Chain	
Photosystem I	
Hydrogen Ion Movement and ATP Formation	

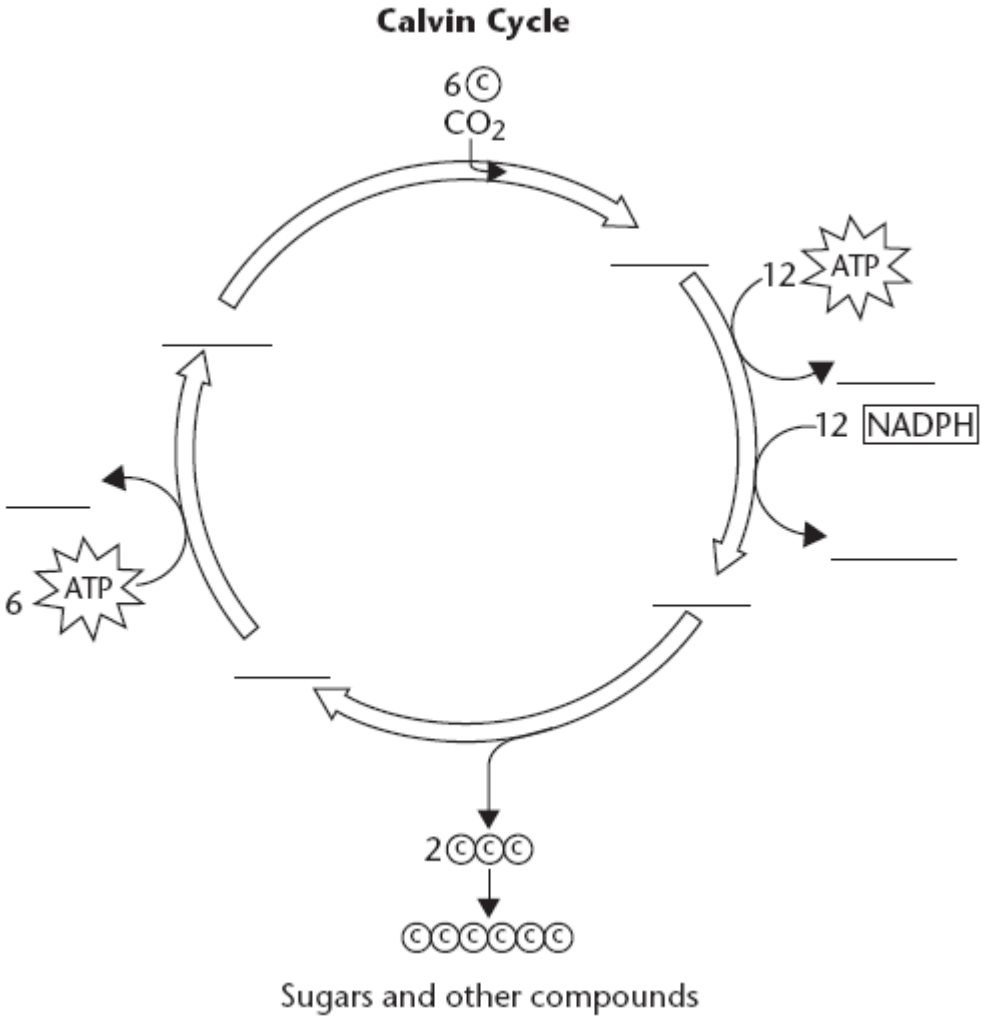
The Light-Independent Reactions: Producing Sugars

10. What does the Calvin cycle use to produce high-energy sugars?

11. Why are the reactions of the Calvin cycle called light-independent reactions?

12. What makes the Calvin cycle a cycle?

13. Complete the diagram of the Calvin cycle by filling in the missing labels.



Factors Affecting Photosynthesis

14. What are three factors that affect the rate at which photosynthesis occurs?

15. Would a plant placed in an atmosphere of pure oxygen be able to conduct photosynthesis? Explain your answer.

16. Complete the table about variations of photosynthesis.

Type	Description	Examples
	Occurs in plants that have a specialized chemical pathway that allows them to capture even very low levels of carbon dioxide and pass it to the Calvin cycle.	
		pineapple trees, many desert cacti, and “ice plants”

17. Photosynthesis plays an important role in supplying energy to living things. Considering what the products of photosynthesis are, what is another way in which photosynthesis is vital to life?

1. What types of organisms do photosynthesis?

2. Sugar is food for plants, what is the type of sugar plants make?

3. What process do plants use to produce sugar?

4. What are the products of photosynthesis?

5. What is the name of the pigment that absorbs sunlight?

6. What plant organelle does photosynthesis take place in?

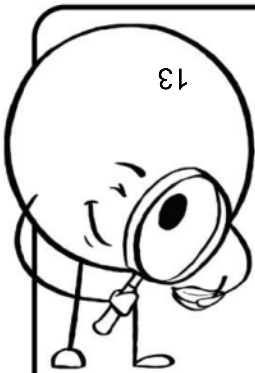
7. What are the two parts of photosynthesis called?

8. The stoma are guard cells that can…

9. What is the MAIN product or purpose of photosynthesis?

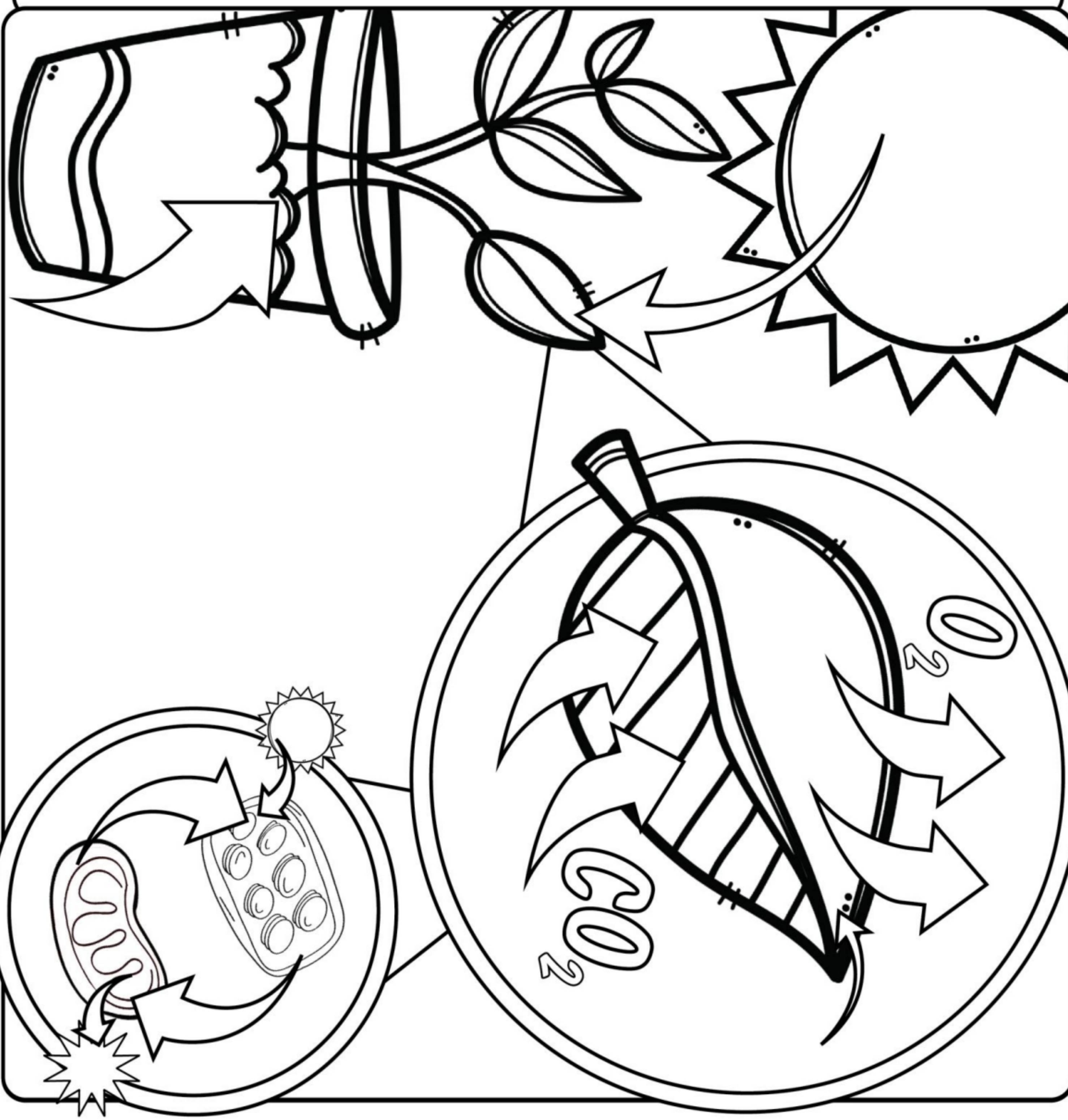
10. When is it “safe” for cacti to open the stomata?

PHOTOSYNTHESIS



REACTANTS **PRODUCTS**

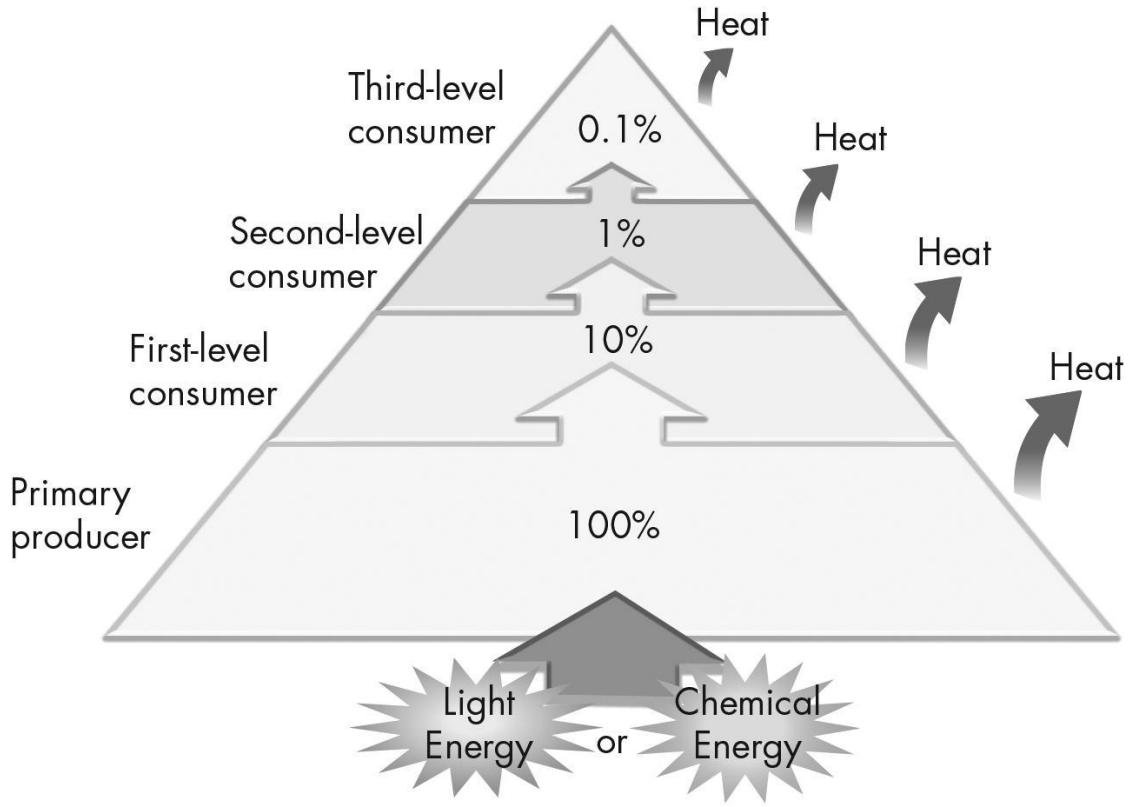
___ CO_2 + ___ H_2O $\longrightarrow$ ___ $C_6H_{12}O_6$ + ___ O_2



Energy Flow Calculations

The 10 Percent Rule

An energy pyramid is a diagram that illustrates the transfer of energy through a food chain or food web. In general, only 10 percent of the energy available in one level is stored in the level above. Look at the energy pyramid and answer the questions below.



1. **Calculate** If there are 1000 units of energy available at the producer level of the energy pyramid, approximately how many units of energy are available to the third-level consumer?

2. **Interpret Diagrams** What is the original source of the energy that flows through most ecosystems? Why must there be a continuous supply of energy into the ecosystem?

3. **Infer** Why are there usually fewer organisms in the top levels of an energy pyramid?

Magic School Bus – Gets Planted

Fill out this worksheet as you watch the video.

1. A plant starts out as a _____
2. Plants need soil, sunlight and _____ to grow.
3. To stay alive all living things must have _____.
4. All plants have leaves, a stem and _____.
5. A soil mite is an insect that lives above / underground. (circle one)
6. Plant roots grow little fibers called root _____ that absorb water from the soil.
7. Water travels up the _____ of the plant towards the leaves.
8. Leaves are green because they contain a green substance called _____.
9. Leaves have tiny holes on their surface that are used for taking in _____.
10. Sunlight gives _____ to the chloroplasts inside the leaves.
11. Chloroplasts make _____ from sunlight, air and water which becomes food for the plant.
12. Even if a plant has enough water and air it must still have _____ to make its own food.
13. A plant will start to wilt / sprout without sunlight. (circle one)
14. Plants cannot make their own food if the leaves are not _____.
15. Only _____ can make their own food from air, water and sun.

What are three things you know now that you have seen this movie:

1.

2

3.

Taste the Rainbow!

Using Skittles to explore the chemistry of photosynthesis and cellular respiration

Name:_____• Class:_____

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Givens •Mister Science 2013

Background Information

Plants cells and animal cells use chemical reactions to engage in photosynthesis and cellular respiration.

During this lab you will be using Skittles to represent the molecules found in photosynthesis and respiration reactions. While studying these two reactions you will encounter the following molecules: CO_2 (carbon dioxide), H_2O (water), $C_6H_{12}O_6$ (glucose), and O_2 (oxygen).

As you know, **photosynthesis** is the process in which plants (also called autotrophs or producers) use water and the radiant energy of the sun to create simple sugar (glucose) as a food source with oxygen as one of the products of the reaction.

Cellular respiration is the process that takes place in the cells of organisms in which chemical reactions turn sugar (glucose) that we get from food along with oxygen into adenosine triphosphate (ATP). For the purposes of this lab, we will refer to ATP as "energy", you can think of it as a kind of chemical battery that allows our body to store energy and rerelease it when needed.

The law of conservation of matter is a fundamental principle of science that states that matter is neither created nor destroyed, it simply changes forms. You will see that during photosynthesis and respiration that the number of atoms in the reactants (the "ingredients" on the left side of the formula) will equal the atoms in the products (the things that are given off after the "ingredients" undergo a chemical reaction, on the right side of the formula). You will also learn the molecules that make up the reactants and products for photosynthesis and respiration.

Directions:

1. Decide what color Skittle you are going to use to represent each kind of atom. Write the color below so you won't forget.

_____Carbon _____Hydrogen _____Oxygen

2. Complete the chart below. Use the provided equations to write out the common names of the molecules that are found in the reactants and products. For example, if NaCl were one of the molecules in the equation, you would write out Sodium Chloride (or salt) in the blank. Refer to the background information if you forgot the common names of any of the molecules.

Photosynthesis: $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

Respiration: $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

	Reactants (ingredients)	**Products (Given off)**
Photosynthesis		
Respiration		

3. How many total carbon atoms are there in the reactants of photosynthesis? _____

4.How many total oxygen atoms are there in the reactants of photosynthesis? _____

5.How many total atoms of hydrogen are there in the reactants of photosynthesis? __

6. How many total carbon atoms are there in the products of photosynthesis? _____

7. How many total oxygen atoms are there in the products of photosynthesis? _____

8. How many total atoms of hydrogen are there in the products of photosynthesis? __

9. Place the correct color and number of Skittles you chose on all of the atoms of the reactants of photosynthesis. For example, if you chose red Skittles to represent carbon, place one red skittle for each atom of carbon on the reactants side. Arrange the Skittles in the correct order so they represent the molecules on the reactants side. Have your teacher check your model for accuracy.

10. Draw a colored picture of your Skittle representation of the photosynthesis and cellular respiration reaction (both the reactants and the products).

Photosynthesis:

Cellular respiration:

11.How many total carbon atoms are there in the reactants of photosynthesis? _____

12. How many total carbon atoms are there in the reactants of respiration? _____

13.How many total oxygen atoms are there in the reactants of photosynthesis? _____

14. How many total oxygen atoms are there in the reactants of respiration? _____

15. Do you notice a pattern between how many atoms are in the reactants and how many are in the products? Can you guess the significance of the pattern?

_____

_____

16. How many total atoms of oxygen are there in the products of photosynthesis? _____

Conclusion questions:

17. What were your observations about the photosynthesis and respiration formulas?

_____

_____

_____

18. What is the law of conservation of matter?

_____

_____

_____

19. How was the law of conservation of matter demonstrated in this lab?

_____

_____

_____

20. Why are the products of the photosynthesis reaction necessary for life on earth?

_____

_____

_____

21. BONUS: What is the relationship between the products of cellular respiration and our respiratory system?

_____

_____

_____

Lesson Review Questions

Lesson 8.1: Energy and Life

1. _____
2. _____
3. _____
4. _____
5. _____

Lesson 8.2: Photosynthesis: An Overview

1. _____
2. _____
3. _____
4. _____
5. _____

Lesson 8.3: The Process of Photosynthesis

1. _____
2. _____
3. _____
4. _____
5. _____

Photosynthesis Test Review

Terms to Know - Photosynthesis

Photosynthesis	ATP	ADP	Heterotroph
Autotroph	Chloroplast	Chlorophyll	Thylakoids
Stroma	Light Dependent Rxns	Light Independent Rxns (Calvin Cycle)	NADPH, NADP+
Electron Transport Chain	ATP Synthase	Cellular Respiration	Stomata

Energy

- What is the purpose of photosynthesis?
- Photosynthesis equation (Symbols & words)
    - Reactants (inputs)
    - Products (outputs)
- Where does photosynthesis take place in the cell?
    - How is this organelle structured?
    - Be able to recognize a picture and identify the parts of this organelle
- Which season(s) does photosynthesis most likely occur AND least likely occur?
- Cellular Respiration equation (Symbols & words)
    - Reactants (inputs)
    - Products (outputs)

Reactions

- Light Dependent Reactions
    - Where does it take place?
    - Reactants
    - Products
- Light Independent Reactions
    - What is another name for this reaction?
    - Where does it take place?
    - Reactants
    - Products
- What are high energy electron carriers?
    - What are two examples of this?
- List all factors that affect the rate of photosynthesis

Ag Biology

Semester 2

Chapter 9 Workbook: Cellular Respiration & Fermentation

Name: _____ Date: _____

Class Period: _____ Teacher: _____

Table of Contents

Chapter 9: Cellular Respiration & Fermentation

9.1 Cellular Respiration: An Overview

Lesson Objectives

- Explain where organisms get the energy they need for life processes.
- Define cellular respiration.
- Compare photosynthesis and cellular respiration.

Lesson Summary

Chemical Energy and Food Chemical energy is stored in food molecules.

- Energy is released when chemical bonds in food molecules are broken.
- Energy is measured in a unit called a **calorie**, the amount of energy needed to raise the temperature of 1 gram of water 1 degree Celsius.
- Fats store more energy per gram than do carbohydrates and proteins.

Overview of Cellular Respiration **Cellular respiration** is the process that releases energy from food in the presence of oxygen.

- Cellular respiration captures the energy from food in three main stages:
  - glycolysis
  - the Krebs cycle
  - the electron transport chain
- Glycolysis does not require oxygen. The Krebs cycle and electron transport chain both require oxygen.
  - **Aerobic** pathways are processes that require oxygen.
  - **Anaerobic** pathways are processes that occur without oxygen.

Comparing Photosynthesis and Cellular Respiration The energy in photosynthesis and cellular respiration flows in opposite directions. Their equations are the reverse of each other.

- Photosynthesis removes carbon dioxide from the atmosphere, and cellular respiration puts it back.
- Photosynthesis releases oxygen into the atmosphere, and cellular respiration uses oxygen to release energy from food.

Chemical Energy and Food

For Questions 1–4, complete each statement by writing the correct word or words.

1. A calorie is a unit of _____.

2. The Calorie used on food labels is equal to _____calories.

3. A Calorie is also referred to as a _____.

4. Cells use the energy stored in chemical bonds of foods to produce compounds that directly power the cell's activities, such as _____.

Overview of Cellular Respiration

For Questions 5–10, complete each statement by writing the correct word or words.

5. The equation that summarizes cellular respiration, using chemical formulas, is___.

6. If cellular respiration took place in just one step, most of the _____would be lost in the form of light and _____.

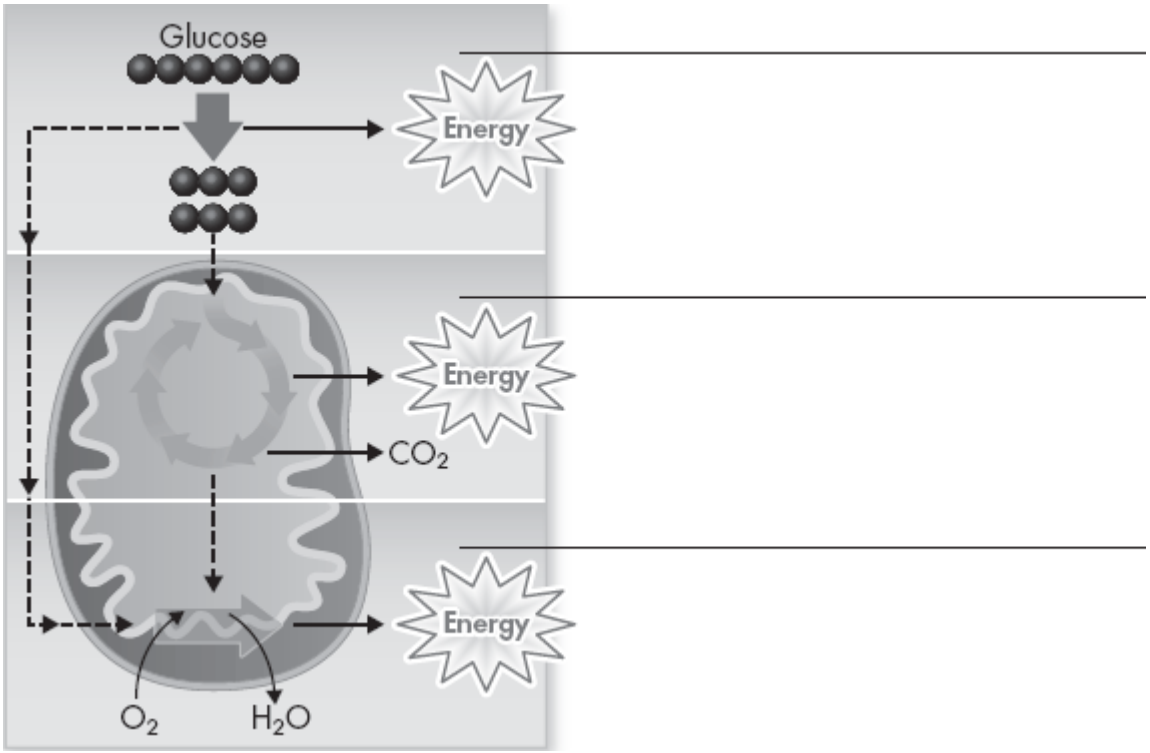
7. Cellular respiration begins with a pathway called _____, which takes place in the _____of the cell.

8. At the end of glycolysis, about _____ percent of the chemical energy is locked in the bonds of the _____ molecule.

9. Cellular respiration continues in the _____ of the cell with the _____and electron transport chain.

10. The pathways of cellular respiration that require oxygen are said to be _____. Pathways that do not require oxygen are said to be _____.

11. Complete the illustration by adding labels for the three main stages of cellular respiration.



Comparing Photosynthesis and Cellular Respiration

For Questions 12–15, write True if the statement is true. If the statement is false, change the underlined word or words to make the statement true.

_____ **12.** The energy flow in photosynthesis and cellular respiration occurs in the <u>same</u> direction.

_____ **13.** Photosynthesis <u>deposits</u> energy in Earth's "savings account" for living organisms.

_____ **14.** Cellular respiration removes <u>carbon dioxide</u> from the air.

_____ **15.** <u>Photosynthesis</u> takes place in nearly all life.

16. Complete the table comparing photosynthesis and cellular respiration.

A Comparison of Photosynthesis and Cellular Respiration

Aspect	Photosynthesis	Cellular Respiration
Function	energy capture	
Location of reactions	chloroplasts	
Reactants		
Products		

17. How does an understanding of the process of cellular respiration support the theory that the cell is the basic functional unit of life?

9.2 The Process of Cellular Respiration

Lesson Objectives

- Describe what happens during glycolysis.
- Describe what happens during the Krebs cycle.
- Explain how high-energy electrons are used by the electron transport chain.
- Identify how much ATP cellular respiration generates.

Lesson Summary

Glycolysis The word **glycolysis** literally means "sugar-breaking." The end result is 2 molecules of a 3-carbon molecule called pyruvic acid.

- 2 ATP molecules are used at the start of glycolysis to get the process started.
- High-energy electrons are passed to the electron carrier **NAD^+**, forming two molecules of NADH.
- 4 ATP are synthesized during glycolysis for a net gain of 2 ATP.

The Krebs Cycle The second stage of cellular respiration is the **Krebs cycle**, which operates only when oxygen is available. The Krebs cycle is a series of energy-extracting reactions.

- Pyruvic acid produced by glycolysis enters mitochondria. In the innermost compartment of a mitochondrion, or the **matrix**, pyruvic acid molecules are broken down into carbon dioxide and acetyl-CoA molecules.
- Acetyl-CoA combines with a 4-carbon compound, producing a 6-carbon molecule—citric acid. Energy released by the breaking and rearranging of carbon bonds is captured in ATP, NADH, and $FADH_2$.
- The Krebs cycle produces four types of products:
  - high-energy electron carriers (NADH and $FADH_2$)
  - carbon dioxide
  - 2 ATP molecules (per glucose molecule)
  - the 4-carbon molecule needed to start the cycle again

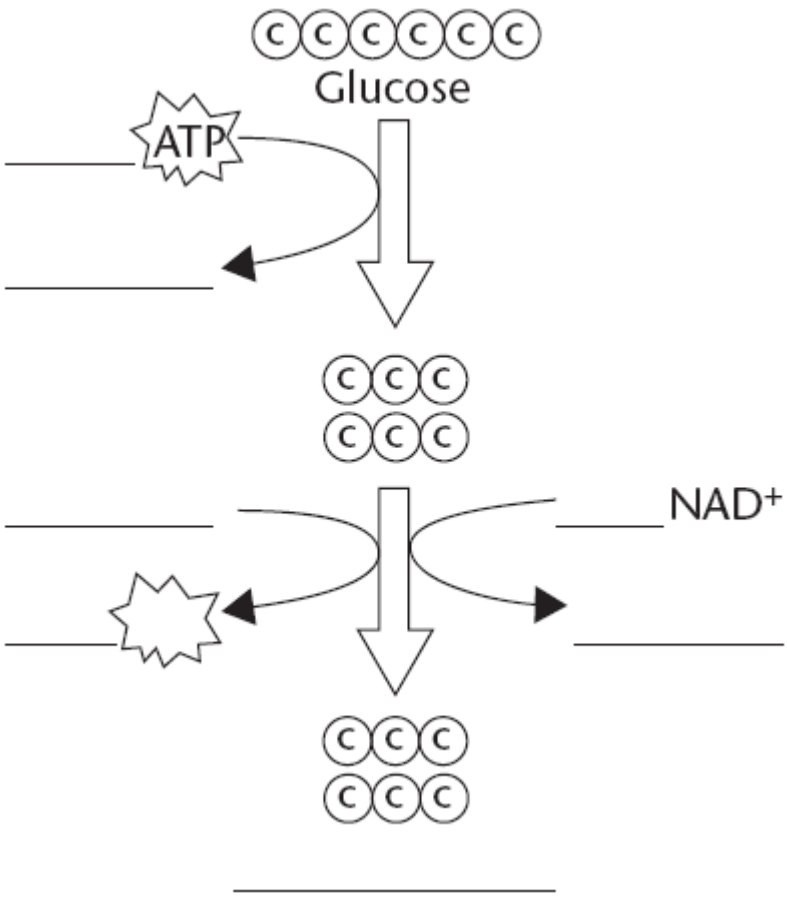
Electron Transport and ATP Synthesis The electron transport chain uses the high-energy electrons from glycolysis and the Krebs cycle to convert ADP into ATP.

- The electron carriers produced during glycolysis and the Krebs cycle bring high-energy electrons to the electron transport chain. Oxygen is the final electron acceptor.
- The passing of electrons through the electron transport chain causes H^+ ions to build up in the intermembrane space, making it positively charged relative to the matrix.
- The charge difference across the membrane forces H^+ ions through channels in enzymes known as ATP synthases. As the ATP synthases spin, a phosphate group is added to ADP, generating ATP.

The Totals Together, glycolysis, the Krebs cycle, and the electron transport chain generate about 36 molecules of ATP per molecule of glucose.

Glycolysis

1. Complete the diagram by writing on the lines provided the names and numbers of molecules used and produced during glycolysis.



2. Why is it an investment for the cell to use two ATP at the beginning of glycolysis?

3. What are two advantages of glycolysis?

The Krebs Cycle

For Questions 4–7, write True if the statement is true. If the statement is false, change the underlined word or words to make the statement true.

_____ **4.** The pyruvic acid produced in glycolysis enters the chloroplasts if oxygen is present in a cell.

_____ **5.** In the matrix, pyruvic acid is converted to lactic acid before the Krebs cycle begins.

_____ **6.** The compound that joins with a 4-carbon molecule in the Krebs cycle is called acetyl-CoA.

_____ **7.** Carbon dioxide is the only product of the Krebs cycle that is not reused or used in other stages of cellular respiration.

8. Complete the flowchart to show which of the Krebs cycle's many products go on to the third stage of cellular respiration.

Electron Transport and ATP Synthesis

For Questions 9–14, complete each statement by writing the correct word or words.

9. In eukaryotes, the electron transport chain is composed of a series of electron carriers located in the_____of the mitochondrion.

10. In prokaryotes, the electron transport chain is in the _____.

11. _____ serves as the final electron acceptor of the electron transport chain.

12. _____ and _____ pass high-energy electrons to the electron transport chain.

13. The transfer of high-energy electrons down the electron transport chain causes ___ to be transported across the mitochondrial membrane.

14. ATP synthases produce the force needed to add one _____ to each ADP molecule by spinning when hydrogen ions flow through them.

The Totals

15. How many ATP molecules per glucose molecule does a cell gain from each of the three stages of cellular respiration?

16. Besides glucose, what other kinds of molecules can be used to produce ATP in cellular respiration?

17. Why is cellular respiration considered an efficient process?

18. Where does the heat that warms your body come from? Explain your answer.

9.3 Fermentation

Lesson Objectives

- Explain how organisms get energy in the absence of oxygen.
- Identify the pathways the body uses to release energy during exercise.

Lesson Summary

Fermentation **Fermentation** releases energy from food molecules by producing ATP without oxygen. Cells convert NADH to the electron carrier NAD^+. This allows glycolysis to produce a steady stream of ATP. There are two forms of fermentation. Both start with the reactants pyruvic acid and NADH.

- alcoholic fermentation produces ethyl alcohol and carbon dioxide
  - occurs in yeast and a few other microorganisms
  - produces alcoholic beverages and causes bread dough to rise
- lactic acid fermentation produces lactic acid
  - occurs in most organisms, including humans
  - used to produce beverages such as buttermilk and foods such as cheese, yogurt, and pickles

Energy and Exercise The body uses different pathways to release energy.

- For short, quick bursts of energy, the body uses ATP already in muscles as well as ATP made by lactic acid fermentation.
- For exercise longer than about 90 seconds, cellular respiration is the only way to continue generating a supply of ATP.

Fermentation

For Questions 1–6, write True if the statement is true. If the statement is false, change the underlined word or words to make the statement true.

_____ **1.** Glycolysis provides the pyruvic acid molecules used in fermentation.

_____ **2.** Fermentation allows glycolysis to continue by providing the NADPH needed to accept high-energy electrons.

_____ **3.** Fermentation is an aerobic process.

_____ **4.** Fermentation occurs in the mitochondria of cells.

_____ **5.** Alcoholic fermentation gives off carbon dioxide and is used in making bread.

_____ **6.** Most organisms perform fermentation using a chemical reaction that converts pyruvic acid to lactic acid.

7. Compare and contrast fermentation and cellular respiration by completing the compare/contrast table. Write your answers in the empty table cells.

Aspect	Fermentation	Cellular Respiration
Function		
Reactants		
Products		

8. Compare and contrast alcoholic fermentation and lactic acid fermentation by completing the compare/contrast table. Write your answers in the empty table cells.

Type of Fermentation	Summary Equation	Use in Industry
Alcoholic		
Lactic acid		

9. What causes humans to become lactic acid fermenters?

Energy and Exercise

10. What are three main sources of ATP available for human muscle cells?

11. During a race, how do your muscle cells produce ATP after the store of ATP in muscles is used?

12. Why does a sprinter have an oxygen debt to repay after the race is over?

13. A runner needs more energy for a longer race. How does the body generate the necessary ATP?

14. Why are aerobic forms of exercise so beneficial for weight control?

15. Compare and contrast the role of fermentation and cellular respiration in the actual production of ATP. In your response, consider which process produces ATP and which process contributes to its production.

Edpuzzle: Cellular Respiration

1. True or False: Plants use cellular respiration.

2. What are all the reactants for cellular respiration?

3. What does the term aerobic mean?

4. True or False: Fermentation occurs when oxygen is present.

5. What organisms use alcoholic fermentation?

6. What kind of products are produced using alcoholic fermentation?

7. When would our muscle cells use lactic acid fermentation?

8. What product can be made using lactic acid fermentation?

9. What process makes more ATP?

Edpuzzle: Fermentation

1. What type of organism needs oxygen to survive?

2. When comparing plant cells to animal cells, what cellular processes are different?

3. What cellular respiration type ***requires*** oxygen?

4. Which cellular classifications (Prokaryotes & Eukaryotes) are able to undergo *anaerobic respiration*?

5. What are the two main products of glycolysis?

6. Which cellular process does not occur during fermentation (anaerobic respiration)?

7. What molecule are we trying to regenerate when we go through fermentation?

8. Yeast undergo anaerobic respiration (fermentation), where glucose is broken down into two (2) ATP and two (2) pyruvate. This pyruvate is then used to create what *waste product*?

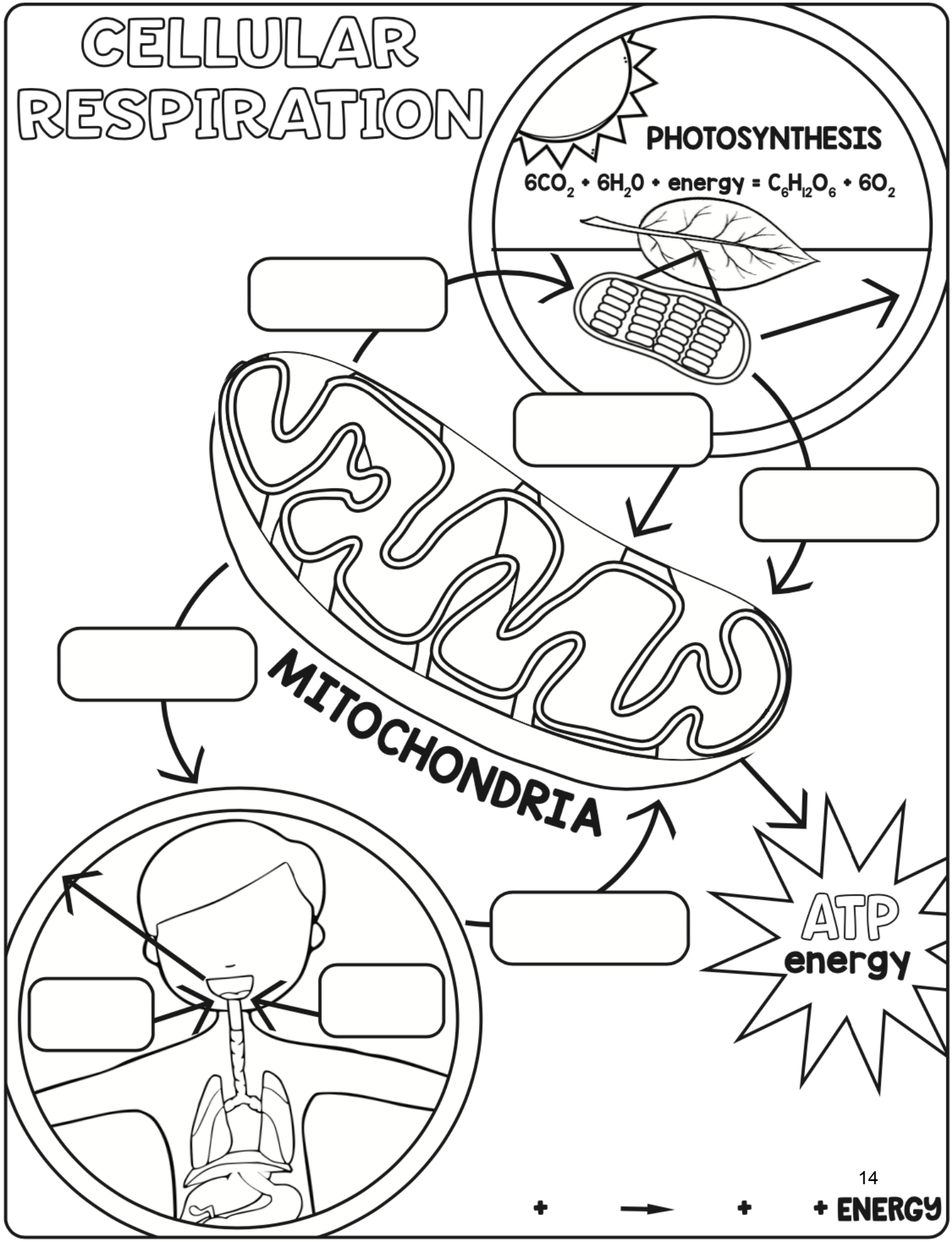
9. When muscle cells “run out” of oxygen and ATP, the cells are able to switch to which cellular process to compensate?

10. Which cellular energy process produces the most amount of ATP per 1 molecule of glucose?

11. When oxygen isn’t available, which cellular process would be performed?

12. What are the two forms of Anaerobic respiration/fermentation?

CELLULAR RESPIRATION



Introduction:

I. Background Information.
Cellular respiration (see chemical reaction below) is a chemical reaction that occurs in your cells to create energy; when you are exercising your muscle cells are creating ATP to contract. Cellular respiration requires oxygen (which is breathed in) and creates carbon dioxide (which is breathed out).

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + 36\ ATP(energy)$$

This lab will address how exercise (increased muscle activity) affects the rate of cellular respiration. You will measure 3 different indicators of cellular respiration: breathing rate, heart rate, and carbon dioxide production. You will measure these indicators at rest (with no exercise) and after 1 and 2 minutes of exercise. Breathing rate is measured in breaths per minute, heart rate in beats per minute, and carbon dioxide in the time it takes bromothymol blue to change color. Carbon dioxide production can be measured by breathing through a straw into a solution of bromothymol blue (BTB). BTB is an acid indicator; when it reacts with acid it turns from blue to yellow. When carbon dioxide reacts with water, a weak acid (carbonic acid) is formed (see chemical reaction below). The more carbon dioxide you breathe into the BTB solution, the faster it will change color to yellow.

$$6CO_2 + 6H_2O \rightarrow 6HCO_3 + 6H^+$$

The purpose of this lab activity is to analyze the effect of exercise on cellular respiration.

Background:

I. Purpose.

- To observe the effects of exercise on cellular respiration
- To identify the role of carbon dioxide production, breathing rate, and heart rate in determining the rate of cellular respiration

II. Pre-Lab. Use your background information AND your Cellular Respiration notes to answer the following:

1. What is the equation for cellular respiration? Label the reactants and the Products.

2. In what part of the cell does cellular respiration occur?

3. Write a prediction/hypothesis of how exercise will affect your body's production of carbon dioxide (i.e. do you think your body will produce more or less carbon dioxide as you exercise). Make sure you EXPLAIN WHY.

Materials:

- Beaker/Test Tube/Cup
- Bromothymol blue solution (BTB)
- Straw
- Stop watch

Safety:

- Always have an adult with you to help you during your experiment.
- Always wear eye protection and gloves when doing chemistry experiments
- Rubbing alcohol is flammable, so it must be kept away from any open flames or heat.
- Conduct this experiment in a well-ventilated area.

Procedure:

PART A: Resting (no exercise)

Measuring Carbon Dioxide Production:

1. Use a graduated cylinder to measure out 20 mL of tap water and pour it into a small beaker.
2. Use a dropper to add 8 drops of bromothymol blue to make a BTB solution.
3. Using a straw, exhale into the BTB solution. (CAUTION: Do not inhale the solution!)
4. Time how long it takes for the blue solution to turn yellow. Record the time in Table 1.
5. Wash out the beaker and repeat steps 1-4 twice more.
6. Average the results of the 3 trials. Record this in Table 1.

Measuring Breathing Rate:

1. Count the number of breaths (1 breath = inhale + exhale) you take in 1 minute. Record this in Table 2.
2. Repeat this 2 more times.
3. Average the 3 trials to get your average breathing rate. Record this in Table 2.

Measuring Heart Rate:

1. While you calculate your breathing rate, have your partner take your pulse.
2. Count the number of beats in 30 seconds and multiply that number by 2. Record this in Table 3.
3. Repeat this 2 more times.
4. Average the 3 trials to get your average heart rate. Record this in Table 3.

PART B: Increased Muscle Activity (Exercise)

1. Exercise for exactly 1 minute by doing jumping jacks.
2. While you are exercising, your partner should get the BTB solution ready as in Part A.
3. After 1 minute of exercise, immediately exhale through the straw into the BTB solution. Time how long it takes for the BTB to turn yellow. Record this in Table 1.
4. Then quickly calculate your breathing and heart rates as you did before. You only need to do this once.
5. Record these values in Tables 2 & 3. Remake your BTB solution.
6. Exercise as you did before, but for 2 continuous minutes.
7. Immediately exhale through the straw into the BTB solution. Time how long it takes for the BTB to turn yellow. Record this in Table 1.
8. Then quickly calculate your breathing and heart rates as you did before. You only need to do this once.
9. Record these values in Tables 2 & 3.
10. If there is time, repeat the entire procedure for your lab partner. Record data from 2 OR 3 other subjects in the class to get more data depending on if your partner was able to go or not.

Data and Observations:

Table 1. Carbon Dioxide Production (time it takes BTB to change color)

		Student 1	Student 2	Student 3	Student 4	Average
RESTING	Trail 1					
	Trial 2					
	Trial 3					
	Average					
EXERCISE	1 minute					
	2 minutes					

Table 2. Breathing Rate (breaths/minute)

		Student 1	Student 2	Student 3	Student 4	Average
RESTING	Trail 1					
	Trial 2					
	Trial 3					
	Average					
EXERCISE	1 minute					
	2 minutes					

Table 3. Heart Rate (beats/minute)

		Student 1	Student 2	Student 3	Student 4	Average
RESTING	Trail 1					
	Trial 2					
	Trial 3					
	Average					
EXERCISE	1 minute					
	2 minutes					

Questions:

Analysis & Conclusions: Answer the questions below using your BACKGROUND information in the lab, as well as your lab data. ANSWER THE QUESTIONS IN COMPLETE SENTENCES.

1. How did exercise affect the time needed for the solution to change color? Explain why the color change occurred (How does BTB work?)

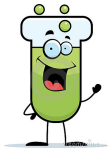
2. What can you conclude about the effect of exercise on the amount of carbon dioxide that is present in your exhaled breath? Why is this so?

3. What can you conclude about the effect of exercise on breathing rate? Why is this so?

4. What can you conclude about the effect of exercise on heart rate? Why is this so? What do your muscles need during exercise that the blood brings?

5. State whether your hypothesis was correct or incorrect and why. In doing so, discuss what you think is going on in the muscles of the body as muscle activity is increased. Address the need to get oxygen to the muscles and get rid of carbon dioxide, as well as how the muscles cells get the energy needed to continue contracting. What did you see? Anything you were not expecting? Something really awesome? Describe it here.

Yeast Respiration Lab



Question: How does sugar affect the carbon dioxide production in yeast?

Hypothesis:

Materials:

- 2 Graduated tubes
- 4 small clear plastic cups
- warm water
- table sugar
- graduated cylinder
- stir sticks
- ¼ tsp, 1 tsp measurements
- tape to label tube
- stop watch

Procedure:

Part 1-

1. With tape, label one graduated tube sugar, and the other no sugar.
2. In a small cup add ¼ teaspoon of yeast and 20 ml of warm water.
3. Mix thoroughly with stir stick (≈30 seconds)
4. In another cup add ¼ teaspoon of yeast, 1 teaspoon of sugar and 20 ml of warm water. Mix thoroughly!

***WAIT AT LEAST 5 Min. FOR THE YEAST TO ACTIVATE**

WHILE YOU WAIT FOR THE YEAST TO BECOME ACTIVE READ AND ANSWER THE FOLLOWING QUESTIONS:

Did you ever wonder how bread gets its "spongy" structure? If you've ever baked homemade bread yourself, you know that you need yeast to make the bread dough rise. Yeasts are single-celled fungi. Like the cells in your body, they can get energy from sugar molecules. They can also break down larger carbohydrate molecules (like starches present in flour) into simple sugar molecules, which are then processed further.

This process is called **cellular respiration**. Cellular respiration uses oxygen to break down carbohydrates (sugar) into carbon dioxide and water with capture of some of the energy in the form of ATP. This all takes place in the mitochondria.

1. Write down the equation for cellular respiration

\+ ⟶ +

2. Why do living organisms carry out the process of respiration?

3. What waste product of yeast respiration is useful in making bread?

Explain how yeast helps the bread dough to rise.

Yeast can take out more energy from sugar when oxygen is present in their environment. In the absence of oxygen, yeast switch to an alternative pathway that does not require oxygen. This process is called ***fermentation*.** With fermentation, yeast can still get energy from sugar, but less energy is made from each sugar molecule. This process allows the yeast to survive and grow where no oxygen is available.

Fermentation partially breaks down the sugar and a small amount of energy is captured in the form of ATP, and a different product is formed. During fermentation in yeast, the products are carbon dioxide and **alcohol.** Alcoholic fermentation in yeast can be used to make wine or beer.

Fermentation Equation:

$$C_6H_{12}O_6 \longrightarrow \underset{\text{(alcohol)}}{2(CH_3CH_2OH)} + 2CO_2 + \text{energy}$$

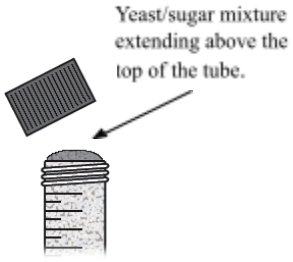
4. What waste product of yeast respiration is useful in making beer/wine? _____

We can respire in both ways too. Normally we use oxygen, but when we are running in a race, we may not get enough oxygen into our blood, so our muscles start to respire without oxygen. Unlike yeast we produce ***lactic acid,*** this causes the 'burning' sensation and cramping in the muscles.

To measure the rate of alcoholic fermentation in yeast, you can measure the amount of CO_2 gas the yeast produces. CO_2 production can be measured by measuring the depth of the layer of bubbles trapped in foam on top of the yeast solution

Part 2-

5. Pour yeast solution without sugar into tube labeled no sugar. Fill the tube all the way to the top, extending the fluid slightly above the top of the tube.
6. **Slowly** screw the cap on the tube, some may squirt out, this is O.K.
7. Turn the tube upside down and check to see that there is only a small bubble or bubbles. If there is a large bubble, you need to add more of the mixture to the tubes and try again.
8. Keep the tube upside down and place it into one of the empty plastic cups. It is o.k. if some of the liquid leaks out!
9. Pour the sugar/yeast solution into the other tube labeled sugar.
10. Repeat steps 7-9.

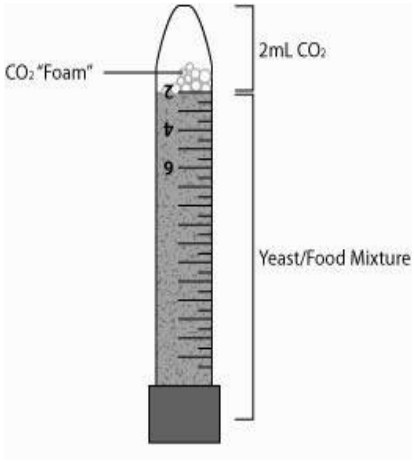


***Now record the volume of carbon dioxide gas (CO_2) that is produced every 2 min. for 12 min. in the data table.**

***Remember the tube is upside down –make sure you read it correctly!**

Data Table:

Time (minutes)	Total Volume of CO_2 Produced	
	Sugar	No Sugar
2		
4		
6		
8		
10		
12		



Graph:

Prepare a graph to summarize the data you recorded in your data table.

- **<u>Label</u>** the Y-axis volume of CO_2 (ml) & **<u>Label</u>** the X-axis time (min)
- Plot the data for yeast with sugar & Plot the data for yeast with no sugar

The Effect of sugar on Respiration in Yeast

Conclusion Questions:

1. Was your hypothesis correct? Explain why or why not using data from the experiment.

2. Which set up was the control group?

3. What is the independent variable (what was changed) in this experiment?

4. What is the dependent variable (what was measured) in this experiment?

5. Explain how the experiment may have produced data that was incorrect (sources of error).

6. What experiment would you test in the future that relates to the ideas in this lab?

Photosynthesis & Cellular Respiration Final Project

In this final project you will be comparing the process of Photosynthesis to the process of Cellular Respiration. Your goal in this project is to use the information you have learned in the last three weeks to create a brochure of what it would be like to go through each stage of the processes. One side will be for Photosynthesis, the other side will be for Cellular Respiration. Think about it as if you were Ms. Frizzle taking the Magic School Bus through each process. Below are some of the key components you need to include for each process.

Photosynthesis:
Equation (both symbols and words)
- Be sure to include the sun's energy

Location of process both in the plant and in the plant cell
Location of gas exchange in the plant
Include description of light independent and light dependent reactions
*Include a picture of a plant
*Include a depiction of the chloroplast

Cellular Respiration:
Equation (both symbols and words)
- Include energy in the form of ATP

Location of the process in the cell
Include all three stages (Glycolysis, Krebs Cycle, Electron Transport Chain)
- Description of what's happening in each stage, inputs and outputs

*Include a picture of an organism that performs Cellular Respiration
*Include depiction of cytoplasm and mitochondria

Both:
-Written description of how photosynthesis and cellular respiration are connected AND why they are important
-All information needs to be included for each process, with the processes flowing in the correct order
-The brochure must be organized and easy to read
-Illustrations and color is required
-All 6 pages of the brochure should contain information

Rubric

Description	Points Possible	Points Earned
- Title (Photosynthesis & Cellular Respiration) - Name, Date, Hour	5	

- Equations (both reactants & products)
  - Symbols
  - Words
	10	

- Locations of processes clearly presented	5	
- All stages identified with description or illustration of process	5	
- Description of what is happening during photosynthesis and respiration - Why they are important - How they are connected	10	
- Correct order of process	5	
- Information organized & easy to read - Illustrations and color - Effort shown - All 6 pages contain information	10	
- Staple this piece of paper to your brochure when you turn it in to be graded		
Total Points	50	

Lesson Review Questions

Lesson 9.1: Cellular Respiration: An Overview

1. _____
2. _____
3. _____
4. _____
5. _____

Lesson 9.2: The Process of Cellular Respiration

1. _____
2. _____
3. _____
4. _____
5. _____

Lesson 9.3: Fermentation

1. _____
2. _____
3. _____
4. _____
5. _____

Ag Biology

Semester 2

Chapter 10 Workbook:
Cell Growth & Division

Name: _____ Date: _____

Class Period: _____ Teacher: _____

Table of Contents

Chapter 10: Cell Growth & Division

10.1 Cell Growth, Division, and Reproduction

Lesson Objectives

- Explain the problems that growth causes for cells.
- Compare asexual and sexual reproduction.

Lesson Summary

Limits to Cell Size There are two main reasons why cells divide:

- Information "overload": The larger a cell gets, the more demands it places on its DNA. Eventually, the cell's DNA cannot meet the cell's needs.
- Exchange of materials: Cells take in nutrients and eliminate wastes through the cell membrane.
  - The larger a cell's volume, the more materials it needs to function and the more waste it creates.
  - A cell's volume increases at a faster rate than its surface area. As a cell grows, its surface-area-to-volume ratio becomes too small.
  - The larger a cell gets, the harder it is for enough materials to move across its cell membrane.
- **Cell division** solves the information overload and materials exchange problems.

Cell Division and Reproduction Cell division is part of both types of reproduction:

- **Asexual reproduction:**
  - produces genetically identical organisms.
  - occurs in many single-celled organisms and in some multicellular organisms.
  - allows rapid reproduction of organisms in favorable environments.
- **Sexual Reproduction:**
  - produces organisms with genetic information from both parents.
  - occurs in most animals and plants and in many single-celled organisms.
  - increases genetic diversity, which aids species survival in changing environments.

Limits to Cell Size

For Questions 1–4, write True if the statement is true. If the statement is false, change the underlined word or words to make the statement true.

_____ **1.** As a cell's size increases, its amount of DNA <u>also increases</u>.

_____ **2.** The amount of activity in a cell is related to its <u>volume</u>.

_____ **3.** The smaller the cell, the <u>smaller</u> its ratio of surface area to volume.

_____ **4.** The <u>information crisis</u> in a cell is solved by the replication of the DNA before cell division

5. In the visual analogy of the growing town, what does the library represent? Identify two characteristics that make it a good choice for this analogy.

Cell Division and Reproduction

For Questions 6–8, complete each statement by writing the correct word or words.

6. _____ is the formation of new individuals.

7. For single-celled organisms, cell division is a form of _____ reproduction.

8. Most multicellular organisms reproduce by _____ reproduction.

9. Use the table to compare and contrast asexual and sexual reproduction.

Asexual and Sexual Reproduction	
Similarities	**Differences**

10. Vascular tissue helps plants transport water against the force of gravity. Because of this, plants that lack vascular tissue do not grow very tall. How is this situation similar to the information you have learned in this lesson? Explain.

10.2 The Process of Cell Division

Lesson Objectives

- Describe the role of chromosomes in cell division.
- Name the main events of the cell cycle.
- Describe what happens during the four phases of mitosis.
- Describe the process of cytokinesis.

Lesson Summary

Chromosomes Packages of DNA called **chromosomes** hold a cell's genetic information.

- Prokaryotic chromosomes consist of a single, circular strand of DNA.
- Eukaryotic chromosomes are highly organized structures.
  - The DNA winds around histone proteins, forming **chromatin.**
  - Chromosomes make the precise separation of DNA possible during cell division.

The Cell Cycle The **cell cycle** is the series of events in the growth and division of a cell.

- In the prokaryotic cell cycle, the cell grows, duplicates its DNA, and divides by pinching in the cell membrane.
- The eukaryotic cell cycle has four stages (the first three of which are referred to as **interphase**):
  - In the G_1 phase, the cell grows.
  - In the S phase, the cell replicates its DNA.
  - In the G_2 phase, the cell produces organelles and materials for division.
  - In the M phase, the cell divides in two stages—**mitosis**, the division of the nucleus, and **cytokinesis**, the division of the cytoplasm.

Mitosis The division of the nucleus, mitosis, occurs in four stages:

- **Prophase :** a cell's genetic material condenses, a spindle starts to form, and the nuclear envelope breaks down.
- **Metaphase :** the duplicated chromosomes line up and spindle fibers connect to the **centromeres**.
- **Anaphase :** sister **chromatids** separate and move toward the **centrioles**.
- **Telophase :** the chromosomes begin to unwind and a nuclear envelope reforms.

Cytokinesis Division of the cytoplasm differs in plant cells and animal cells.

- In animal cells, the cell membrane draws in and pinches off.
- In plant cells, a cell plate forms, followed by a new cell membrane, and finally a new cell wall forms.

Chromosomes

For Questions 1–5, complete each statement by writing the correct word or words.

1. Cells carry genetic information in packages of DNA called _____.

2. Most _____ have only one circular strand of DNA.

3. In eukaryotic cells, the genetic structure consists of DNA and a tightly wound protein, which together form a substance called _____.

4. The bead-like structures formed by DNA wrapped around _____ molecules are called nucleosomes.

5. _____ make possible the precise separation of DNA during cell division.

The Cell Cycle

6. What is the name of the type of cell division that occurs in the prokaryotic cell cycle?

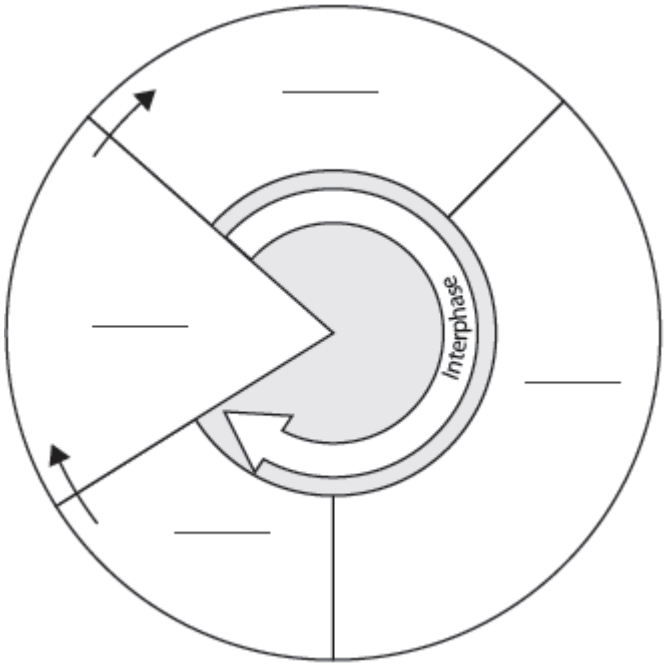
_____

7. What happens during interphase?

_____

_____

8. Complete the cell cycle diagram by writing the correct name of a phase on each line.



9. In eukaryotic cells, what happens in the G_1 phase that differs from the G_2 phase?

_____

10. In eukaryotic cells, what are the two main stages of cell division?

Mitosis

11. During prophase, when cell chromosomes become visible, what are the duplicated strands of DNA called? What is the name for the area in which these duplicated strands are joined?

_____

_____

12. What structures are spindle fibers attached to that help pull the paired chromosomes apart?

_____

_____

For Questions 13–16, match the description of the event with the phase of mitosis in which it occurs. Each phase may be used more than once

Event

_____ **13.** The chromosomes separate and begin to move to opposite sides of the cell.

_____ **14.** The chromosomes become visible. The centrioles take up positions on opposite sides of the nucleus.

_____ **15.** A nuclear envelope re-forms around each cluster of chromosomes. The nucleolus becomes visible in each daughter nucleus.

_____ **16.** The chromosomes line up across the center of the cell.

Phase of Mitosis

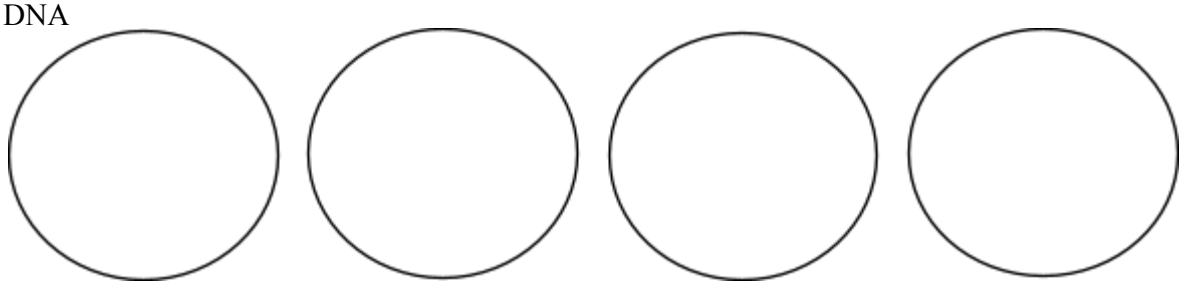
A. Telophase

B. Prophase

C. Metaphase

D. Anaphase

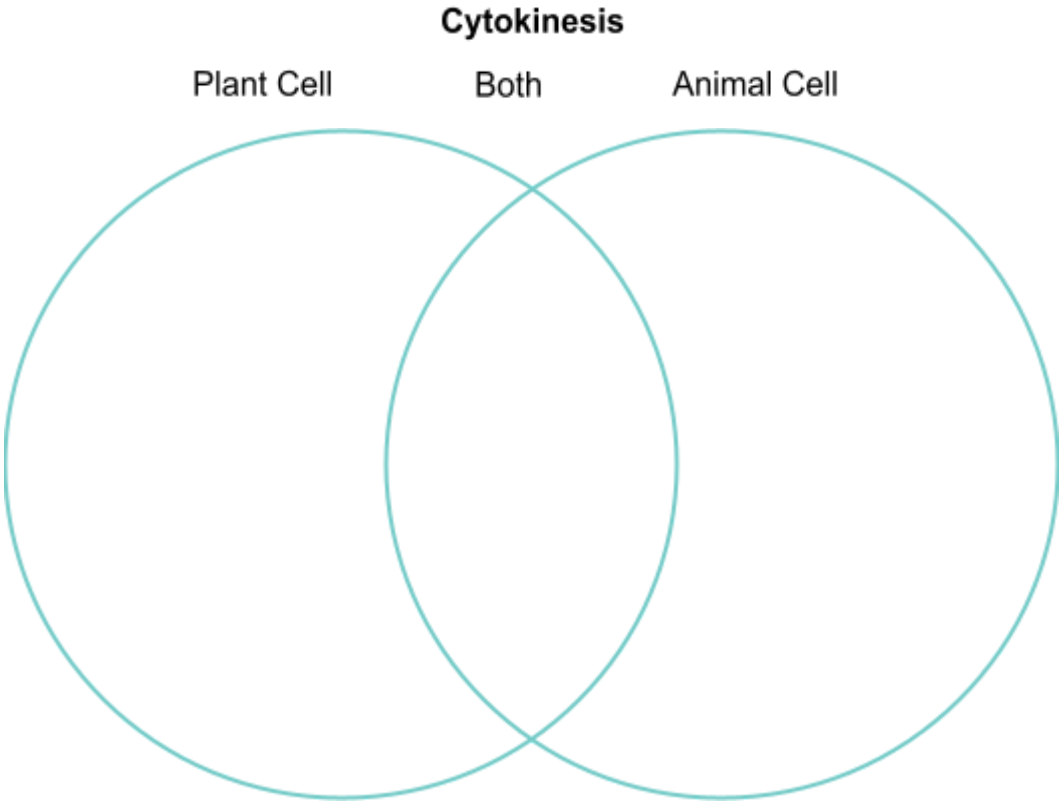
17. The four circles below represent the nucleus of a cell going through mitosis. Draw four chromosomes as they go through each phase. Label each phase and describe what is happening to the DNA



Cytokinesis

18. What is cytokinesis?

19. Use the Venn diagram to compare and contrast cytokinesis in animal cells with cytokinesis in plant cells.



20. During certain stages of their life cycle, some cells repeatedly undergo mitosis but do not undergo cytokinesis. What would you expect to see if you looked at such cells, or a tissue made up of such cells, under a microscope? Explain your answer.

Edpuzzle: Cell Division

1. True or False: Mitosis is the process of cell growth and division. This is responsible for repairing damage.

2. We have to make more _____ to repair ourselves.

3. Which one of these produces body cells?

4. True or False: Mitosis makes identical cells.

5. Mitosis accounts for _____ of the cell cycle.

6. What are the condensed units of DNA?

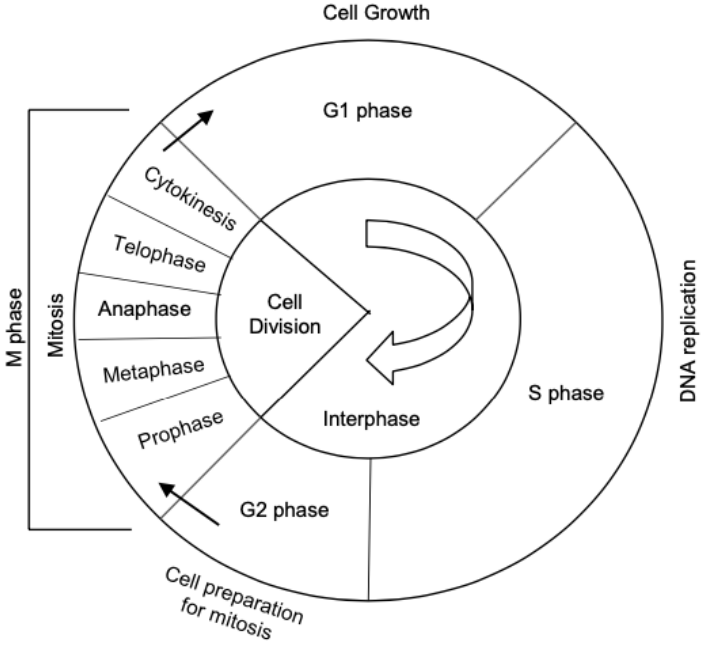
7. Draw an illustration of a chromosome.

8. How many stages of mitosis are there?

9. What does each stage of mitosis stand for?

10. What is an easy way to remember the order of Mitosis?

THE CELL CYCLE & MITOSIS



The Cell Cycle is _____

_____

During the Cell Cycle, a cell

_____

_____

_____

_____

Interphase is _____

_____

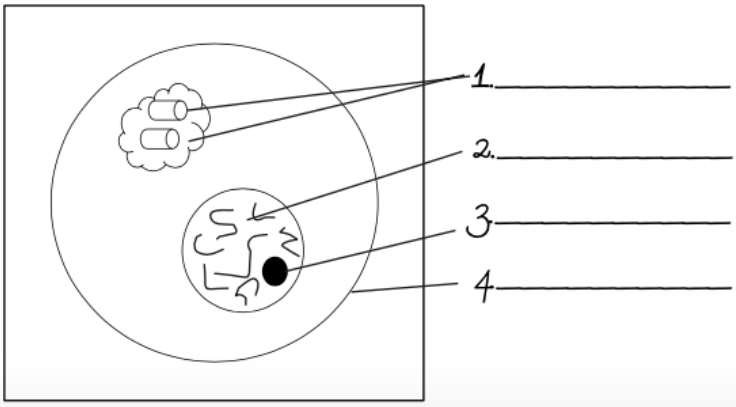
Interphase is divided into three phases: ____, ____, & ____

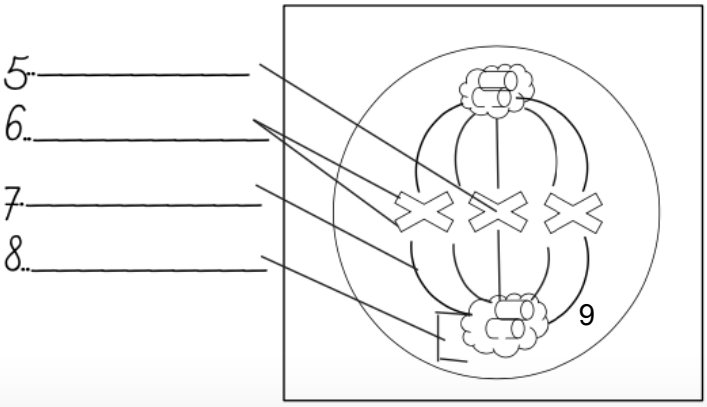
G_1 Phase	S Phase	G_2 Phase
The G_1 phase is a period of activity in which cells _____ _____ _____ Cells will _____ and synthesize new _____ _____ _____	The S phase replicates _____ and synthesizes _____ molecules. When DNA replication is completed, _____ _____ _____ _____	During the G_2 phase, many of the organelles and molecules required for _____ _____ When G_2 is completed, the cell is ready to enter the _____

Mitosis are divided into four phases: _____, _____, _____, & _____

Below are cells in two different phases of the cell cycle, fill in the blanks using the word bank:

Chromatin, Nucleolus, Nuclear Envelope, Spinder Fiber, Chromosome, Centrosome, Sister Chromatids, Centrioles





THE CELL CYCLE & MITOSIS

MICROSCOPE LAB: INTERPHASE, MITOSIS, & CYTOKINESIS

Directions: Look under the microscope slides and draw what you see

Interphase

Interphase is divided into three phases:

_____, _____, & _____

Interphase is the in between stages of cell division.

Prophase

- _____
- _____
- _____
- _____

Metaphase

- _____
- _____

Anaphase

- _____

Telophase

- _____
- _____

Cytokinesis

- _____
- _____

CELL DIVISION EDITION

Welcome teams! *Today you will get to compete in a Biology Minute to Win It competition. Each member of your team must participate in at least one game, so read the descriptions below and choose wisely!*

PHASE PAINTER: **One** member of your team must draw a given phase of mitosis on the chalkboard/whiteboard. The team that draws the phase and labels the parts the fastest wins!

ORDER MASTER: **One** member of your team must stack cups with the phases of the cell cycle in order without using his or her hands. The team to stack the cups in the correct order the fastest wins!

ID EXPERT: **One** member of your team must match pictures of the phases of mitosis to its title and description. The team to make the correct matches the fastest wins!

BUZZWORD: This game requires **two** team members. One team member will be given a vocabulary word to describe, *without using the word itself!* The other team member must try to guess the word. The team that correctly identifies the most words in one minute wins!

MODEL SCRAMBLE: **One** member of your team must put the mitosis models in order as quickly as possible. The team that puts the models in the correct order the fastest wins!

FACT OR GARBAGE: **One** member of your team must read statements written on balled up pieces of paper. If the statements are true, the paper ball is kept. If it is false, the ball is tossed into the trash. The team with the most correct statements OR trashed facts at the end of a minute wins!

Oreo Mitosis Modeling

Purpose: To model the phases of Mitosis

Material:
6 Oreo Cookies (per group)
2 Tablespoons assorted color rod-shaped candy sprinkles
Toothpicks
Paper Towels

Procedure:
Wash Hands before & after experiment

1) Using your textbook or Cell Cycle notes, find images of the cell cycle that include: **Interphase**, **Mitosis** (**Prophase, Metaphase, Anaphase** and **Telophase**) and **Cytokinesis**.

2) Using the images you found, you will create a model for each stage of the cell cycle listed above.

4) Carefully remove the top cookie from all six cookies by twisting the top cookie in a circular motion while holding the bottom cookie with your other hand. The bottom cookie with the cream filling attached will be used for your models. Lay aside the top of the cookie (you can eat it **later**).

5) The cream filling represents the Cytoplasm of the cell. You must create the structures inside the cell that play a role in the Cell Cycle using candy sprinkles.

6) The toothpicks may be used to remove or divide the Cytoplasm or to move around the sprinkles.

7) Once you have created a model for each stage of the Cell Cycle, summarize what is happening in each stage in the table below.

Summary- Illustrate and explain each phase
Interphase:

Prophase:

Metaphase:

Anaphase:

Telophase:

Cytokinesis:

8) Once you have modeled each stage and summarized the key events, have your teacher check your models and summary.

9) After your teacher checks over your model and summaries, you and your group may consume what remains of your Oreo cookie models.

10) Clean-up: Discard all materials from your lab. Wipe off all surfaces to remove crumbs.

Analysis/Conclusions:

1. During what phase do the sister chromatids move to opposite sides of the cell?

2. During what phase does the nuclear membrane reappear around the new chromosome set?

3. When is the DNA/chromosomes copied?

4. What are the spindle fibers attached to?

5. What is chromatin?

6. Draw and label a chromosome with the sister chromatids and the centromere.

Lesson Review Questions

Lesson 10.1: Cell Growth, Division and Reproduction

1. _____
2. _____
3. _____
4. _____
5. _____

Lesson 10.2: The Process of Cell Division

1. _____
2. _____
3. _____
4. _____
5. _____

Cell Cycle Quiz Review

Terms to Know - Cell Cycle

Asexual Reproduction	Sexual Reproduction	Chromosomes	Chromatin
Interphase	Mitosis	Cytokinesis	Prophase
Metaphase	Anaphase	Telophase	Centromere
Chromatids	Centrioles	Spindle Fibers	

Cell Division

- What are the two main reasons for cells dividing?
- Compare Asexual Reproduction vs. Sexual Reproduction
- Compare Eukaryotic chromosomes vs. Prokaryotic chromosomes
- What are the three stages of Interphase?
    - What happens during each stage?
- What are the four stages of Mitosis?
    - What happens during each stage?
- How is cell division different in animal cells vs plant cells?
- What stage of cell division takes the longest?
- Be able to identify different stages of mitosis by pictures
- What is the final result of the cell cycle?
- Be able to identify all of the components of the cell during division

Ag Biology

Semester 2

Chapter 11 Workbook: Genetics

Name: _____ Date: _____

Class Period: _____ Teacher: _____

Table of Contents

Chapter 11: Genetics

11.1 The Work of Gregor Mendel

Lesson Objectives

- Describe Mendel's studies and conclusions about inheritance.
- Describe what happens during segregation.

Lesson Summary

The Experiments of Gregor Mendel

The delivery of characteristics from parents to offspring is heredity. The scientific study of heredity is **genetics**. Gregor Mendel founded modern genetics with his experiments on a convenient model system, pea plants:

- **Fertilization** is the process in which reproductive cells (egg from the female and sperm from the male) join to produce a new cell.
- A **trait** is a specific characteristic, such as (in peas) seed color or plant height.
- Mendel prevented self-pollination in the peas. He controlled fertilization so he could study how traits passed from one generation to the next.
- He created **hybrids**, which are crosses between true-breeding parents (the P generation) with different traits.
  - These hybrids were the F_1 (first filial) generation.
  - They each showed the characteristic of only one parent.
- Mendel found that traits are controlled by factors that pass from parent to offspring. Those factors are **genes**. The different forms of a gene are **alleles.**
- Mendel's **principle of dominance** states that some alleles are dominant and others are recessive. The recessive allele is exhibited only when the dominant allele is not present.

Segregation

Mendel allowed members of the F_1 generation to self-pollinate. The trait controlled by the recessive allele appeared in the next generation (F_2) in about one-fourth of the offspring—even when it did not appear in the F_1 generation.

- Separation of alleles is **segregation.**
- When **gametes** (sex cells) form, alleles segregate so that each gamete carries only one allele for each gene.
- The F_2 generation gets a new combination of alleles: one from each parent.

The Experiments of Gregor Mendel

Match the term with its definition.

Term		Definition
_____ **1.**	genes	**A.** Specific characteristics that vary among individuals
_____ **2.**	hybrids	**B.** The offspring of true-breeding parents with different traits
_____ **3.**	traits	**C.** Factors that determine traits
_____ **4.**	alleles	**D.** Sex cells, egg or sperm
_____ **5.**	gametes	**E.** The different forms of a gene

6. Why are peas a good model system for studying heredity?

7. How did Mendel cross-pollinate flowers?

8. What is the difference between a gene and an allele?

9. State the principle of dominance.

The table shows some crosses between true-breeding parents that carry pairs of dominant alleles (such as SS) or pairs of recessive alleles (such as ss). Complete the table to show the combination of alleles in the offspring. Then use it to answer Questions 10–11.

Dominant and Recessive Forms of Pea Plant Traits

Trait	Parent Plants (P Generation)			Offspring (F_1 Generation)
Seed Color	Yellow *YY* 	X	Green *yy* 	Yellow *Yy* 
Seed Coat Color	White *gg* 	X	Gray *GG* 	Gray _____ 
Pod Shape	Constricted *ss* 	X	Smooth *SS* 	Smooth _____ 
Pod Color	Green *CC* 	X	Yellow *cc* 	Green _____ 

10. What is the dominant shape of a pea pod? How do you know?

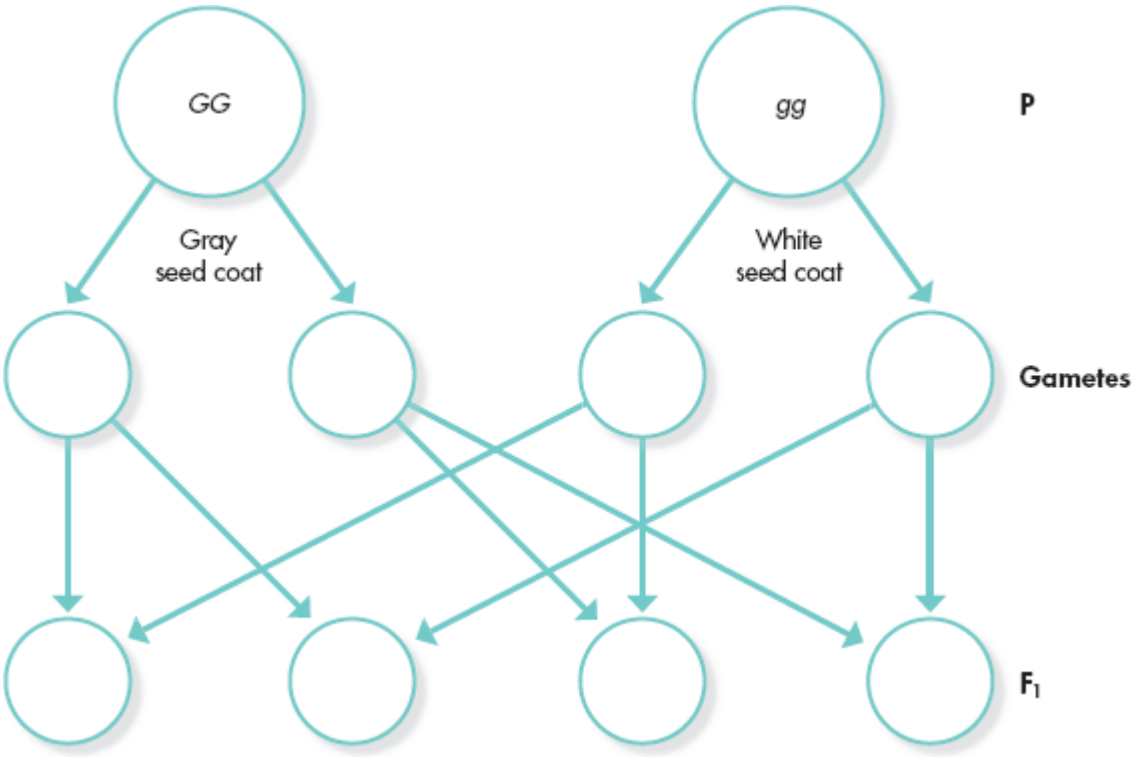
11. What symbol represents the recessive allele for pod color?

Segregation

12. What is segregation? What is the result of segregation?

13. The capital letter *G* represents the allele in peas that causes the dominant trait, gray seed coat. The lower-case letter *g* represents the recessive allele that causes the recessive trait, white seed coat.

In the circles, show the alleles in the gametes of the parent generation. Show how the alleles recombine in the F_1 plants.



14. A black cat and a white cat have four black kittens in the F_1 generation. In the F_2 generation, there are three black kittens and one white kitten. Explain how the F_2 generation proves that genetic information passes unchanged from one generation to the next, even when a specific trait is not exhibited.

11.2 Applying Mendel's Principles

Lesson Objectives

- Explain how geneticists use the principles of probability to make Punnett squares.
- Explain the principle of independent assortment.
- Explain how Mendel's principles apply to all organisms.

Lesson Summary

Probability and Punnett Squares

Probability is the likelihood that a particular event will occur. Probability predicts the recombination of alleles:

- Of an allele pair, the probability of each allele in a gamete is ½, or 50 percent.
- When F_1 hybrid individuals are crossed, the probability of
  - two recessive alleles is ¼.
  - two dominant alleles is ¼.
  - one dominant allele and one recessive allele is ½ (¼ + ¼).
- Organisms that have two identical alleles for a gene are **homozygous** for that trait. If they have different alleles for the same gene, they are **heterozygous** for that trait.
- Physical traits are an organism's **phenotype**. Its **genotype** is its genetic makeup.
- A **Punnett square** is a mathematical tool that helps predict combinations in genetic crosses.

Independent Assortment

The principle of **independent assortment** states that genes for different traits segregate independently during the formation of gametes. In two-factor crosses, the phenotypes of the F_2 offspring occur in a 9:3:3:1 ratio: 9 with with both traits dominant, 3 with the first trait dominant and the second trait recessive, 3 with the first trait recessive and the second trait dominant, and 1 with both traits recessive.

A Summary of Mendel's Principles

- Genes are passed on from parents and determine traits.
- Where two or more alleles for a gene exist, some may be dominant and others recessive.
- In sexually reproducing organisms, offspring receive a copy of each gene from each parent. The alleles segregate when forming gametes.
- Alleles for different genes usually segregate independently.

Probability and Punnett Squares

1. What is probability?_____

_____

2. In a parent pea plant with the allele pair *Gg*, what is the probability that one gamete will contain the *G* allele?_____

3. Complete the graphic organizer to define the characteristics of homozygous and heterozygous genotypes and phenotypes.

	Homozygous	**Heterozygous**
Genotype		
Phenotype		

4. The dominant allele for smooth pod shape in peas is *S*. The recessive allele for constricted pod shape is *s*. In the Punnett square, show the result of crossing two heterozygous parents (*Ss*). Write the genotype and the phenotype of each type of offspring in the space provided.

	S	**s**
S	Genotype:_____ Phenotype:_____	Genotype:_____ Phenotype:_____
s	Genotype:_____ Phenotype:_____	Genotype:_____ Phenotype:_____

For Questions 5–9, refer to the Punnett square above.

5. What is the probability of a heterozygous offspring? Explain your answer.

_____

_____

6. What is the probability of a homozygous offspring? Explain.

_____

7. What is the probability of a homozygous recessive offspring?

_____

8. What is the probability of a smooth phenotype?

_____

9. What is the probability of a homozygous recessive individual (*ss*) producing a gamete with a dominant allele (*S*)? Explain.

_____

_____

Independent Assortment

10. State the principle of independent assortment below.

_____

11. Using the principle of independent assortment, complete the Punnett square to show the results of an F_1 cross between two individuals heterozygous for both pod color (*C* = green and *c* = yellow) and pod shape (*S* = smooth and *s* + constricted). The gametes and some of the genotypes of the F_2 offspring are given.

	CS	**cS**	**Cs**	**cs**
CS	CCSS			
cS				ccSs
Cs			CCss	
cs		ccSs		

For Questions 12–15, refer to the Punnett square above.

12. Which genotype belongs to an offspring that is homozygous recessive for both traits? What is the probability of that genotype?

_____

13. What is the phenotype of an individual heterozygous for both traits?

_____

14. What is the probability of an F_2 offspring having the green pod color and smooth pod shape? Explain. (Note: Remember that more than one genotype can produce this phenotype.)

_____

_____

15. The Punnett square predicts a 9:3:3:1 ratio for phenotypes. Explain what that ratio means.

_____

_____

_____

_____

_____

_____

Summary of Mendel's Principles

For Questions 16–20, complete each statement by writing the correct word or words

16. The units that determine the inheritance of biological characteristics are _____.

17. A form of a gene is a(n)_____.

18. If two or more forms of a gene exist, some may be dominant and others may be_____.

19. The offspring of most sexually reproducing organisms have two copies of each gene. One came from each_____.

20. Alleles from different genes usually_____independently from each other when gametes form.

For Questions 21–25, match the term with its description.

_____**21.**Determine traits	**A.**parents
_____**22.**Can be two of these in one gene	**B.**alleles
_____**23.**Allele that is expressed	**C.**dominant
_____**24.**Where genes come from	**D.**segregate
_____**25.**What genes do during gamete formation	**E**.genes

26. Explain the importance of Thomas Hunt Morgan's experiments with fruit flies. Why was his work an important addition to Mendel's research?

_____

_____

27. Four sisters begin attending your school. One has brown hair and brown eyes. Another has brown hair and blue eyes. The third also has blue eyes, but blond hair. The fourth has blond hair, too, but she has brown eyes. Explain how the principle of independent segregation accounts for these sisters having four different phenotypes for two traits.

_____

_____

_____

_____

11.3 Other Patterns of Inheritance

Lesson Objectives

- Describe the other patterns of inheritance.
- Explain the relationship between genes and the environment.

Lesson Summary

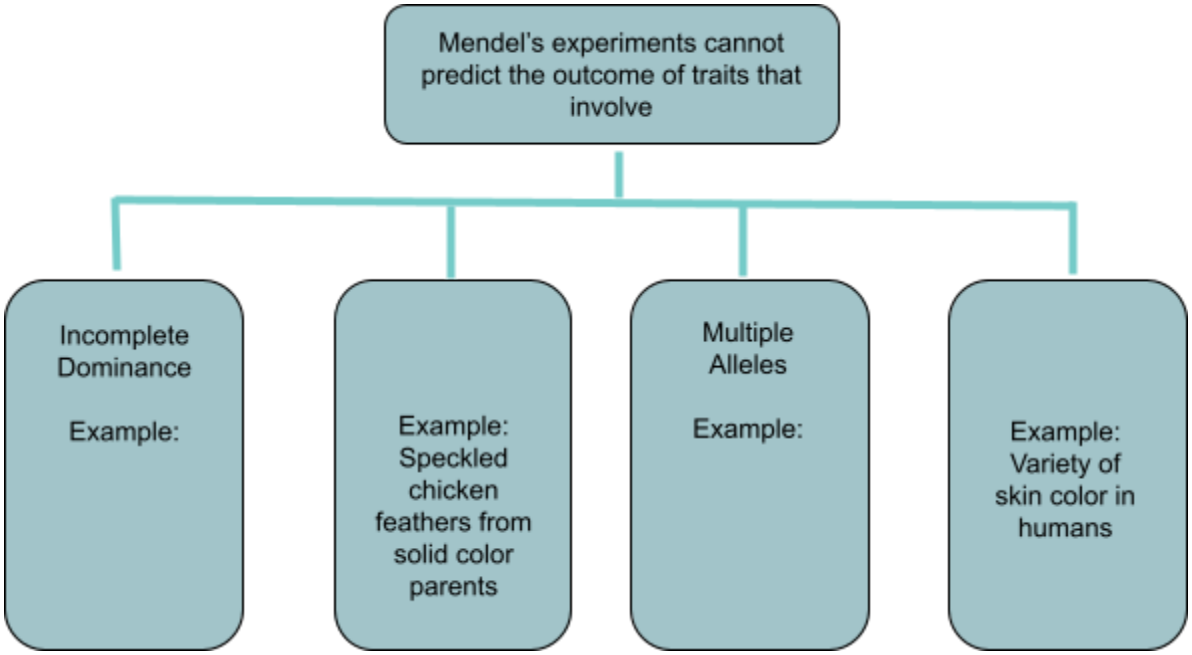
Beyond Dominant and Recessive Alleles Some alleles are neither dominant nor recessive:

- In cases of **incomplete dominance**, neither allele is completely dominant over the other.The phenotype is a blend of the two homozygous phenotypes.
- In cases of **codominance**, both alleles in the heterozygous genotype are expressed in the phenotypes.
- Genes with **multiple alleles** have more than two forms of the same gene. There may be more than one dominant form and several different phenotypes.
- **Polygenic traits** are controlled by the interaction of two or more genes and exhibit a wide range of phenotypes.

Genes and the Environment The phenotype of an organism results only partly from its genotype. Environmental conditions can affect how genes are expressed.

Beyond Dominant and Recessive Alleles

1. Complete the graphic organizer to summarize exceptions to Mendel's principle.



For Questions 2–8, write True if the statement is true. If the statement is false, change the underlined word to make the statement true.

_____ **2.** When offspring show a blend of the parents' traits, <u>one</u> allele is dominant over the other.

_____ **3.** In <u>complete</u> dominance, the heterozygous phenotype lies somewhere between the two homozygous phenotypes.

_____ **4.** A heterozygous individual that exhibits the traits of both parents is an example of <u>codominance</u>.

_____ **5.** Many genes exist in several forms and are said to have codominant alleles.

_____ **6.** While multiple alleles may exist in a population, an individual usually carries only two alleles for each <u>gene</u>.

_____ **7.** Traits produced by two or more genes are <u>codominant</u>.

_____ **8.** Polygenic traits often show a wide range of <u>phenotypes</u>.

9. A plant breeder produced a purple flower by crossing a red parent with a blue parent. Use *RR* as the genotype for the red parent and *BB* for the blue parent. Complete the Punnett Square to show the resulting genotypes and phenotypes of the offspring.

	Gamete allele: _____	**Gamete allele:** _____
Gamete allele: _____	Genotype:_____ Phenotype:_____	Genotype:_____ Phenotype:_____
Gamete allele: _____	Genotype:_____ Phenotype:_____	Genotype:_____ Phenotype:_____

For Questions 10–11, refer to the Punnett square above.

10. What type of inheritance is the example in Question 9?

_____

11. If the offspring had been red and blue spotted flowers, what kind of inheritance would be most likely?

_____

12. Explain the difference between multiple alleles and polygenic traits.

_____

_____

_____

Genes and the Environment

For Questions 13–16, complete each statement by writing in the correct word or words.

13. An organism's _____ results from its genotype and its environment.

14. Some _____ produce variable traits depending on environmental conditions.

15. Western white butterflies vary in their wing color because their _____ varies depending on when they hatch.

16. _____ is an environmental variable that affects wing color in western white butterflies.

For each of the following examples, write G if the trait is determined by genotype, and E if it is determined by environment.

17. _____ Turtles whose eggs hatch at higher temperatures tend to be female.

18. _____ A blue-eyed girl is born to two blue-eyed parents.

19. _____ Bees in a colony are assigned different jobs. As they develop, workers begin to look dramatically different.

20. _____ A pair of twins is separated at birth. They grow up in different countries and speak different languages.

21. _____ A litter of puppies is born. They are all gray except one, which is brown.

22. _____ Tall pea plant seeds are planted in different locations around a yard. They Produce plants of different heights.

23. _____ A kitten is born with six toes.

24. _____ A rabbit is born weak with hunger.

25. A dog gave birth to four puppies. The father has brown eyes, and the mother has green eyes. Two puppies have brown eyes. One has green eyes. One puppy has blue eyes. What Does this tell you about how the cellular information for eye color is passed on? Explain.

_____

_____

_____

_____

_____

11.4 Meiosis

Lesson Objectives

- Contrast the number of chromosomes in body cells and in gametes.
- Summarize the events of meiosis.
- Contrast meiosis and mitosis.
- Describe how alleles from different genes can be inherited together.

Lesson Summary

Chromosome Number

Homologous chromosomes are pairs of chromosomes that correspond in body cells. One chromosome from each pair comes from each parent.

- A cell that contains both sets of homologous chromosomes has a **diploid** number of chromosomes (meaning "two sets").
- **Haploid** cells contain only one set of chromosomes. Gametes are haploid.

Phases of Meiosis

Meiosis is the process that separates homologous pairs of chromosomes in a diploid cell, forming a haploid gamete. The phases are as follows:

- Meiosis I, which is preceded by a replication of chromosomes. Its stages are
  - Prophase I: Each replicated chromosome pairs with its corresponding homologous chromosome forming a **tetrad.** During tetrad formation, alleles can be exchanged between chromatids, a process called **crossing-over.**
  - Metaphase I: Paired homologous chromosomes line up across the center of the cell.
  - Anaphase I: Spindle fibers pull each homologous pair toward opposite ends of the cell.
  - Telophase I: A nuclear membrane forms around each cluster of chromosomes. Cytokinesis then occurs, resulting in two new cells. The resulting daughter cells contain chromosome sets that are different from each other and the parent cell.
- Meiosis II: Chromosomes do not replicate.
  - Prophase II: Chromosomes, each consisting of two chromatids, become visible.
  - Metaphase II, Anaphase II, Telophase II, and Cytokinesis: These phases are similar to meiosis I. Four haploid cells form. They are the gametes. During fertilization, two gametes unite forming a **zygote.**

Comparing Meiosis and Mitosis

- Mitosis is one cell division that results in two genetically identical diploid cells.
- Meiosis is two cell divisions that result in four genetically different haploid cells.

Gene Linkage and Gene Maps

- Alleles tend to be inherited together if they are located on the same chromosome.
- Chromosomes, not genes, segregate independently.
- The farther apart genes are on a chromosome, the more likely it is crossover.
- Information on linkage and the frequency of crossing-over lets geneticists construct maps of the locations of genes on chromosomes.

Chromosome Number

For Questions 1–8, write True if the statement is true. If the statement is false, change the underlined word to make the statement true.

_____ **1.** The offspring of two parents obtains a single copy of every gene from each parent.

_____ **2.** A gamete must contain one complete set of genes.

_____ **3.** Genes are located at specific positions on spindles.

_____ **4.** A pair of corresponding chromosomes is homozygous.

_____ **5.** One member of each homologous chromosome pair comes from each gene.

_____ **6.** A cell that contains both sets of homologous chromosomes is haploid.

_____ **7.** The gametes of sexually reproducing organisms are haploid.

_____ **8.** If an organism's haploid number is 6, its diploid number is 3.

Phases of Meiosis

On the lines provided, identify the stage of meiosis I or meiosis II in which the event described occurs.

_____ **9.** Each replicated chromosome pairs with its corresponding homologous chromosome.

_____ **10.** Crossing-over occurs between tetrads.

_____ **11.** Paired homologous chromosomes line up across the center of the cell.

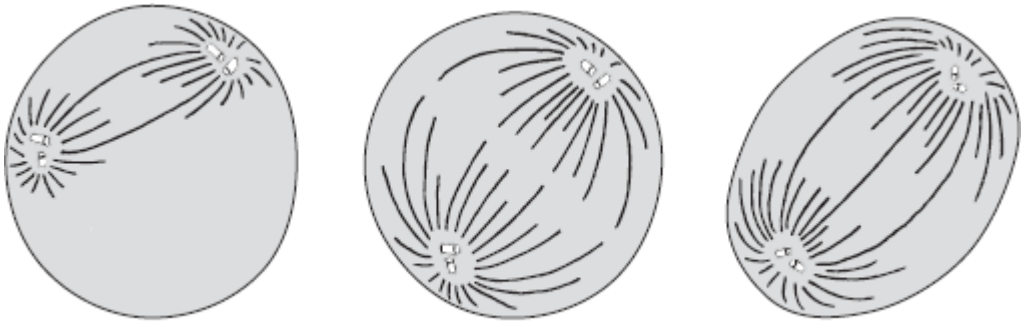
_____ **12.** Spindle fibers pull each homologous chromosome pair toward an opposite end of the cell.

_____ **13.** A nuclear membrane forms around each cluster of chromosomes and cytokinesis follows, forming two new cells.

_____ **14.** Chromosomes consist of two chromatids, but they do not pair to form tetrads.

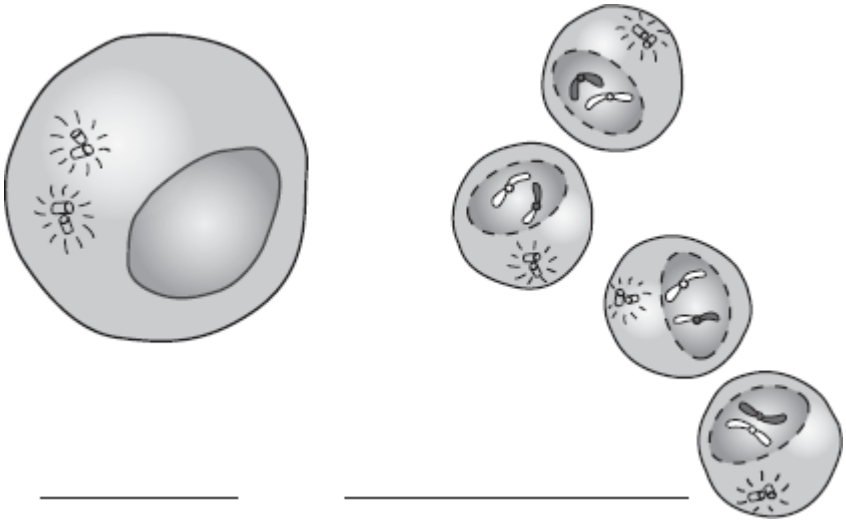
_____ **15.** A nuclear membrane forms around each cluster of chromosomes and cytokinesis follows, forming four new cells.

16. Draw two homologous pairs of chromosomes (in different colors if you have them) in these diagrams to illustrate what happens during these three phases of meiosis.



Prophase I Metaphase I Anaphase II

17. Identify which phase of meiosis is shown in the diagrams below.



_____ _____

Use this diagram to answer Questions 18–20.

18. What does the diagram show?

_____

_____

19. During what phase of meiosis does this process occur?

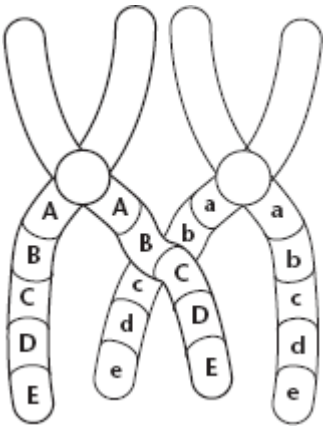
_____

_____

20. What is the result of this process?

_____

_____



Comparing Meiosis and Mitosis

21. Complete the table to compare meiosis and mitosis.

	Mitosis	**Meiosis**
Form of reproduction		
Number of daughter cells		
Change in chromosome number		
Number of cell divisions		
Difference in alleles between parent cell and daughter cells		

For Questions 22–27, complete each statement by writing the correct word or words.

22. A diploid cell that enters mitosis with 16 chromosomes will divide to produce _____ daughter cells. Each of these daughter cells will have _____ chromosomes.

23. If the diploid number of chromosomes for an organism is 16, each daughter cell after mitosis will contain _____ chromosomes.

24. A diploid cell that enters meiosis with 16 chromosomes will pass through _____ cell divisions, producing _____ daughter cells, each with _____ chromosomes.

25. Gametes have a _____ number of chromosomes.

26. If an organism's haploid number is 5, its diploid number is _____.

27. While a haploid number of chromosomes may be even or odd, a diploid number is always _____.

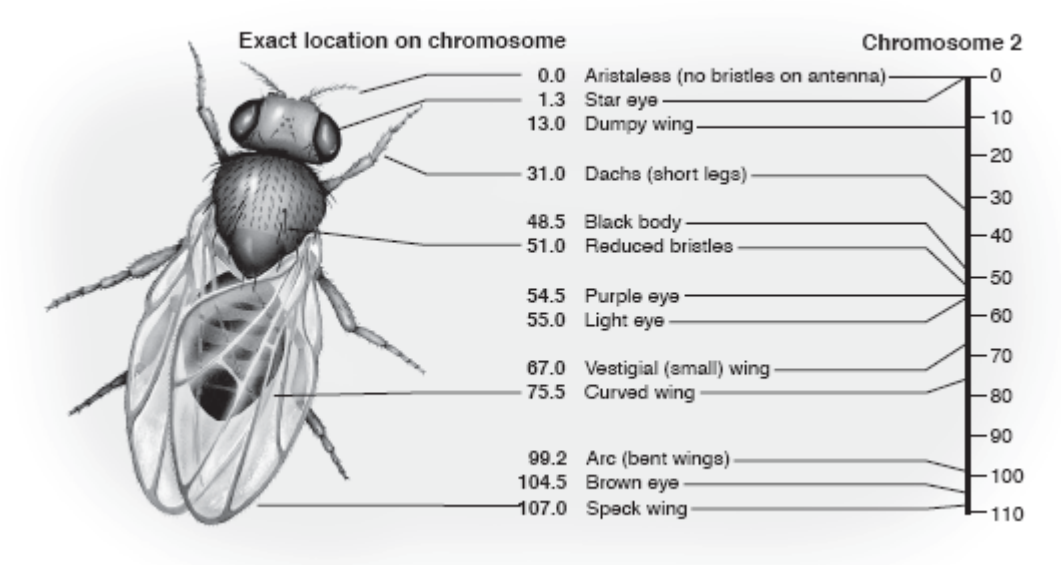
Gene Linkage and Gene Maps

28. What did Thomas Hunt Morgan discover that seemed to violate Mendel's principles?

29. How did Morgan explain his finding?

30. How did Alfred Sturtevant use gene linkage to create gene maps?

Use this diagram to answer Questions 31–34.



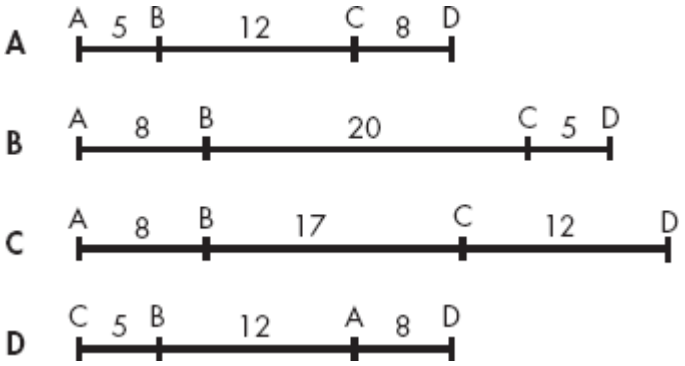
31. What does the diagram show?

32. How was the information in this diagram gathered?

33. Which pairs of characteristics are more likely to cross over: curved wing and dumpy wing; or curved wing and vestigial (small) wing? Why?

34. Which pair of genes shown is least likely to cross over? How do you know?

Use this diagram to answer Questions 35–38.



35. In which gene map is the probability of crossing-over between A and D greatest? _____

36. In which gene map is the probability of crossing-over between A and D the least? _____

37. In which map are genes C and D most closely linked? _____

38. In map D, which genes are least likely to cross over? _____

39. Some housecats have orange fur with darker orange stripes. The traits of these *tabby* cats are usually seen in male cats. *Tortoiseshell* cats have patches of many different colors. "Torties," as they are called, are almost always female. What does this tell you about the way cellular information about color and sex are passed on in cats?

_____

_____

_____

_____

Edpuzzle: Genetics

1. True or False: Traits are physical characteristics that offspring inherit from both parents.

2. Where is DNA found in the cell?

3. Where do you get your DNA?

4. Which of the following is NOT a trait controlled by DNA?

5. What does DNA stand for?

6. DNA is made up of repeating units called _____.

7. What holds the bases together in the middle of the DNA strand?

8. Genes code for the production of _____ which can control traits.

Edpuzzle: Meiosis

1. What is Mitosis NOT used for?

2. Fruit fly body cells have six chromosomes. How many chromosomes do fruit fly egg cells have?

3. How many chromosomes are in a human cell about to start Meiosis?

4. How many chromatids are in a human cell about to start Meiosis?

5. How many times does a cell divide during Meiosis?

6. How many times does a cell divide during Mitosis?

7. True or False: During Prophase 1 chromosomes condense, thicken, and line up with their homologous pairs.

8. During Metaphase…

9. What separates the chromosomes during Anaphase 1?

10. Circle the answer: Are the cells after Meiosis 1 haploid or diploid?

11. What was separated after Meiosis 1?

12. True or False: Crossing over occurs in Prophase II.

13. During Anaphase II what is separated?

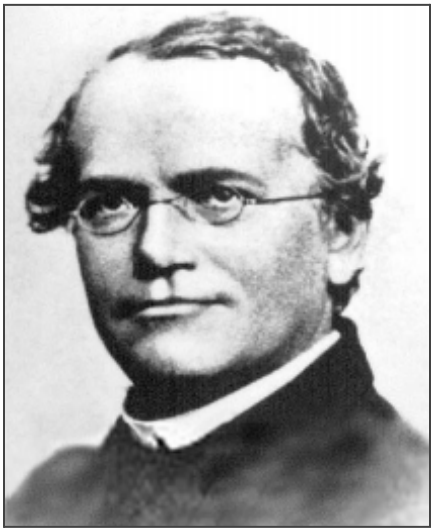
14. The cells produced during Meiosis II are…

15. What separates during Meiosis II?

WHO WAS GREGOR MENDEL?

Gregor Mendel is one of the most influential contributors to what we now know about genetics. Let's check out how he got there...

Early life



Gregor Mendel was born in 1822, in Heinzendorf, Austria. Growing up was a hardship; his parents were farmers and did not have a lot of money. Mendel decided to join a monastery in order to find a better life for himself, though he never forgot the farming skills his parents taught him.

Mendel attended the University of Vienna to acquire an education. It was there that Mendel was introduced to a biologist by the name of Frank Unger. Mendel was impressed with Unger because he had a practical view of inheritance. This sparked Mendel's curiosity. Mendel, growing up on a farm, had a background in botany and wanted to experiment using plants. It took about two years until Mendel finally began experimenting with variation, heredity and evolution in plants. He chose to study in detail the common garden pea, which he grew in the monastery garden.

1. **What did Mendel's parents do when he was growing up?**

2. **Where did Mendel go to try to find a better life for himself?**

3. **What type of plants did Mendel use in his experiments?**

Mendel's experiments

Between 1856 and 1863 Mendel grew, cared for, and tested nearly 30,000 pea plants. In doing this, he paid special attention to seven traits such as: shape of seed, color of seed, tall stemmed and short stemmed plants, flower color, pod shape and pod color.

Mendel worked on this for several years, carefully self-pollinating the pea plants, as well as covering each individual plant to prevent accidental pollination by insects. Mendel collected the seeds produced by the plants and studied the offspring of these seeds by observing that some plants bred true and others not. For example, Mendel discovered that by **crossing** tall and short parent plants he got offspring that resembled the tall parent rather than a medium height offspring. Rather than their traits mixing together, Mendel noticed that one trait was more powerful than

the other, he called this the **dominant** version of the trait (dominant allele). The **recessive** version of the trait (recessive allele) was the one that was overpowered (masked) by the dominant trait. Mendel's work made way for present day genetics. The patterns of inheritance of various traits that he discovered lead to the laws of heredity.

4. At least how many pea plants did Mendel care for over the seven years he did his experiments?

5. What traits did Mendel study the inheritance of in pea plants?

6. Mendel ***crossed*** plants with different traits to observe the traits their offspring showed.
What do you think "crossed" means in this context?

7. What happened when Mendel crossed a tall plant with a short plant? What did the offspring look like?

8. What is the dominant version of a trait?

9. What is the recessive version of a trait?

Mendel's conclusions

In 1866 Mendel published his findings on heredity in the Journal of the Bruno Natural History Society. Unfortunately, his Publication had absolutely no impact on the scientific world (at least in 1866). Mendel's findings were too complex, even the most influential scientists did not understand his work. It collected dust for about 34 years before anyone reviewed it. Mendel died in 1884.

In the early 1920s and early 1930s the full significance of Mendel's work was finally recognized and specifically used to gain an understanding of evolution. All because of Mendel's years of research in population genetics, investigators were able to demonstrate that Darwin's theory of evolution could be described in terms of the change in gene frequency in a population over successive generations.

10. Why didn't Mendel's work have an impact on the scientific community during his lifetime?

11. What theory did Mendel's ideas eventually help support?

PRACTICE MENDEL'S IDEAS

Fertilization in plants

When Mendel began his experiments, he knew that the male part of the flower contains **male gametes in pollen**, and the female portion of the flower contains **female gametes called eggs**. During pollination, pollen is transferred from the male to the female part of the plant. The male and female reproductive cells then join in a process known as fertilization. This produces a new cell which grows into a seed.

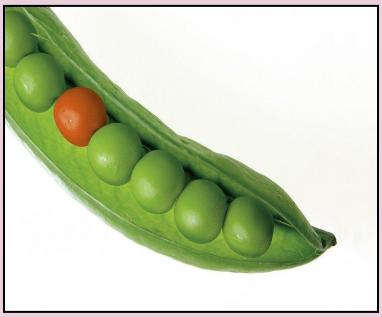
In cross-pollination, a plant has two different parents. Pollen is transferred from the male part of a plant's flower to the female part of a different plant's flower.

Self-pollination is when pollen fertilizes an egg on the same plant it came from. As a result, the offspring inherits all of its characteristics from the single plant that bore it. This is a weird example of a time when there is only 1 parent in sexual reproduction.

12. What happens during pollination?

13. What happens during fertilization?

14. What is the difference between self-pollination and cross pollination?



Genes and Alleles

When doing genetic crosses, we call each original pair of plants the P or parental generation. Their offspring are called the F1 generation. An individual's characteristics are determined by factors that are passed from one parental generation to the next. These factors that are passed from parent to offspring are called genes. The different forms of a gene are called alleles.

Example: Tall and short, green or yellow

15. When doing genetic crosses, what do P and F_1 represent?

16. What is an allele?

Principle of Dominant and Recessive

This principle states that some alleles are dominant and others are recessive. An organism with at least one dominant allele for a particular form of a trait will exhibit that form of the trait. An organism with a recessive allele for a trait will exhibit the recessive trait only when there are no dominant alleles for the trait present.

Dominant alleles are represented by **capital letters.** For example: Tall plant is T

Recessive alleles are represented by **lowercase letters**. For example: Short plant is t

17. How many dominant alleles does an organism need to receive from their parents to show the dominant trait?

18. The information above states that having at least 1 dominant allele causes the dominant trait to be shown. We already know we have two alleles for every trait (one from each parent).
How many recessive alleles does an organism need to receive from their parents to show a recessive trait?

19. What type of letter represents dominant alleles? . What type of letter represents recessive alleles?

DIAGRAM INTERPRETATION CHALLENGE

In the first column: Seed Shape

1. What alleles are there for seed shape in the parental generation?
( ) and ( )

2. What is the seed shape of the offspring in the F1 generation?
( )

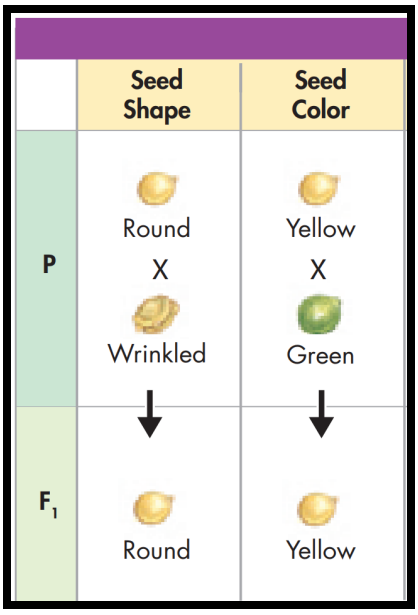
3. Is round the dominant or recessive allele?
( )

In the second column: Seed Color

4. What alleles are there for seed color in the parental generation?
( ) and ( )

5. What is the seed color of the offspring in the F1 generation?
( )

6. Is green the dominant or recessive allele?
( )



Word Bank:

genetics **fertilization** **self-pollination** **cross-pollination**

1. The scientific study of heredity, known as ( ).
2. During sexual reproduction, male and female reproductive cells join in a process known as ( ) to produce a new cell.
3. A plant grown from a single seed produced by ( ) inherits all of its characteristics from the single plant that bore it; it has a single parent.
4. In a process, known as ( ), a plant that has two different parents.

Word Bank:

genes **P, or parental generation** **alleles** **F1 generation**

1. The factors that are passed from parent to offspring are called ( ).
2. The different forms of a gene are called ( ).
3. When doing genetic crosses, we call each original pair of plants the ( ).
4. The p generation's offspring are called the ( ).

Word Bank:

dominant **lowercase letter** **recessive** **capital letter**

1. An organism with at least one ( ) allele for a particular form of a trait will exhibit that form of the trait.
2. Recessive alleles are represented by a ( ).
3. An organism with a ( ) allele for a particular form of a trait will exhibit that form only when the dominant allele for the trait is not present.
4. Dominant alleles are represented by a ( )

Pea Plant Punnett Squares

1. Identify each of the genotypes below as homozygous (Ho) or heterozygous (He).

RR _____ Yy _____ AA _____ ff _____ tt _____

Aa _____ ww _____ Gg _____ Tt _____ Aa _____

2. Identify the phenotype for each of the genotypes below using the information about pea plants.

a. Green pea pod color is dominant over yellow.

GG _____ Gg _____ gg _____

b. Purple flowers are dominant over white flowers.

PP _____ Pp _____ pp _____

3. Identify the possible genotypes for each of the phenotypes.

a. Tall pea plants (T) are dominant over short pea plants (t).

Tall = _____ Short = _____

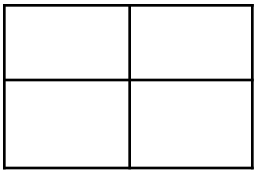
b. Smooth pea pods (S) are dominant over wrinkled pea pods (s).

Smooth = _____ Wrinkled = _____

4. In pea plants, purple flowers are dominant over white flowers. If a homozygous dominant plant was crossed with a homozygous recessive plant for flower color, what percentage of their offspring would have white flowers? Show your work.

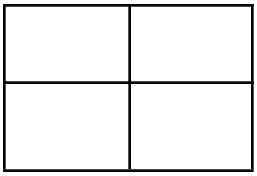
5. If two offspring from the previous question were crossed, what percentage of the offspring would have purple flowers? Show your work.

6. In pea plants, tall plants are dominant over short plants. If a heterozygous plant was crossed with a homozygous recessive plant, what percent of the offspring would have each phenotype? Show your work.



7. In pea plants, round seeds are dominant over wrinkled seeds. If a plant heterozygous for seed shape is crossed with a plant that is homozygous dominant plant, what percent of the offspring would have round seeds?

8. If two heterozygous plants were crossed for seed color (yellow is dominant), give the percentages for each genotype.



9. If a heterozygous tall plant is crossed with a short plant, what is the ratio of tall to short offspring?

10. When a plant with green pods (dominant) is crossed with a plant with yellow pods, all the offspring have green pods. What are the genotypes of the parent plants? Show your work.

Chapter 10: Dihybrid Cross Worksheet

In rabbits, gray hair is dominant to white hair. Also in rabbits, black eyes are dominant to red eyes. These letters represent the genotypes of the rabbits:

GG = gray hair Gg = gray hair gg = white hair	BB = black eyes Bb = black eyes bb = red eyes

1. What are the phenotypes (descriptions) of rabbits that have the following genotypes?

Ggbb _____ ggBB _____

ggbb _____ GgBb _____

2. A male rabbit with the genotype GGbb is crossed with a female rabbit with the genotype ggBb the square is set up below. Fill it out and determine the phenotypes and proportions in the offspring.

	Gb	Gb	Gb	Gb
gB				
gB				
gb				
gb				

How many out of 16 have gray fur and black eyes? _____

How many out of 16 have gray fur and red eyes? _____

How many out of 16 have white fur and black eyes? _____

How many out of 16 have white fur and red eyes_____

3. A male rabbit with the genotype GgBb is crossed with a female rabbit with the genotype GgBb The square is set up below. Fill it out and determine the phenotypes and proportions of offspring

	GB	Gb	gB	gb
GB				
Gb				
gB				
gb				

How many out of 16 have gray fur and black eyes? _____

How many out of 16 have gray fur and red eyes? _____

How many out of 16 have white fur and black eyes? _____

How many out of 16 have white fur and red eyes? _____

4. Show the cross between a ggBb and a GGBb. You'll have to set this one up yourself: Punnett Square:

5. An aquatic arthropod called a Cyclops has antennae that are either smooth or barbed. The allele for barbs (B) is dominant over smooth (bb). In the same organism Non-resistance to pesticides (N) is dominant over resistance to pesticides (nn). Make a "key" to show all the possible genotypes (and phenotypes) of this organism.

Genotype Phenotype

BB
Bb
bb
NN
Nn
nn

6. A Cyclops that is resistant to pesticides and has smooth antennae is crossed with one that is heterozygous for both traits. Show the genotypes of the parents.

_____ x _____

7. Set up a punnett square for the cross.

8. What are the phenotypic ratios of the offspring?

DiHybrid Practice Problems

1. In man, assume that spotted skin (S) is dominant over non-spotted skin (s) and that wooly hair (W) is dominant over non-wooly hair (w). Cross a marriage between a heterozygous spotted, non-wooly man with a heterozygous wooly-haired, non-spotted woman. Give genotypic and phenotypic ratios of offspring.

2. In horses, black is dependent upon a dominant gene, B, and chestnut upon its recessive allele, b. The trotting gait is due to a dominant gene, T, the pacing gait to its recessive allele, t. If a homozygous black pacer is mated to a homozygous chestnut trotter, what will be the appearance of the F_1 generation?

3. In summer squash, white fruit color (W) is dominant over yellow fruit color (w) and disk shaped fruit (D) is dominant over sphere-shaped fruit (d).. If a squash plant true-breeding for white, disk-shaped fruit is crossed with a plant true-breeding for yellow, sphere-shaped fruit,

5. In mice, the ability to run normally is a dominant trait. Mice with this trait are called running mice (R). The recessive trait causes mice to run in circles only. Mice with this trait are called waltzing mice (r). Hair color is also inherited in mice. Black hair (B) is dominant over brown hair (b).For each of the following problems, determine the parent genotypes, determine possible gametes then construct a Punnett square to solve.

a. Cross a heterozygous running, heterozygous black mouse with a homozygous running, homozygous black mouse

Parental genotypes _____

Possible gametes _____ _____ _____ _____

Offspring phenotypic ratio_____

b. Cross a homozygous running, homozygous black mouse with a heterozygous running, brown mouse

Parental genotypes _____

Possible gametes _____ _____ _____ _____

Offspring phenotypic ratio _____

c. Cross a waltzing brown mouse with a waltzing brown mouse

Parental genotypes _____

Possible gametes _____ _____ _____ _____

Offspring phenotypic ratio _____

Bio - Non-Mendelian Genetics: <u>Incomplete Dominance</u>

In snapdragons, flower color is controlled by incomplete dominance. The two alleles are red (R) and white (W).

The heterozygous genotype is expressed as pink.

1. What are the genotypes of the following flowers?

a. Red: _____

b. White: _____

c. Pink: _____

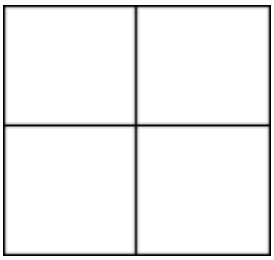
2. A white-flowered plant is crossed with a red-flowered plant. Complete a Punnett Square.

a. Parent Genotypes: _____ x _____

b. Percent offspring that are Red: _____ %

c. Percent offspring that are White: _____ %

d. Percent offspring that are Pink: _____ %



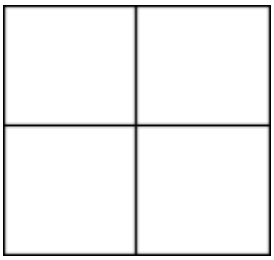
3. A pink-flowered plant is crossed with a white-flowered plant. Complete a Punnett Square.

a. Parent Genotypes: _____ x _____

b. Percent offspring that are Red: _____ %

c. Percent offspring that are White: _____ %

d. Percent offspring that are Pink: _____ %



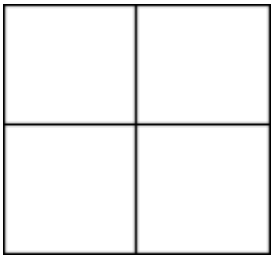
4. A red-flowered plant is crossed with a red-flowered plant. Complete a Punnett Square.

a. Parent Genotypes: _____ x _____

b. Percent offspring that are Red: _____ %

c. Percent offspring that are White: _____ %

d. Percent offspring that are Pink: _____ %



Codominance

Shorthorn cattle: Roan cattle are a mix between red and white cattle. Roan cattle have both red and white fur because they are heterozygous for fur color and both alleles are expressed. This is another example of codominance. White cattle are homozygous for the W allele. Red cattle are homozygous for the R allele.

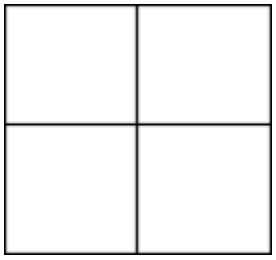
1. What are the genotypes for the cows below?

Red Cattle: _____ White Cattle: _____ Roan Cattle: _____

Bull: Male Cow: Female

2. What offspring are expected from mating a roan bull and a roan cow?

a. What would the genotypes of the two parents be? _____ x _____



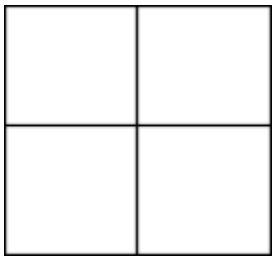
b. What is the probability that they will have a red offspring? _____%

c. What is the probability that they will have a white offspring? _____%

d. What is the probability that they will have roan offspring? _____%

3. What phenotypes would you expect from a cross between a red bull and a white cow?

a. What would the genotypes of the two parents be? _____ x _____



b. What is the probability that they will have a red offspring? _____%

c. What is the probability that they will have a white offspring? _____%

d. What is the probability that they will have roan offspring? _____%

4. What phenotypes would you expect from a cross between a white bull and a white cow?

a. What would the genotypes of the two parents be? _____ x _____

b. What is the probability that they will have a red offspring? _____%

c. What is the probability that they will have a white offspring? _____%

d. What is the probability that they will have roan offspring? _____%

5. What phenotypes would you expect from a cross between a red bull and a roan cow?

a. What would the genotypes of the two parents be? _____ x _____

b. What is the probability that they will have a red offspring? _____%

c. What is the probability that they will have a white offspring? _____%

d. What is the probability that they will have roan offspring? _____%

Codominance

Guinea Pigs: In guinea pigs, straight hair (SS) and curly hair (CC) are co-dominant traits that result in hybrids that have wavy hair (SC). Male guinea pigs are known as boars while female guinea pigs are known as sows.

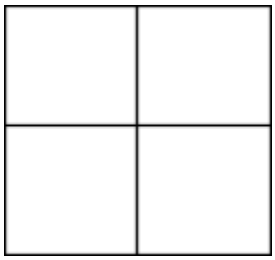
6. Cross between a straight hair boar and a curly hair sow.

a. What would the genotypes of the two parents be? _____ x _____

b. Percent offspring that are Straight Hair: _____ %

c. Percent offspring that are Wavy Hair: _____ %

d. Percent offspring that are Curly Hair: _____ %



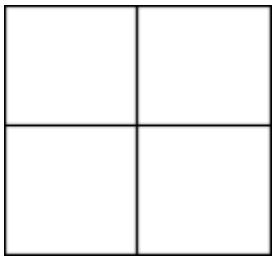
7. Cross between a straight hair boar and a straight hair sow.

a. What would the genotypes of the two parents be? _____ x _____

b. Percent offspring that are Straight Hair: _____ %

c. Percent offspring that are Wavy Hair: _____ %

d. Percent offspring that are Curly Hair: _____ %



8. Cross between two wavy hair guinea pigs.

a. What would the genotypes of the two parents be? _____ x _____

b. Percent offspring that are Straight Hair: _____ %

c. Percent offspring that are Wavy Hair: _____ %

d. Percent offspring that are Curly Hair: _____ %

9. Cross between a wavy hair boar and a curly hair sow?

a. What would the genotypes of the two parents be? _____ x _____

b. Percent offspring that are Straight Hair: _____ %

c. Percent offspring that are Wavy Hair: _____ %

d. Percent offspring that are Curly Hair: _____ %

Meiosis Pipe Cleaner Lab

Background: Meiosis is the division of the nucleus (and the chromosomes inside of it) in sex cells. One cell divides to form 4 cells with a lower chromosome number. This process happens continuously in all living things that are made up of more than one cell, after puberty. In males, the process will lead to the formation of sperm cells, and in females, meiosis leads to the formation of one egg cell at a time.

Objective: To model the various stages of Meiosis using two different colors of pipe cleaners.

Materials:
- 2 strands of different color pipe cleaner (2 long strands of each color 2 short strands of each color)
- beads of two different colors
- Colored pencils

INTERPHASE:
Questions:
1. What happens during the G1 and G2 phases of interphase?

2. What happens during the S phase of interphase?

3. What links together the two sister chromatids after DNA replication?

4. What are homologous chromosomes?

5. Which color pipe cleaner represents maternal chromosomes?

6. Which color pipe cleaner represents paternal chromosomes?

- Now you are going to help your cell go through the S phase and you are going to replicate or copy the chromosomes.
- Link 2 of the long strands of the same color together by twisting the pipe cleaners together (the twist should represent the CENTROMERE)
- Repeat for small strands of all colors.
- Once completed with this step you should have two large double chromosomes, and two small double chromosomes.
- Now add a blue bead to the bottom right leg of your blue chromosomes (X's) and add a pink bead to the bottom right leg of your pink chromosomes (X's)

▪ These beads represent a section of DNA (gene)

7. How many total chromosomes does our parent cell therefore have? (hint: count the number of X's)

MEIOSIS 1:

Questions:

8. What is the first stage of meiosis 1 called?

9. Where do your homologous chromosomes originally inherit (come) from?

10. What is a tetrad?

11. What is crossing over?

- You are now in Prophase 1.

- First you need to make sure that your homologous chromosomes have found one another and are placed next to one another in the cell

- **Hint: homologous chromosomes are the same size**

A. - Draw what you see on your lab report: **Title the picture: PROPHASE 1 Label: HOMOLOGOUS CHROMOSOMES, CENTROMERES, TELL ME WHICH COLOR PIPE CLEANER IS MATERNAL AND WHICH IS PATERNAL**

Next you need to demonstrate crossing over. Remove the small blue bead from the bottom of the large blue chromosome and remove the small pink bead from the bottom of the large pink chromosome. Then place the blue bead on the pink chromosome and the pink bead on the blue chromosome. (Repeat for small chromosomes!)

12. What happens during Metaphase

- **You are now in Metaphase 1.**

- Line up the homologous chromosomes in the center of the cell.
- Draw what you see on your lab report:

B. Title the picture: METAPHASE 1

- **Label: HOMOLOGOUS CHROMOSOMES, CENTROMERES**

- You are now in Anaphase 1.

- Pull one homologous chromosome to one side of the cell and the other homologous chromosome to the other side of the cell.
- Repeat for the other set of homologous chromosomes.

- You are now in Telophase 1 and Cytokinesis.

- **Draw two new daughter cells.**
- You should have two chromosomes in one cell and two chromosomes in the other cell. (The chromosomes in each daughter cell should be made of different sizes of pipe cleaners)

13. After Anaphase 1 have the centromeres (pipe cleaners) been split? _____
14. How many daughter cells do you end up with after Telophase 1? _____
15. Is it possible to have all the same color pipe cleaners in the same daughter cell? _____
16. Why is it bad to have all the pipe cleaners the same color? _____

MEIOSIS 2:

Questions:

17. During Meiosis 2 what will happen to the sister chromatids?_____
18. What other process is Meiosis 2 very similar too? _____

- You are now in Prophase 2.

- Draw what you see on your lab report:

C. Title the picture: PROPHASE 2

- **Label: SISTER CHROMATIDS, CENTROMERES, DAUGHTER CELLS**

19. What happens during Metaphase 2?

- You are now in Metaphase 2.

- Line up the sister chromatids in the center of both daughter cells.
- Draw what you see on your lab report:

D. Title the picture: METAPHASE 2

- **Label: SISTER CHROMATIDS, CENTROMERES**

- **You are now in Anaphase 2.**
  - Pull the sister chromatids apart (breaking the bond made by the twisting of the pipe cleaners)

- **You are now in Telophase 2 and Cytokinesis.**
  - **Draw four new daughter cells on your lab report.**
  - Place the correct number of chromosomes in the daughter cells.

20. After Anaphase 2 have the centromeres (pipe cleaners) been split?
21. How many daughter cells do you end up with after Telophase 2?

- Draw what you see on your lab report:

E. Title the picture: TELOPHASE 2

- **Label: CHROMOSOMES, DAUGHTER CELLS**

CONCLUSION QUESTIONS:

1. How many chromosomes did your original parent cell have (at the beginning of the lab)?

2. Was this parent cell diploid or haploid?

3. How many chromosomes did each of your daughter cells have (at the end of the lab)?

4. Were the daughter cells diploid or haploid?

5. If human somatic cells have 46 chromosomes, how many chromosomes do human gametes have?

6. Are human gametes haploid or diploid?

7. Are human somatic cells haploid or diploid?

8. Are fertilized eggs haploid or diploid?

Lesson Review Questions

Lesson 11.1: The Work of Gregor Mendel

1. _____
2. _____
3. _____
4. _____
5. _____

Lesson 11.2: Applying Mendel's Principles

1. _____
2. _____
3. _____
4. _____
5. _____

Lesson 11.3: Other Patterns of Inheritance

1. _____
2. _____
3. _____
4. _____
5. _____

Lesson 11.4: Meiosis

1. _____
2. _____
3. _____
4. _____
5. _____

Genetics Test Review Guide

Terms to Know- Genetics

Trait	Genes	Alleles	Gametes
Dominant	Recessive	Homozygous	Heterozygous
Probability	Genotype	Phenotype	Incomplete Dominance
Codominance	Multiple Alleles	Polygenic Traits	P, F1, F2
Homologous	Diploid	Haploid	Meiosis
Crossing over	Zygote	Gene Map	Gene Linkage

Gregor Mendel

- What did his parents do?
- Where did he go to try to find a better life for himself?
- What type of plants did Mendel use in his experiments?
- What traits did Mendel study the inheritance of in pea plants?

Mendelian Genetics/Punnett Squares

- Four Box Punnett Square
    - Identify parental genotypes
    - Set up and fill out Punnett Square
    - Identify percentages for each genotype
    - Identify phenotype for each genotype
- Sixteen Box Punnett Square
    - Identify parental genotypes
    - Set up and fill out Punnett Square
    - Identify gametes
    - Identify phenotype for each genotype
    - Identify phenotypic ratio

Non-Mendelian Genetics/Punnett Squares

- Four Box Punnett Square
    - Identify the type of inheritance (Incomplete Dominance or Codominance)
    - Identify parental genotypes
    - Identify phenotypic percentages of offspring

Meiosis

- What is the purpose of Meiosis?
- Be able to identify all the stages of Meiosis through descriptions and pictures
- How are Mitosis and Meiosis different?
- What happens during crossing over of chromosomes?

Punnett Square Practice Problems

1. In Guinea Pigs, having a brown coat (B) is dominant over having a white coat (b). Cross two heterozygous parents to determine their possible offspring. Be sure to answer all of the following questions in your answer.

2. In Guinea Pigs, having a brown coat (B) is dominant over having a white coat (b). Hair texture is also an inherited trait in guinea pigs. Straight hair (H) is the dominant trait and curly hair (h) is the recessive trait.

   Cross a heterozygous brown, heterozygous straight haired guinea pig with a heterozygous brown, heterozygous straight haired guinea pig. Be sure to answer all of the following questions in your answer.

3. In radishes, red (R) and white (W) are pure-breeding colors, while hybrids are purple. If a red radish is crossed with a purple radish, what will be the results of their offspring? Be sure to answer all of the following questions in your answer.

4. In some chickens, the allele for black feathers is B and the allele for white feathers is W. The heterozygous phenotype results in black and white spotted feathers. If two heterozygous chickens were crossed, what would be the results of their offspring? Be sure to answer all of the following questions in your answer.

Ag Biology

Semester 2

Chapter 12 Workbook: DNA

Name: _____ Date: _____

Class Period: _____ Teacher: _____

Table of Contents

Chapter 12: DNA

12.1 Identifying the Substance of Genes

Lesson Objectives

- Summarize the process of bacterial transformation.
- Describe the role of bacteriophages in identifying genetic material.
- Identify the role of DNA in heredity.

Lesson Summary

Bacterial Transformation In 1928, Frederick Griffith found that some chemical factor from heat-killed bacteria of one strain could change the inherited characteristics of another strain.

- He called the process **transformation** because one type of bacteria (a harmless form) had been changed permanently into another (a disease-carrying form).
- Because the ability to cause disease was inherited by the offspring of the transformed bacteria, he concluded that the transforming factor had to be a gene.

In 1944, Oswald Avery tested the transforming ability of many substances. Only DNA caused transformation. By observing bacterial transformation, Avery and other scientists discovered that the nucleic acid DNA stores and transmits genetic information from one generation of bacteria to the next.

Bacterial Viruses A **bacteriophage** is a kind of virus that infects bacteria. When a bacteriophage enters a bacterium, it attaches to the surface of the bacterial cell and injects its genetic material into it.

- In 1952, Alfred Hershey and Martha Chase used radioactive tracers to label proteins and DNA in bacteriophages.
- Only the DNA from the bacteriophage showed up in the infected bacterial cell.
- Hershey and Chase concluded that the genetic material of the bacteriophage was DNA.
- Their work confirmed Avery's results, convincing many scientists that DNA was the genetic material found in genes—not just in viruses and bacteria, but in all living cells.

The Role of DNA The DNA that makes up genes must be capable of storing, copying, and transmitting the genetic information in a cell.

Bacterial Transformation

1. What happened when Griffith injected mice with the pneumonia-causing strain of bacteria that had been heat-killed?

_____

2. What happened when Griffith injected mice with a mixture of heat-killed, pneumonia-causing bacteria and live bacteria of the harmless type?

_____

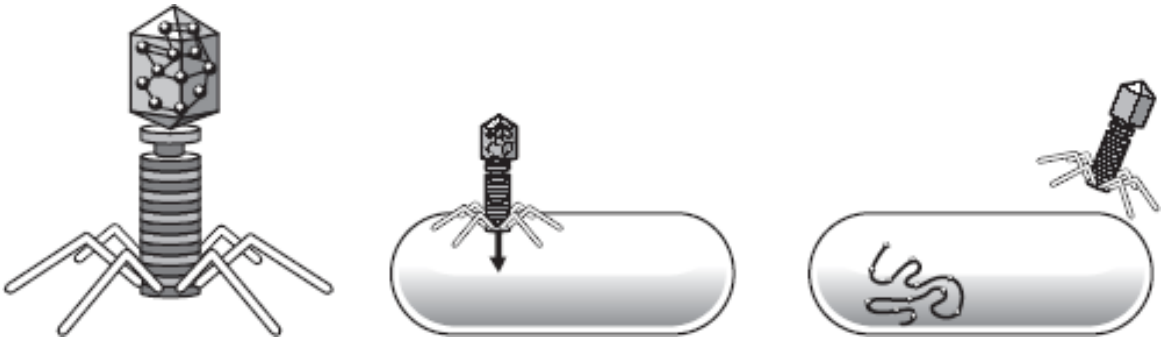
3. What was the purpose of Oswald Avery's experiments?

4. What experiments did Avery do?

5. What did Avery conclude?

Bacterial Viruses

6. Fill in the blanks to summarize the experiments of Hershey and Chase. (Note: The circles represent radioactive labels.)



_____ with radioactive label _____ _____

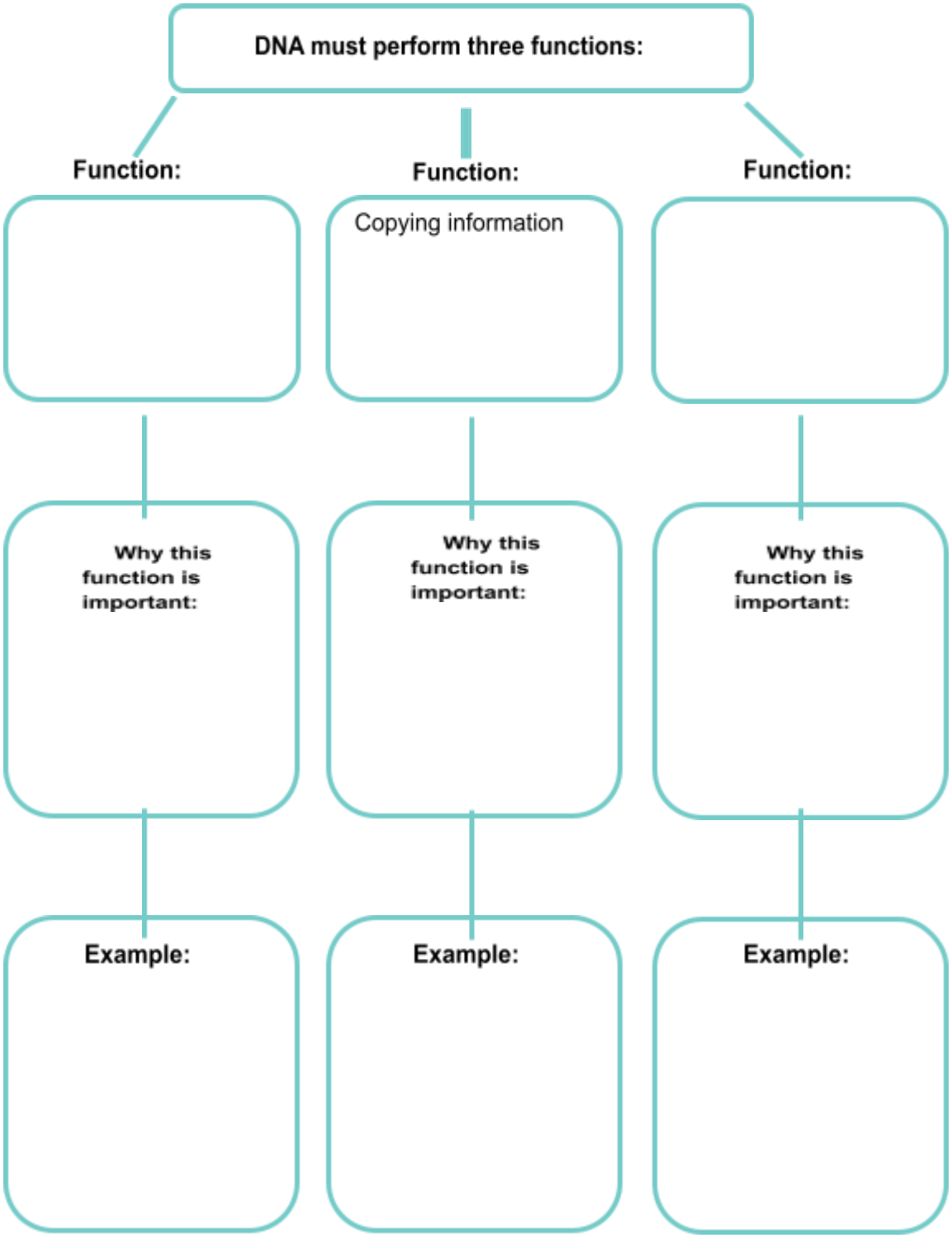
_____ with radioactive label _____ _____

7. What did Hershey and Chase conclude? Why?

8. How did Hershey and Chase confirm Avery's results?

The Role of DNA

1. Complete this graphic organizer to summarize the assumptions that guided research on DNA in the middle of the twentieth century. Use an oak tree to give an example of each function.



9. DNA is like a book titled *How to Be a Cell.* Explain why that title is appropriate for each of DNA's three functions.

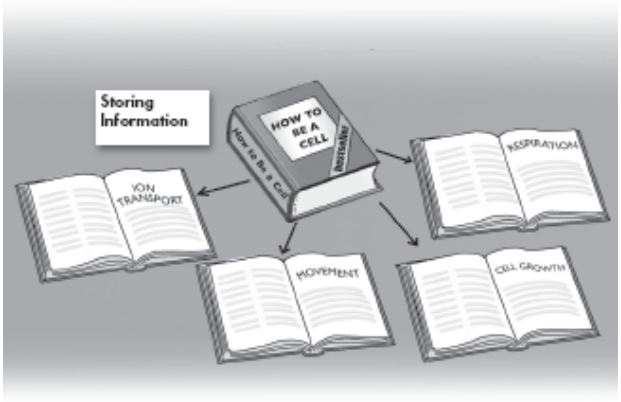
a. _____

_____

_____

_____

_____



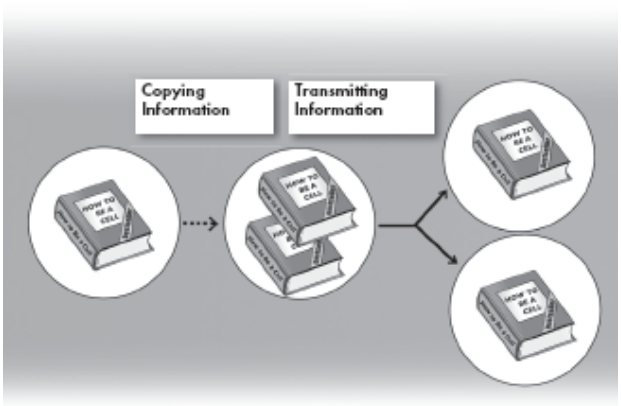
b. _____

_____

_____

_____

_____



c. _____

_____

_____

_____

_____

The Role of DNA

Storing Information The main job of DNA is to store genetic information. Genes must have the information needed to produce traits such as eye color or blood type.

Make a list of six things about this dog that are controlled by its DNA.

1. _____

2. _____

3. _____

4. _____

5. _____

6. _____

12.2 The Structure of DNA

Lesson Objectives

- Identify the chemical components of DNA.
- Discuss the experiments leading to the identification of DNA as the molecule that carries the genetic code.
- Describe the steps leading to the development of the double-helix model of DNA.

Lesson Summary

The Components of DNA DNA is a nucleic acid made up of nucleotides joined into long strands or chains by covalent bonds. Nucleotides may be joined in any order.

- A DNA nucleotide is a unit made of a nitrogenous base, a 5-carbon sugar called deoxyribose, and a phosphate group.
- DNA has four kinds of nitrogenous bases: adenine, guanine, cytosine, and thymine.

Solving the Structure of DNA

- Erwin Chargaff showed that the percentages of adenine and thymine are almost always equal in DNA. The percentages of guanine and cytosine are also almost equal.
- Rosalind Franklin's X-ray diffraction studies revealed the double-helix structure of DNA.
- James Watson and Francis Crick built a model that explained the structure of DNA.

The Double-Helix Model The double-helix model explains Chargaff's rule of base pairing and how the two strands of DNA are held together. The model showed the following:

- The two strands in the double helix run in opposite directions, with the nitrogenous bases in the center.
- Each strand carries a sequence of nucleotides, arranged almost like the letters in a four letter alphabet for recording genetic information.
- Hydrogen bonds hold the strands together. The bonds are easily broken allowing DNA strands to separate.
- Hydrogen bonds form only between certain base pairs–adenine with thymine, and cytosine with guanine. This is called **base pairing.**

The Components of DNA

For Questions 1–5, complete each statement by writing in the correct word or words.

1. The building blocks of DNA are _____.
2. Nucleotides in DNA are made of three basic components: a sugar called _____,a _____, and a nitrogenous_____.
3. DNA contains four kinds of nitrogenous bases: _____, _____, _, and _____.
4. In DNA, _____ can be joined in any order.
5. The nucleotides in DNA are joined by _____ bonds.

Solving the Structure of DNA

6. Complete the table to describe each scientist's contribution to solving the structure of DNA.

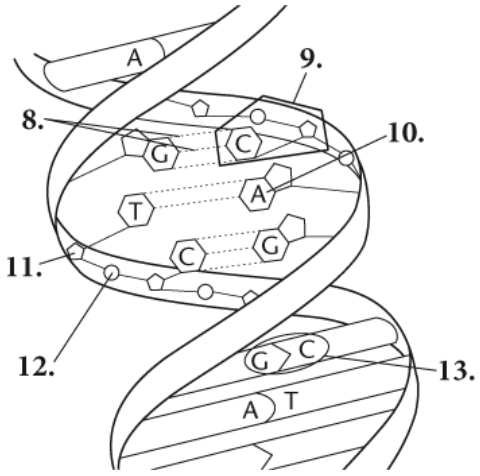
Scientist	Contribution
Erwin Chargaff	
Rosalind Franklin	
James Watson and Francis Crick	

7. Complete the table by estimating the percentages of each based on Chargaff's rules.

DNA sample	Percent of adenine	Percent of thymine	Percent of guanine	Percent of cytosine
1	31.5			
2		30	20	
3				17

The Double-Helix Model

For Questions 8–13, on the lines provided, label the parts of the DNA molecule that correspond to the numbers in the diagram.



Solving the Structure of DNA

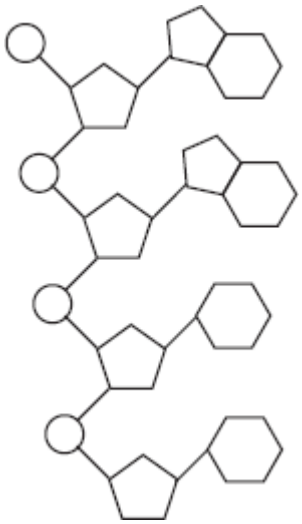
Nucleic Acid and Nucleotides DNA is made of long chains of nucleotides. Each nucleotide contains three basic parts: a base, a deoxyribose molecule, and a phosphate group. There are four different bases: adenine, cytosine, guanine, and thymine. Only one base is found in each nucleotide.

Follow the directions.

14. In the diagram below, the sequence of nucleotides has the code AGCT.

Color the diagram using this key:
Deoxyribose: red
Phosphate Group: blue
Adenine: yellow
Cytosine: green
Guanine: orange
Thymine: black

15. Circle one complete nucleotide.



Answer the questions.

16. Circle the correct answers. What two parts do all nucleotides have in common?

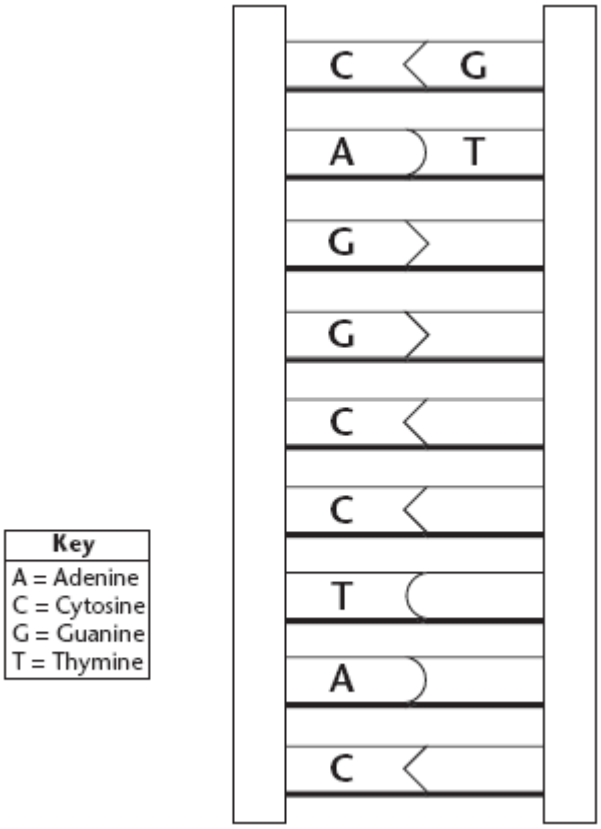
guanine deoxyribose phosphate group

17. Each nucleotide is connected to the next nucleotide. The connection is found between

A. sugar of one nucleotide and phosphate of another
B. base of one nucleotide and sugar of another
C. phosphate groups of two nucleotides

18. What are the parts of a DNA nucleotide?

19. The drawing below shows half of a DNA molecule. Fill in the appropriate letters for the other half.



20. What nucleotide is always paired with thymine?_____

21. What nucleotide is always paired with guanine?_____

22. Whose rule does base pairing prove?_____

23. Suppose a strand of DNA has the following code on one side. A G T C C A G T A

What would be the matching other side of a DNA strand?_____

24.Complete this table to show how the structure of the DNA molecule allows it to perform each essential function.

Function	**Structure of the Molecule**
Store information	
Copy information	
Transmit information	

12.3 DNA Replication

Lesson Objectives

- Summarize the events of DNA replication.
- Compare DNA replication in prokaryotes with that of eukaryotes.

Lesson Summary

Copying the Code Each strand of the double helix has all the information needed to reconstruct the other half by the mechanism of base pairing. Because each strand can be used to make the other strand, the strands are said to be complementary. DNA copies itself through the process of **replication:**

- The two strands of the double helix unzip, forming replication forks.
- New bases are added, following the rules of base pairing (A with T and G with C).
- Each new DNA molecule has one original strand and one new strand.
- **DNA polymerase** is an enzyme that joins individual nucleotides to produce a new strand of DNA.
- During replication, DNA may be lost from the tips of chromosomes, which are called **telomeres.**

Replication in Living Cells The cells of most prokaryotes have a single, circular DNA molecule in the cytoplasm. Eukaryotic cells have much more DNA. Nearly all of it is contained in chromosomes, which are in the nucleus.

- Replication in most prokaryotic cells starts from a single point and proceeds in two directions until the entire chromosome is copied.
- In eukaryotic cells, replication may begin at dozens or even hundreds of places on the DNA molecule, proceeding in both directions until each chromosome is completely copied.

Copying the Code

1. Why are the strands of a DNA molecule said to be complementary?

_____

2. What is the first step in eukaryotic DNA replication?

_____

_____

3. If the base sequence on a separated DNA strand is CGTAGG, what will the base sequence on its complementary strand be?

_____

4. What enzyme joins individual nucleotides to produce the new strand of DNA?

_____

Copying the Code

The Role of Enzymes

Enzymes have several important jobs in DNA replication. The jobs of some enzymes are listed below.

Write the jobs in the order in which they occur.

Also label which enzyme performs each job.

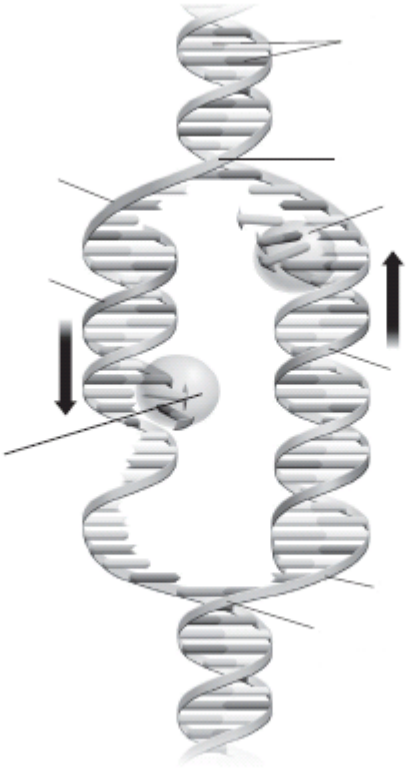
join free nucleotides to existing DNA strand
unwind DNA
unzip DNA

1. _____

2. _____

3. _____

The diagram below shows the replication of DNA. Label all parts of the diagram using the example in the book.



4. Enzymes usually end in -ase. What is the name of the enzyme that joins individual nucleotides? _____

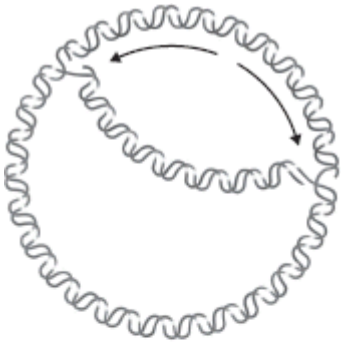
5. Circle the correct answer to complete the sentence. A(n) _____ is the place where a DNA strand opens to make new strands.

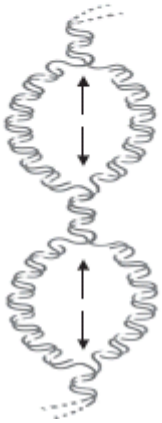
original strand old strand replication fork

Replication in Living Cells

During replication, a DNA molecule copies itself. In eukaryotes, DNA is organized into chromosomes within the nucleus. In prokaryotes, DNA is a circular molecule that is free in the cytoplasm.

1. Label one diagram as Prokaryotic DNA.
2. Label the other as Eukaryotic DNA.
3. Label both drawings with the following terms: unreplicated DNA, replication fork, origin of replication.





4. In which type of cell is DNA circular?
   prokaryotic eukaryotic
5. In which type of cell does replication begin at several points?
   prokaryotic eukaryotic
6. Complete the table to compare and contrast DNA replication in prokaryotes and eukaryotes.

	Prokaryotes	**Eukaryotes**
Location of DNA		
Amount of DNA		
Starting Point(s) for Replication		

Edpuzzle: DNA Structure

1. What is deoxyribose?
2. What does the phosphate do?
3. What do the bases do?
4. Identify the FOUR bases in a DNA molecule.
5. What happens if pairs of bases are mismatched?
6. Which base always pairs with Adenine? How can you remember this?
7. Which base always pairs with Cytosine? How can you remember this?
8. What holds the bases together?
9. What are Nucleotides made of?
10. Draw an illustration of a Nucleotide.

Edpuzzle: DNA Replication

1. What are three examples of traits that your DNA codes for?

2. Which base does Adenine pair with?

3. Which base does Guanine pair with?

4. What is a good way to remember which bases pair together?

5. In general, a gene provides the sequence to make _____.

6. True or False: Cells do not use all of the DNA in the nucleus all of the time - some parts of the DNA are turned off.

7. How many chromosomes do you have in each body cell?

8. Where do you get those chromosomes from?

9. What does the term ***replicate*** mean?

10. What do you think the term ***DNA Replication*** refers to?

11. Look closely at the 2 new DNA molecules. Are they identical or different from each other?

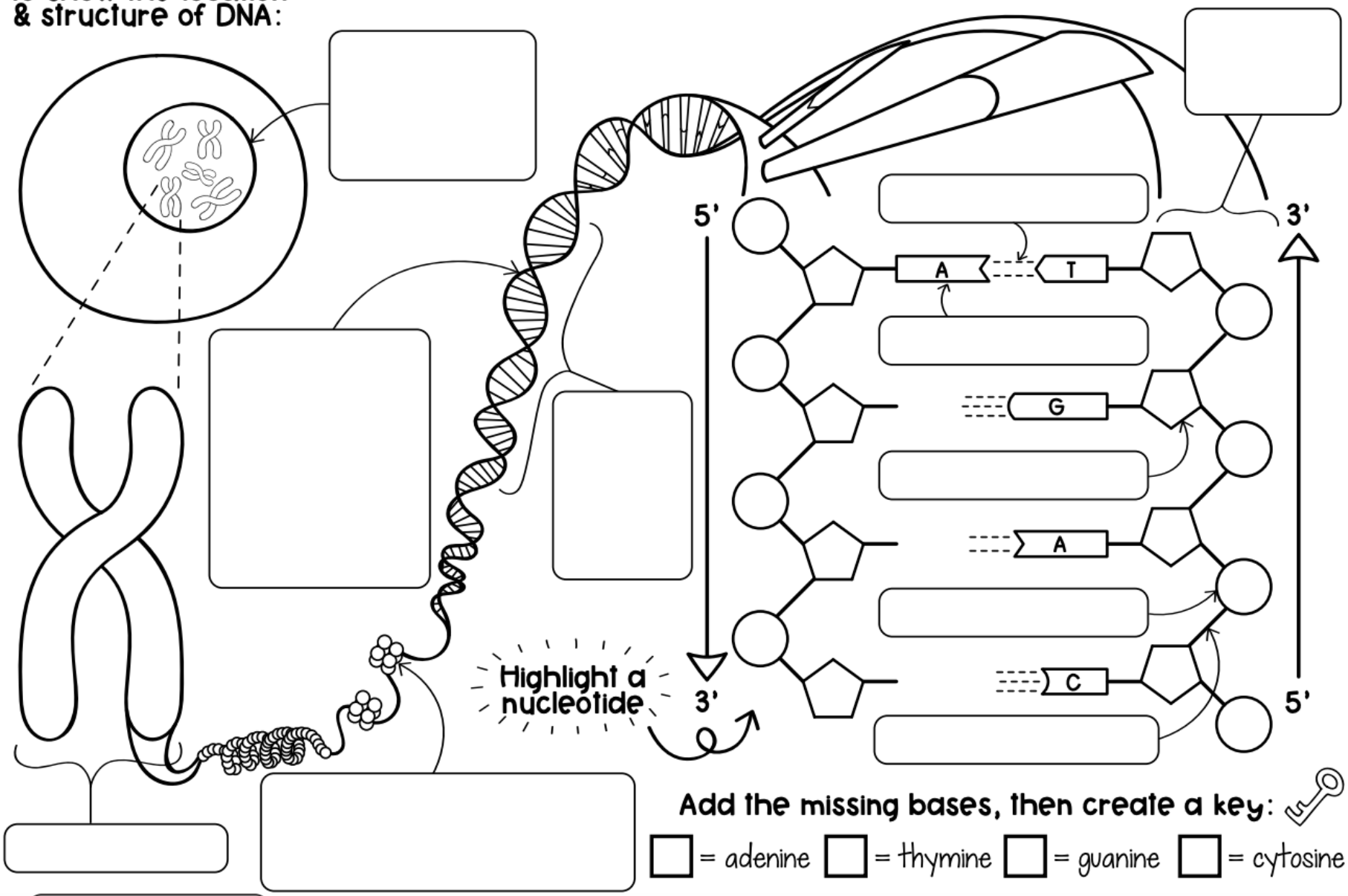
12. Write the steps of DNA Replication based on the information given in the video.

13. DNA Replication is the _____ step in the theory of the Central Dogma.

The structure of DNA

DNA stands for.....?

Label the diagram to show the location & structure of DNA:



Add the missing bases, then create a key:

☐ = adenine ☐ = thymine ☐ = guanine ☐ = cytosine

History of DNA studies

Fill in the gaps to describe the DNA discoveries of each of these scientists, then add a doodle to summarize their discovery!

1869

Name:
Discovery:

DOODLE

1919

DOODLE

Name:
Discovery:

1950

Name:
Discovery:

DOODLE

1952

DOODLE

Name:
Discovery:

1953

Names:
Discovery:

DOODLE

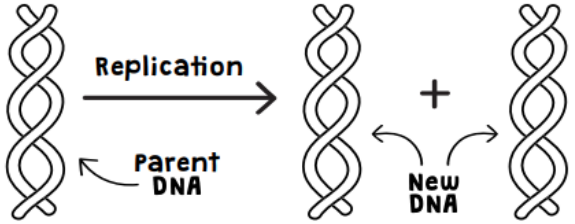
Watson & Crick were awarded the Nobel Prize for their work on DNA - Franklin had passed away at the age of 38 & the award is not given post-humously.

DNA Replication

Why do cells need to do this?

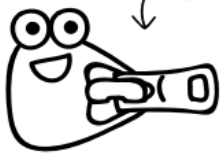
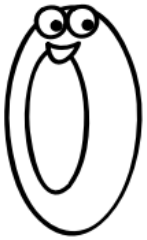
COMPLETE THIS SENTENCE:

"DNA replication is described as semi-conservative because..."



Color in the DNA strands to show how semi-conservative replication works.

ENZYME ANALOGIES!

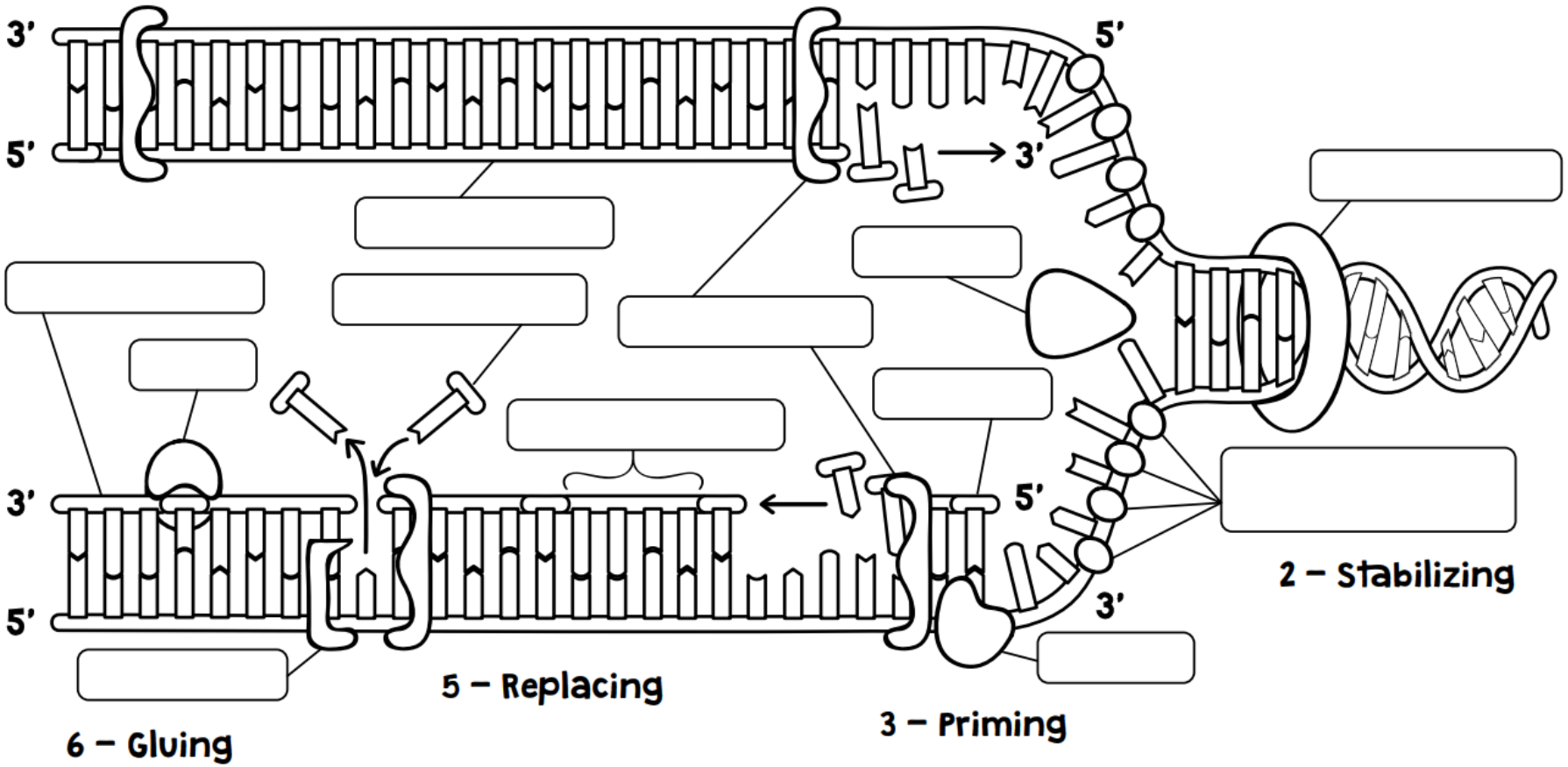
Helicase	 DESCRIBE AN ANALOGY FOR EACH ENZYME, THEN ADD A DOODLE, E.G.... This enyzme unzips DNA like a zipper on a coat, creating two single strands of DNA!	DNA polumerase	 ADD A BUILDER'S HAT!
Topoisomer-ase	 ADD MUSCLY ARMS!	Exonuclease	 ADD A PAIR OF SCISSORS!
Primase	 ADD A RACE FLAG!	Ligase	 ADD A GLUE STICK!

7 – Proofreading

4 – Building and extending

Describe each stage of DNA replication

1 – Unzipping



2 – Stabilizing

3 – Priming

5 – Replacing

6 – Gluing

DNA Structure
Analyzing Lab Data

Base Percentages

In 1949, Erwin Chargaff discovered that the relative amounts of A and T, and of G and C, are almost always equal. The table shows a portion of the data that Chargaff collected.

Percentages of Bases in Five Organisms				
Source of DNA	**A**	**T**	**G**	**C**
Streptococcus	29.8	31.6	20.5	18.0
Yeast	31.3	32.9	18.7	17.1
Herring	27.8	27.5	22.2	22.6
Human	30.9	29.4	19.9	19.8
E.coli	24.7	23.6	26.0	25.7

1. **Interpret Tables:** Which organism has the highest percentage of adenine?

2. **Calculate:** If a species has 35 percent adenine in its DNA, what is the percentage of the other three bases?

3. **Draw Conclusions:** What did the fact that A and T, and G and C, occurred in equal amounts suggest about the relationship among these bases

4. **Looking at our own data:** Using the DNA model you created yesterday, we are going to calculate the percentage present of the base pairs.

    a. How many of each base did you have:
    T- A- G- C-

    b. Divide each base by the total amount of bases:
    T- A- G- C-

    c. Multiple each by 100 to get percentage:
    T- A- G- C-

5. How many students in the class ended up with each of the following base pair ratios:
    a. 3:3-
    b. 4:2-
    c. 5:1-

6. Write the complementary strand for the DNA sequence below:
    T A C G T A T G A A A T

    _____

7. Calculate the percentage of each of the base pairs in the above sequence:
    T- A- G- C-

8. What is the base pair ratio for the above sequence?

9. Write the complementary strand for the DNA sequence below:
    G G T C C C A T G

    _____

10. Calculate the percentage of each of the base pairs in the above sequence:
    T- A- G- C-

11. What is the base pair ratio for the above sequence?

12. On a scale of 1-10, how comfortable do you feel with calculating data from a DNA strand?

DNA Base Pairing Practice

Below you will find 5 template DNA strands. Use Chargaff's Rules of Base Pairing to create the complementary strand of DNA.

1. CCT CTT TGC ACT CGG ATC GTA CGC TAT TCT ATG ATT

2. AGA TAC TAG GAC CTT ACT CGA TTG CTG ATT GCG CGA

3. TCC CTT GGG AAA GAA TAT ACA CGC TGG CTT ACT CGA

4. AGA ACA TAA CTC TTA ACA CTC TAA AGA CCA GCA CTC

5. TAA ACT CGG TAC ATT CTA GCT TAG CAC TAA TTA CCC

6. DNA's shape is considered a _____ _____.
7. What type of bond holds DNA base pairs together?
8. The building blocks of DNA are called _____.
9. The 3 parts of the nucleotide are _____, _____, and _____.
10. The backbone of DNA is made up of _____ and _____.
11. Calculate the percentage of each of the base pairs in Question 1.

    T- A- G- C-

12. What is the base pair ratio for the above sequence?

13. Calculate the percentage of each of the base pairs in Question 3.

    T- A- G- C-

14. What is the base pair ratio for the above sequence?

15. Calculate the percentage of each of the base pairs in Question 5.

T- A- G- C-

16. What is the base pair ratio for the above sequence?

Chapter 12 Lab Extracting DNA

Problem

What properties of DNA can you observe when you extract DNA from cells?

Introduction

A strawberry is an excellent choice for a DNA extraction. Each strawberry cell has eight copies of its chromosomes, this is called an octopoid, because of this, you will be able to collect a large amount of DNA. Ripe strawberries also contain enzymes that help break down cell walls.

In this lab, you will extract the DNA from a strawberry. You must crush the strawberry to break apart its cells, and then add a detergent to dissolve the cell membranes. You will use a filter to remove the solids from the mixture. The solution that you collect will contain DNA, proteins, sugars, and other dissolved molecules. You will use ethanol to isolate the DNA from the other dissolved molecules in the solution.

Skills Focus

Predict, Observe, Draw Conclusions

Materials

- self-sealing plastic freezer bag
- ripe strawberry
- detergent solution
- 25-mL graduated cylinder
- cheesecloth
- funnel
- test tube, medium-sized
- test-tube rack
- chilled 95% ethanol
- stirring rod

Safety

The ethanol used in this lab could be toxic if absorbed through the skin. So rinse off any solution that spills on your skin immediately. Wash your hands thoroughly with soap and hot water at the end of the lab. Do not handle broken glassware.

Pre-Lab Questions

1. Apply Concepts Why do strawberry cells need DNA? Where is it found?

_____

_____

2. Infer If you observe a cell nucleus under a compound microscope, you will not see a molecule of DNA. Why will you be able to see the DNA you extract?

_____

_____

Procedure

1. Place your strawberry in the freezer bag. Press the bag to remove as much air as possible and then seal the bag. Crush the strawberry by mashing it with your fist for about 2 minutes.

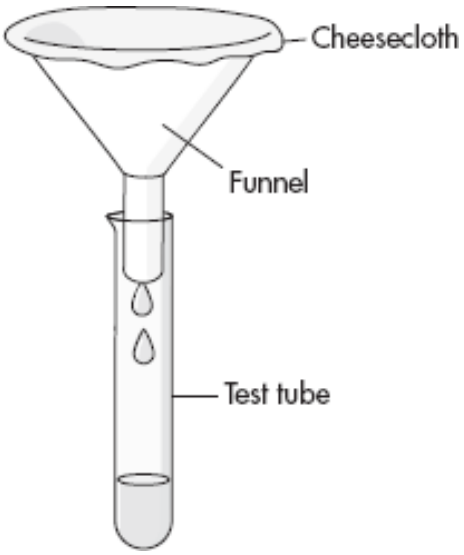
2. Open the bag and add 10 mL of detergent solution. Carefully press out the air and reseal the bag.

3. Squeeze or mash the strawberry and detergent mixture for about 1 minute.

4. Prepare the setup shown in Figure 1. If you have a test-tube rack, secure the test tube in the rack. Make sure the cheesecloth hangs over the funnel at all points.

5. Pour the liquid from the freezer bag into the funnel. When the test tube is about one-eighth full of liquid, remove the funnel. Discard the cheesecloth and any leftover strawberry pulp.

Figure 1 Filtration setup



6. You are going to use a dropper bottle to slowly add ethanol to the test tube. Position the dropper so that the drops run down the side of the test tube. Slowly add drops until the test tube is half full. The ethanol should form a separate layer above the filtered solution. Record what you observe.

_____

_____

_____

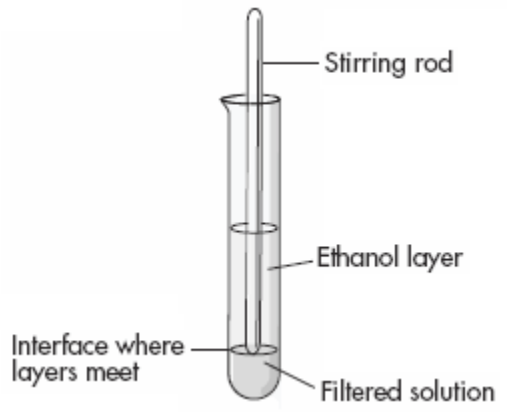
7. Place the tip of the stirring rod at the point where the two layers meet as shown in Figure 2. As you gently twirl the rod, bend down so you can observe what is happening at eye level. Record what you observe.

_____

_____

8. After you dispose of the materials as instructed by your teacher, wash your hands thoroughly with soap and warm water.

Figure 2 Placement of stirring rod



Analyze and Conclude

Questions	Explanation	Drawing
1. What was the purpose of mashing the strawberries?		
2. What does adding DNA extraction or buffer solution do?		
3. What happened when the alcohol was added?		
4. What did the DNA look like?		
5. What was the purpose of the salt in the DNA extraction?		

6. Could the information found from extracting strawberry DNA be important to strawberry farmers? Explain your answer.

Modeling the Structure of DNA
Candy Lab

We have been talking about the structure of DNA. We know that there were several people involved in the discovery of the structure of DNA including Erwin Chargoff, Rosalind Franklin, James Watson and Francis Crick. Chargoff's Rule helped us to recognize that the percentage of Adenine present in a strand of DNA was the same percentage as Thymine, and the same goes for Cytosine and Guanine. Franklin's X-rays helped us to discover many things about the structure of DNA by using a 2D X-ray of a purified strand of DNA. She discovered the helix shape, that there are likely two strands present, and that the nitrogenous bases can be found in the center of the molecule. Watson and Crick created a 3D model of DNA, and using Franklin's findings helped us to determine that the two strands of DNA fit together tightly through the bonding of the nitrogenous bases in the center of the molecule.

In this lab we will be creating our own 3D model of DNA, much like Watson and Crick, except instead of using cardboard and wire, we are going to use candy. Follow the steps below to build your candy DNA model.

Pre-Lab Work:

1. The first thing we need to do is design a 2D model of DNA. Using the space below, draw an example of the DNA strand you plan to create.
   (Hint: draw it as if it were NOT twisted)
   a. Include 2 strands or sides of DNA (the phosphate and sugar component)
   b. Include 6 base pairings (the nitrogenous bases component). These can be in any order you come up with, just make sure you have **6 pairings**.
2. Second, we need to color code our 4 nitrogenous bases. You can use whatever colors your instructor has depending on the candy they use.

2D DNA Molecule:

Nitrogenous Base Key:
Adenine-
Thymine-
Guanine-
Cytosine-

Materials:
2 Twizzlers
10 Gumdrops/Gummy Bears/Dots (be sure to get the exact amount/colors you need)
10 Toothpicks

Lab Procedure:

1. Obtain all the materials you need to build your DNA molecule.
2. Using a toothpick, stick two of the gumdrops/gummy bears onto the toothpick making sure to pair the right nitrogenous bases together.
3. Repeat step 2 until all 10 of your base pairings are put together.
4. Once all of your pairs are together, attach the twizzlers to the ends of the toothpicks.
5. After you attach the sides of your DNA strands you should now have a completed molecule. Use your molecule to answer the post-lab questions below

Post-Lab Questions:

1. How many A-T and G-C pairings did you have?

2. What component(s) of a nucleotide did the Twizzlers represent?

3. Where would the Covalent Bonds be found in this candy model?

4. What type of bond did the toothpick represent in between the two bases?

5. What makes your DNA different from someone else's?

Lesson Review Questions

Lesson 12.1: Identifying the Substance of Genes

1. _____
2. _____
3. _____
4. _____
5. _____

Lesson 12.2: The Structure of DNA

1. _____
2. _____
3. _____
4. _____
5. _____

Lesson 12.3: DNA Replication

1. _____
2. _____
3. _____
4. _____
5. _____

DNA Test Review

Terms to Know - DNA

Gene	Nucleotide	Phosphate	Deoxyribose Sugar
Nitrogenous Base	Hydrogen Bond	Covalent Bond	Base Pairing
Enzyme	Helicase	DNA Polymerase	Ligase
Replication Fork	Leading Strand	Lagging Strand	

People to Know

- For each scientist, know what their research concluded.
    - Alfred Hershey and Martha Chase
    - Erwin Chargaff
    - Rosalind Franklin
    - James Watson and Francis Crick

DNA Structure

- What does DNA stand for?
- Identify the three functions of DNA and why they are important
- DNA Molecule
    - 3D structure is called?
    - What are the three components of a nucleotide?
    - What are the four nitrogenous bases? Which pairs with which?
    - Be able to identify components of a DNA molecule
- Be able to write a complementary strand of DNA based off the original strand

DNA Replication

- Why do cells need to replicate their DNA?
- Know the functions of each enzyme
    - Helicase
    - DNA Polymerase
    - Ligase
- Know the steps of Replication
- How is Prokaryotic DNA and Eukaryotic DNA different?
    - Shape
    - Location
    - Amount
    - Starting Point(s) for replication

Ag Biology

Semester 2

Chapter 13 Workbook:
RNA & Protein Synthesis

Name: _____ Date: _____

Class Period: _____ Teacher: _____

Table of Contents

Chapter 13: RNA & Protein Synthesis

13.1 RNA

Lesson Objectives

- Contrast RNA and DNA.
- Explain the process of transcription.

Lesson Summary

The Role of RNA **RNA** (ribonucleic acid) is a nucleic acid like DNA. It consists of a long chain of nucleotides. The RNA base sequence directs the production of proteins. Ultimately, cell proteins result in phenotypic traits. The main differences between RNA and DNA are:

- The sugar in RNA is ribose instead of deoxyribose.
- RNA is generally single-stranded and not double-stranded like DNA.
- RNA contains uracil in place of thymine.

RNA can be thought of as a disposable copy of a segment of DNA. Most RNA molecules are involved in protein synthesis. The three main types of RNA are:

- **Messenger RNA** (mRNA) carries copies of instructions for polypeptide synthesis from the nucleus to ribosomes in the cytoplasm.
- **Ribosomal RNA** (rRNA) forms an important part of both subunits of the ribosomes, the cell structures where proteins are assembled.
- **Transfer RNA** (tRNA) carries amino acids to the ribosome and matches them to the coded mRNA message.

RNA Synthesis Most of the work of making RNA takes place during transcription. In **transcription**, segments of DNA serve as templates to produce complementary RNA molecules. In prokaryotes, RNA synthesis and protein synthesis takes place in the cytoplasm. In eukaryotes, RNA is produced in the cell's nucleus and then moves to the cytoplasm to play a role in the production of protein. The following focuses on transcription in eukaryotic cells.

- The enzyme **RNA polymerase** binds to DNA during transcription and separates the DNA strands. It then uses one strand of DNA as a template from which to assemble nucleotides into a complementary strand of RNA.
- RNA polymerase binds only to **promoters,** regions of DNA that have specific base sequences. Promoters are signals to the DNA molecule that show RNA polymerase exactly where to begin making RNA. Similar signals cause transcription to stop when a new RNA molecule is completed.
- RNA may be "edited" before it is used. Portions that are cut out and discarded are called **introns.** The remaining pieces, known as **exons**, are then spliced back together to form the final mRNA.

The Role of RNA

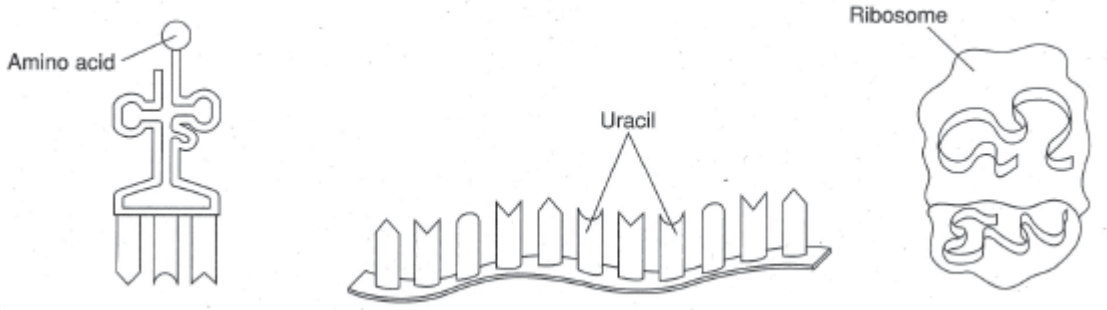
1. Complete the chart by writing in the definition for each term.

Term	Definition
Exon	
Intron	
Messenger RNA	
Ribosomal RNA	
RNA	
RNA polymerase	
Transcription	
Transfer RNA	

2. Complete the table to contrast the structures of DNA and RNA.

	Sugar	Number of Strands	Bases
DNA			
RNA			

3. On the lines provided, identify each kind of RNA.



a. _____ **b** _____ **c.** _____

RNA Synthesis

For Questions 4–10, complete each statement by writing the correct word or words.

4. The process of using DNA to produce complementary RNA molecules is called _____

5. The sequence of _____ in mRNA complements the sequence in the DNA template.

6. In eukaryotes, RNA is formed in the _____ and then travels to the _____.

7. The enzyme _____ binds to DNA during transcription.

8. RNA polymerase binds to regions of DNA called _____, which are "start" signals for transcription.

9. _____ are portions of RNA that are cut out and discarded.

10. _____ are spliced together to make the final mRNA.

RNA Synthesis

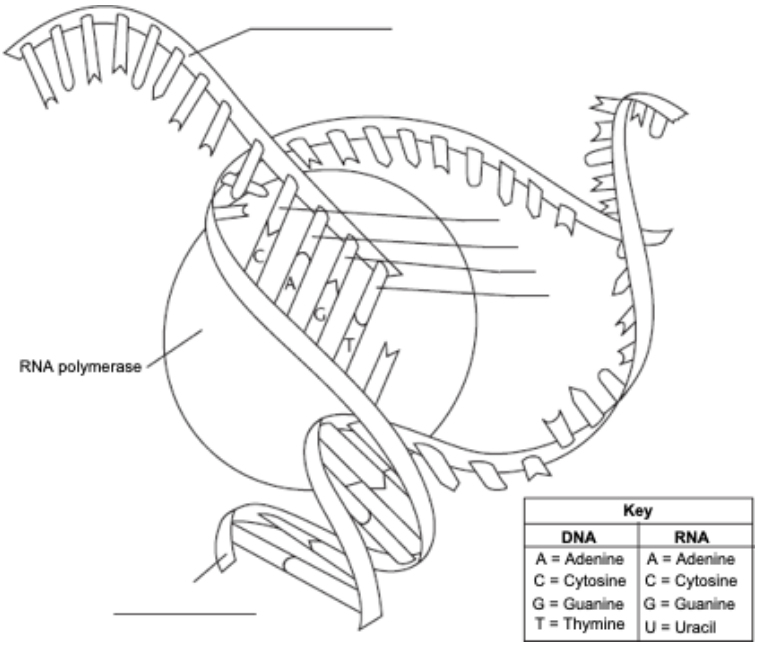
In transcription, RNA polymerase separates the two DNA strands. RNA then uses one strand as a template to make a complementary strand of RNA. RNA contains the nucleotide uracil instead of the nucleotide thymine.

Follow the directions.

1. Label the RNA

2. Label the DNA.

3. Use the key to label the missing nucleotides marked on the diagram.



Answer the questions. Circle the correct answer.

4. In DNA, _____ is always paired with cytosine.
adenine guanine uracil

5. In RNA, _____ replaces thymine.
uracil cytosine adenine

6. In DNA, _____ is paired with adenine.
uracil thymine guanine

RNA Synthesis

In DNA replication a cell copies its DNA. Both strands of the double helix are used as templates to make complementary, or matching, strands of DNA. In DNA transcription a single strand of DNA is used as a template to generate a strand of mRNA.

Follow the directions.

1. Fill in the missing information. One row has been completed for you.

Template	Complementary DNA	Messenger RNA (mRNA)
TTACGG	AATGCC	AAUGCC
	GGCGGC	
		ACGUAG
AGACTC		
	GATAAG	
		CUGGCUACA

Answer the questions.

2. What is the mRNA if the complementary DNA is TCTGAG? _____

3. What does a cell copy in DNA replication? _____

4. How many strands of DNA are used to make complementary strands of DNA? _____

5. How does the cell make RNA? _____

_____

6. What are introns? _____

_____

7. What are exons? _____

_____

Follow the directions.

Create your own example of DNA. Fill in the chart.

Template	Complementary DNA	Messenger RNA (mRNA)

13.2 Ribosomes and Protein Synthesis

Lesson Objectives

- Identify the genetic code and explain how it is read.
- Summarize the process of translation.
- Describe the "central dogma" of molecular biology.

Lesson Summary

The Genetic Code A specific sequence of bases in DNA carries the directions for forming a **polypeptide,** a chain of amino acids. The types and order of amino acids in a polypeptide determine the properties of the protein. The sequence of bases in mRNA is the **genetic code.** The four bases, A, C, G, and U, act as "letters."

- The code reads three "letters" at a time, so that each "word" is three bases long and corresponds to a single amino acid. Each three-letter "word" in mRNA is known as a **codon.**
- Some codons serve as "start" and "stop" signals for protein synthesis.

Translation Ribosomes use the sequence of codons in mRNA to assemble amino acids into polypeptide chains. The process of decoding an mRNA message into a protein is **translation.**

- Messenger RNA is transcribed in the nucleus and then enters the cytoplasm.
- On the ribosome, translation begins at the start codon. Each codon attracts an **anticodon,** the complementary sequence of bases on tRNA.
- Each tRNA carries one kind of amino acid. The match between the codon and anticodon ensures that the correct amino acid is added to the growing chain.
- The amino acids bond together, each in turn. The ribosome moves along the mRNA, exposing codons that attract still more tRNAs with their attached amino acids.
- The process concludes when a "stop code" is reached. The newly formed polypeptide and the mRNA molecule are released from the ribosome.

The Molecular Basis of Heredity Molecular biology seeks to explain living organisms by studying them at the molecular level, using molecules like DNA and RNA.

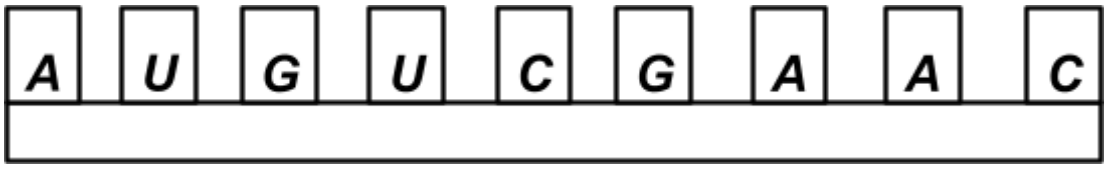
- The central dogma of molecular biology is that information is transferred from DNA to RNA to protein.
- **Gene expression** is the way in which DNA, RNA, and proteins are involved in putting genetic information into action in living cells.
- The genetic code is generally the same in all organisms.

Term	Definition
Anticodon	
Codon	
Gene expression	
Genetic code	
Polypeptide	
Translation	

The Genetic Code

A codon is a group of three nucleotide bases in messenger RNA. Each codon corresponds to one amino acid.

1. Circle each codon in the diagram of RNA below.



2. What is a polypeptide?

A. a chain of amino acids

B. a chain of enzymes

3. What does the letter A stand for in the genetic code?

A. amino acid

B. adenine

4. Can a codon contain two of the same nucleotide bases?

A. yes

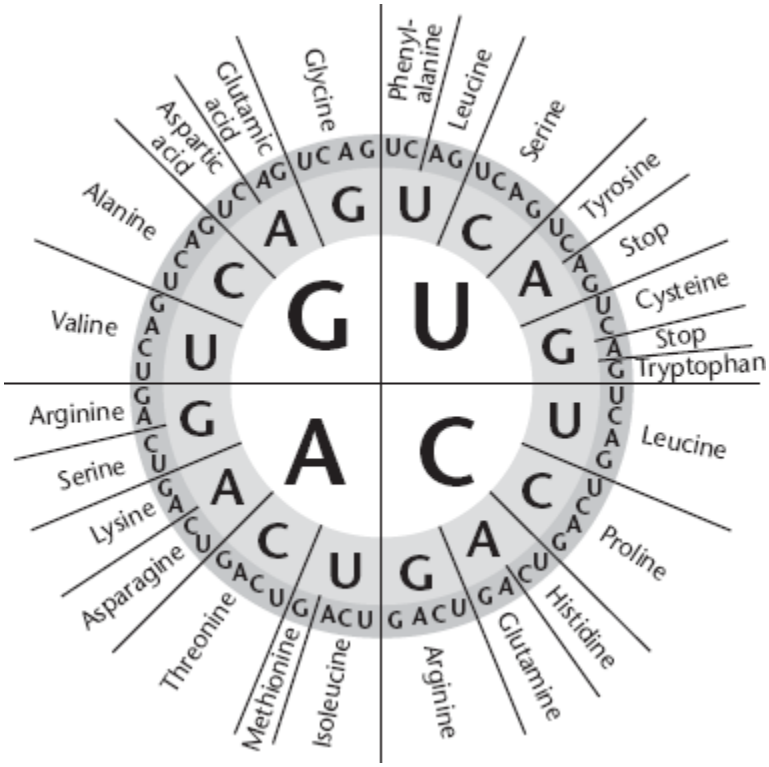
B. no

The Genetic Code

The diagram below shows the mRNA codes that correspond to amino acids and stop codons. Read the diagram from the center outwards. For example, the mRNA code UAC corresponds to the amino acid tyrosine.

Follow the directions.

1. In the chart below the diagram, write the name of the amino acid that corresponds to each mRNA code.



mRNA Code	Amino Acid
AAA	lysine
GCG	
GAU	
CAA	

Answer the questions.

2. Which two mRNA codes correspond to histidine?

CAU & CAC CAA & CUC

3. How many different mRNA codes correspond to arginine?

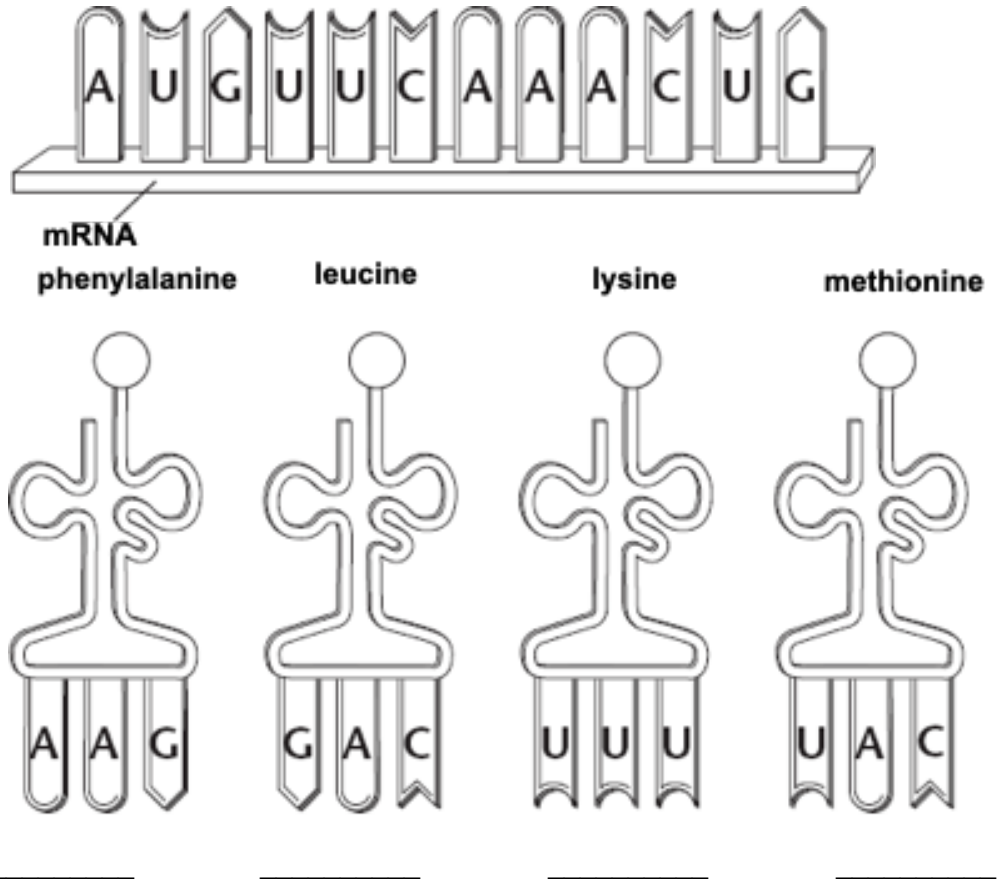
2 4 6

4. How many different mRNA codes correspond to methionine? _____

Translation

During translation, transfer RNA (tRNA) anticodons match to messenger RNA (mRNA) codons. Each tRNA molecule can carry one particular amino acid. The amino acids are joined to form a polypeptide.

1. Number the four tRNA anticodons in the order in which they should appear to match the codons in the mRNA strand.



_____ _____ _____ _____

2. Which anticodon matches the mRNA codon UUC? _____

3. Which amino acid is carried by the anticodon UUU? _____

4. List the amino acids in the order they would appear in the polypeptide coded for by the mRNA.__

Step	Description
Beginning of translation	
Assembly of polypeptide	
Completing the polypeptide	

13.3 Mutations

Lesson Objectives

- Define mutations and describe the different types of mutations.
- Describe the effects mutations can have on genes.

Lesson Summary

Types of Mutations

Mutations are heritable changes in genetic information. There are two categories of mutations: gene mutations and chromosomal mutations.

- Gene mutations produce changes in a single gene. **Point mutations** involve only one or a few nucleotides. Substitutions, insertions, and deletions are all types of point mutations.
  - In a substitution, one base is changed to a different base, which may affect only a single amino acid and have no effect at all.
  - In insertions and deletions, one base is inserted or removed from the DNA sequence. Insertions and deletions are called **frameshift mutations** because they shift the "reading frame" of the genetic message. Frameshift mutations can change every amino acid that follows the point of mutation and can have dramatic effects on the organism.
- Chromosomal mutations produce changes in the number or structure of chromosomes. They include deletions, duplications, inversions, and translocations.
  - Deletion involves the loss of all or part of a chromosome.
  - Duplication produces an extra copy of all or part of a chromosome.
  - Inversion reverses the direction of parts of a chromosome.
  - Translocation occurs when part of one chromosome breaks off and attaches to another.

Effects of Mutations

Genetic material can be altered by natural events or by artificial means. Errors can be made during replication. Environmental conditions may increase the rate of mutation. **Mutagens** are chemical or physical agents in the environment that cause mutations.

The effects of mutations on genes vary widely:

- Some mutations have little or no effect.
- Some mutations produce beneficial variations. One example is **polyploidy** in plants, in which an organism has extra sets of chromosomes. Polyploid plants are often larger and stronger than diploid plants. Mutations can also produce proteins with new or altered functions that can be useful to organisms in different or changing environments.
- Some mutations negatively disrupt gene function or dramatically change protein structure. Genetic disorders such as sickle cell disease can result.

Types of Mutations

Definition

_____ **1.** The change of one base to anothe DNA sequence

_____ **2.** A change in one or a few nucleotides that occur at a single point in the DNA sequence

_____ **3.** Part of one chromosome breaks off and attaches to another

_____ **4.** A heritable change in genetic information

_____ **5.** A mutation that produces an extra copy of all or part of a chromosome

_____ **6.** A chromosomal mutation that reverses the direction of parts of a chromosome

_____ **7.** A kind of mutation that can change every amino acid that follows the point of mutation

_____ **8.** The addition of a base to the DNA sequence

Term

A. mutation
B. substitution
C. point mutation
D. frameshift mutation
E. insertion
F. translocation
G. inversion
H. duplication

9. Complete the table.

Type	Description	Outcome
Substitution		
Insertion		
Deletion		

10. Deletion can happen as a gene mutation or as a chromosomal mutation. What is the difference?

_____

_____

Effects of Mutations

For Questions 10–17, write the letter of the correct answer on the line at the left.

_____ **10.** The cellular machinery that replicates DNA inserts an incorrect base

A. most of the time.

B. about half the time.

C. roughly once in every million bases.

D. roughly once in every 10 million bases.

_____ **11.** Small changes in genes

A. disappear quickly.

B. gradually accumulate over time.

C. prevent the next generation from developing.

D. do not affect future generations.

_____ **12.** A possible mutagen is

A. an anticodon.

B. translocation.

C. hemoglobin.

D. ultraviolet light.

_____ **13.** What happens when cells cannot repair the damage caused by a mutagen?

A. The DNA base sequence changes permanently.

B. The DNA base sequence is not affected.

C. The organism is not affected.

D. The organism is affected temporarily.

_____ **14.** Which of the following most accurately summarizes the effects of mutations on living things?

A. Most mutations are harmful, but some have little effect.

B. Many mutations have little or no effect, but some can be harmful or beneficial.

C. Most mutations are beneficial, and a few are harmful.

D. About half of mutations are beneficial and half are harmful.

_____ **15.** Mutations are important to the evolution of a species because they

A. happen over the long period of time that evolution requires.

B. cut out and replace damaged or useless genes.

C. are a source of genetic variability.

D. accelerate the transcription rate of DNA.

_____ **16.** Cancer is the product of a mutation that

A. causes the uncontrolled growth of cells.

B. changes the structure of hemoglobin in the blood.

C. brings about stunted growth and severe pain.

D. causes a translocation in a pair of chromosomes.

_____ **17.** Polyploidy is the condition in which

A. a piece of a chromosome breaks off and reattaches to another chromosome.

B. an organism has an extra set of chromosomes.

C. a mutagen speeds the mutation rate.

D. an insect develops a resistance to a pesticide.

18. Mutations that change whole chromosomes are called chromosomal mutations. The diagrams below show chromosomal mutations. Each diagram represents an original chromosome and a possible mutation of the chromosome.

Original Chromosome

Deletion

Original Chromosome

Inversion

Original Chromosome

Translocation

Original Chromosome

Duplication

Follow the directions.

1. Use the diagrams to help you complete the table.

Mutation	Description

Answer the questions.

2. Which types of mutations can add genes to a chromosome? _____

3. Which type of mutation can take genes away from a chromosome? _____

4. Which type of mutation changes the order of the genes, but not the number of genes in a chromosome? _____

13.4 Gene Regulation and Expression

Lesson Objectives

- Describe gene regulation in prokaryotes.
- Explain how most eukaryotic genes are regulated.
- Relate gene regulation to development in multicellular organisms.

Lesson Summary

Prokaryotic Gene Regulation Prokaryotes do not need to transcribe all of their genes at the same time. They can conserve energy and resources by regulating their activities, producing only those genes necessary for the cell to function. In prokaryotes, DNA-binding proteins regulate genes by controlling transcription. An **operon** is a group of genes that are regulated together. An example is the *lac* operon in the bacterium *E. coli*:

- This group of three genes must be turned on together before the bacterium can use lactose as food.
- When lactose is not present, the DNA-binding protein called *lac* repressor binds to a region called the **operator,** which switches the *lac* operon off.
- When lactose binds to the repressor, it causes the repressor to fall off the operator, turning the operon on.

Eukaryotic Gene Regulation Transcription factors are DNA-binding proteins. They control the expression of genes in eukaryotes by binding DNA sequences in the regulatory regions. Gene promoters have multiple binding sites for transcription factors, each of which can influence transcription.

- Complex gene regulation in eukaryotes makes cell specialization possible.
- The process by which microRNA (miRNA) molecules stop mRNA molecules from passing on their protein-making instructions is **RNA interference (RNAi).**
- RNAi technology holds the promise of allowing scientists to turn off the expression of genes from viruses and cancer cells, and it may provide new ways to treat and perhaps even cure diseases.

Genetic Control of Development Regulating gene expression is especially important in shaping the way a multicellular organism develops. Gene regulation helps cells undergo **differentiation,** becoming specialized in structure and function. Master control genes are like switches that trigger particular patterns of development and differentiation in cells and tissues.

- **Homeotic genes** are master control genes that regulate organs that develop in specific parts of the body.
- **Homeobox genes** share a similar 130-base DNA sequence called homeobox. They code for transcription factors that activate other genes that are important in cell development and differentiation in certain regions of the body.
- **Hox genes** are a group of homeobox genes that tell the cells of the body how to differentiate as the body grows.

Environmental factors can also affect gene expression.

Prokaryotic Gene Regulation

1. How do prokaryotes conserve energy?

2. How do DNA-binding proteins in prokaryotes regulate genes?

3. What is an operon?

4. What is in the *lac* operon in *E. coli*?

5. What is the function of the genes in the *lac* operon of *E. coli*?

6. What turns the *lac* operon off?

7. How does a repressor protein turn off the *lac* operon?

8. How does lactose turn on the *lac* operon?

9. Complete the table to describe the role of each regulatory region or molecule in the operation of the *lac* operon.

Regulatory Region or Molecule	**What It Does**
Repressor protein	
Operator	
RNA polymerase	
Lactose	

Eukaryotic Gene Regulation

10. In what two ways is gene regulation in eukaryotes different from gene regulation in prokaryotes?

a. _____

b. _____

_____

11. What is a TATA box? What does a TATA box do?

_____

_____

_____

12. What are transcription factors and what do they do?

_____

_____

13. Explain how gene regulation makes cell specialization possible.

_____

_____

14. What is microRNA and how is it related to mRNA?

_____

_____

15. Explain how the process of RNA interference works.

_____

_____

_____

_____

Genetic Control of Development

_____ **16.** As an embryo develops, different sets of genes are regulated by

A. mRNA and *lac* repressors.
C. transcription factors and repressors.
B. operons and operators.
D. promoters and operators.

_____ **17.** The process through which cells become specialized in structure and function is

A. transcription.
C. differentiation.
B. gene expression.
D. RNA interference.

_____ **18.** Homeotic genes are

A. regulator genes that bind to operons in prokaryotes.
B. master control genes that regulate organs that develop in specific parts of the body.
C. parts of the silencing complex that regulates gene action through RNA interference.
D. base sequences complementary to sequences in microRNA.

_____ **19.** What role do homeobox genes play in cell differentiation?

A. They code for transcription factors that activate other genes important in cell development and differentiation.

B. They block certain gene expression.

C. They cut double-stranded loops into microRNA.

D. They attach to a cluster of proteins to form a silencing complex, which binds to and destroys certain RNA.

_____ **20.** In flies, the group of homeobox genes that determines the identities of each segment of a fly's body is the group known as

A. silencing complexes.

B. promoters.

C. operators.

D. Hox genes.

_____ **21.** Clusters of Hox genes are found in

A. flies only.

B. flies and frogs only.

C. plants only.

D. nearly all animals.

_____ **22.** The "switches" that trigger particular patterns of development and differentiation in cells and tissues are

A. mRNA molecules.

B. master control genes.

C. silencing complexes.

D. Dicer enzymes.

_____ **23.** Metamorphosis is

A. a series of transformations from one life stage to another.

B. the master switch that triggers development and differentiation.

C. the product of interactions among homeotic genes.

D. the process by which genetic information is passed from one generation to the next.

24. Environmental factors can influence gene expression. Fill in the table below to show how organisms respond to conditions in their environment.

	Environmental Factor Influencing Gene Expression	**How the Organism Responds**
***E. coli* with limited food supply**	nutrient availability	
A tadpole in a drying pond		

Edpuzzle: DNA vs. RNA

1. What are two functions of DNA?

2. What is the basic function of RNA?

3. Complete the sentence: All living organisms (including eukaryotes & prokaryotes)

4. What type of biomolecule are both DNA and RNA?

5. DNA & RNA are both made up of monomers called _____.

6. Characteristics of DNA include:

7. Characteristics of RNA include:

8. What are the FOUR bases found in DNA?

9. Write the correct base pairs that form in DNA.

10. What are the FOUR bases found in RNA?

11. Write the correct base pairs that form in RNA.

12. What is the job of mRNA?

13. What are the three types of RNA?

14. What would be the complementary DNA bases for this strand? ATTGAC

15. What would be the complementary RNA bases for this strand? ATTGAC

Edpuzzle: Protein Synthesis

1. What “codes” for proteins that your body uses to make eye pigment, hair color, hair texture, and etc.?

2. What does protein synthesis mean?

3. Where is DNA located in eukaryotes?

4. What is NOT different between RNA and DNA?

5. What is the name of the enzyme that is responsible for building a mRNA strand that is complementary to a DNA template strand?

6. Which RNA strand is transcribed from DNA to carry a message?

7. Write a summary of transcription.

8. What is the monomer of proteins?

9. Which molecule has ***codons*** and is used to tell tRNA which amino acid is needed?

10. What is a codon?

11. What molecule is responsible for transferring amino acids to the ribosome during translation?

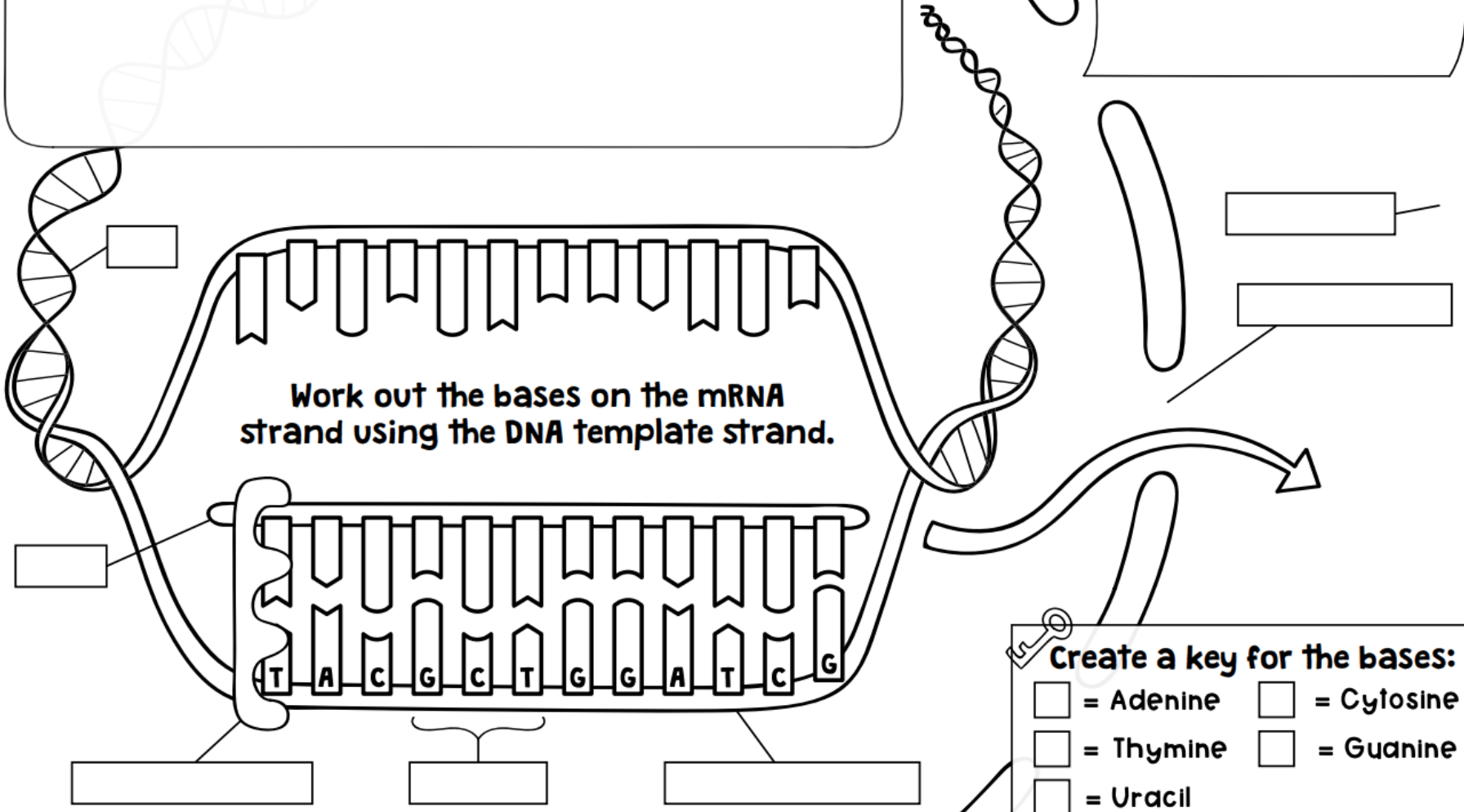
12. Write a summary of translation.

Transcription

How does transcription work?

How is RNA different to DNA?

Uracil



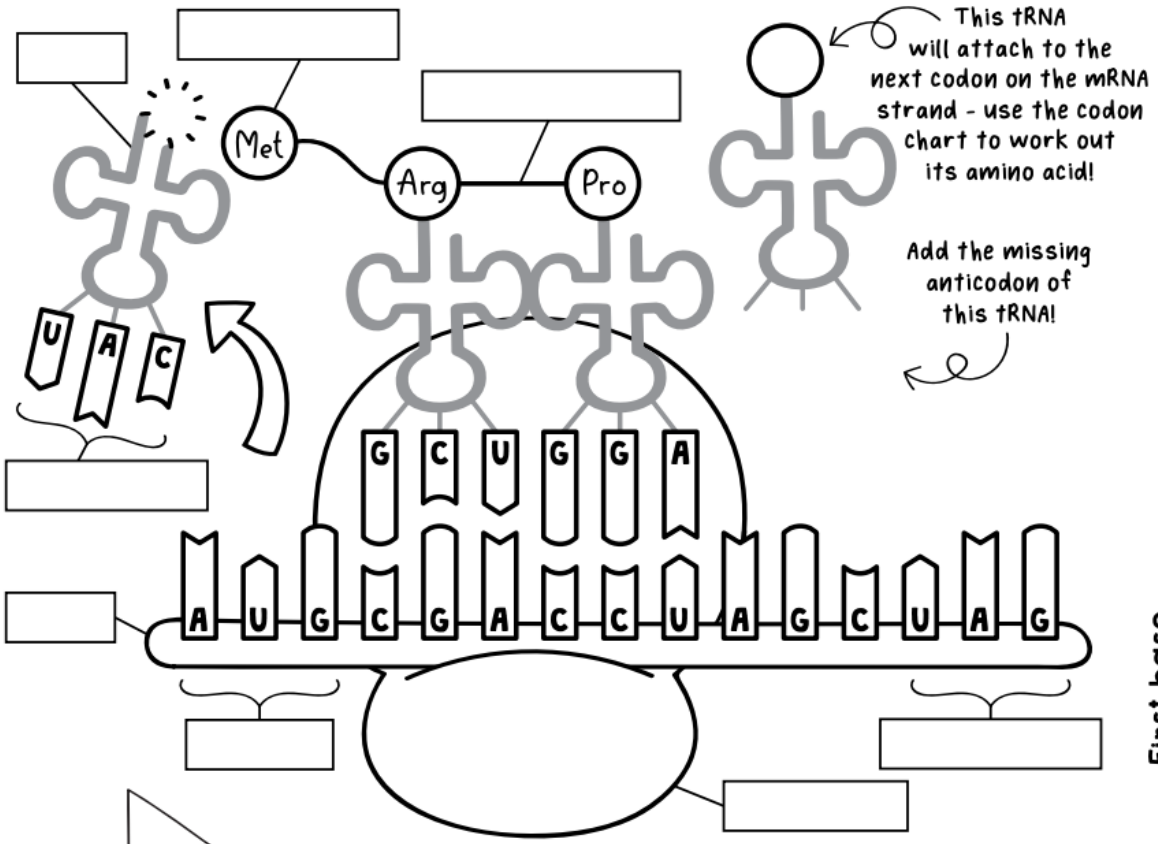
Create a key for the bases:

= Adenine = Cytosine

= Thymine = Guanine

= Uracil

Translation



How does translation work?

<<< Codon charts >>>

Use the codon chart & what you've learnt to work out the missing information:

mRNA codons UAC - ACC - GUC

amino acids

Reminder: RNA has Uracil - not Thymine!

DNA triplets GCA - AAT - ACC

mRNA codons

amino acids

Second base

First base	U	C	A	G	Third base
U	phe phe leu leu	ser ser ser ser	tyr tyr STOP STOP	cys cys STOP trp	U C A G
C	leu leu leu leu	pro pro pro pro	his his gln gln	arg arg arg arg	U C A G
A	ile ile ile met	thr thr thr thr	asn asn lys lys	ser ser arg arg	U C A G
G	val val val val	ala ala ala ala	asp asp glu glu	gly gly gly gly	U C A G

MUTATIONS

What are mutations and how do they happen?

There are three types of mutations – summarize each one using a doodle or description. Then draw the bases of each mutated DNA strand using the original DNA strand!

ORIGINAL DNA STRAND

SUBSTITUTION

The fifth base is exchanged for cytosine.

INSERTION

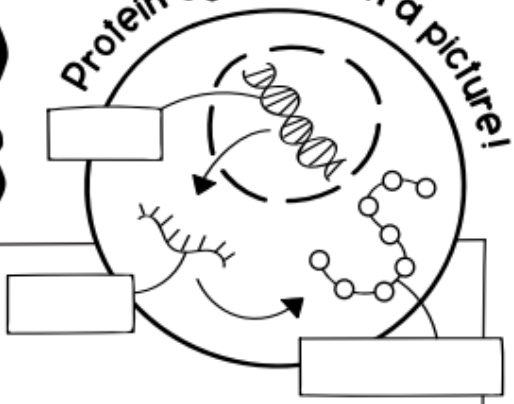
A guanine is inserted before the fourth base.

DELETION

The second base is deleted from the DNA strand.

EFFECTS OF MUTATIONS

Protein Synthesis in a picture!

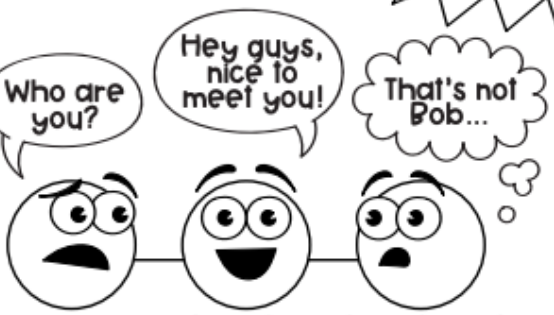


Explain why DNA mutations can impact the proteins synthesized in a cell.

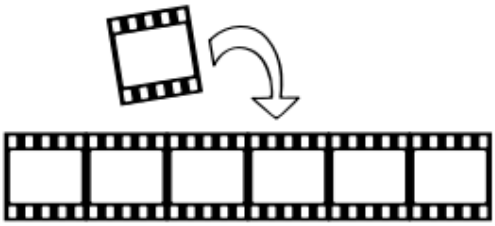
Describe the effect of each type of mutation on the amino acids coded for.

SILENT MUTATION

MISSENSE MUTATION



FRAMESHIFT MUTATION



NONSENSE MUTATION

Highlight the difference in the original & mutated DNA sequences, and then state the type of mutation.

PRACTICE

practice makes perfect after all!

Original DNA sequence	GTGATACGC			
Mutated DNA sequence	GAGATACGC	GTGAACGC	GTGATACGT	GTGATTACGC
Type of mutation (insertion, deletion or substitution?)				

Now work out the mutated mRNA sequences and the amino acids coded for & finally the effect on the polypeptide!

Original mRNA & amino acids	CACUAUGCG ⇨ His – Tyr – Ala			
Mutated mRNA	CUCUAUGCG	CACUUGCG	CACUAUGCA	CACUAAUGCG
Amino acid chain	○○○	○○○	○○○	○○○
Mutation effect (Missense, frameshift, nonsense or silent?)				

This is a mRNA codon chart – use it to work out the amino acids!

IMPACT

Second base

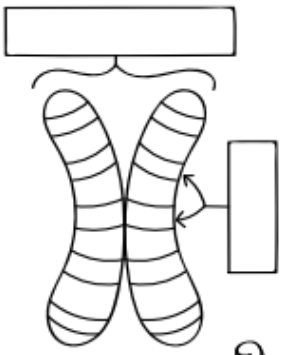
First base	U	C	A	G	Third base
U	phe	ser	tyr	cys	U
	phe	ser	tyr	cys	C
	leu	ser	STOP	STOP	A
	leu	ser	STOP	trp	G
C	leu	pro	his	arg	U
	leu	pro	his	arg	C
	leu	pro	gln	arg	A
	leu	pro	gln	arg	G
A	ile	thr	asn	ser	U
	ile	thr	asn	ser	C
	ile	thr	lys	arg	A
	met	thr	lys	arg	G
G	val	ala	asp	gly	U
	val	ala	asp	gly	C
	val	ala	glu	gly	A
	val	ala	glu	gly	G

✓ beneficial

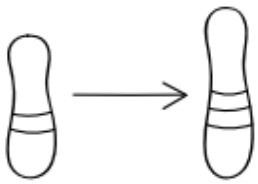
= neutral

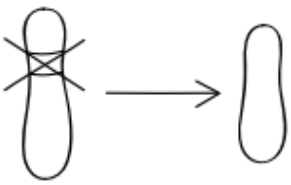
✗ negative

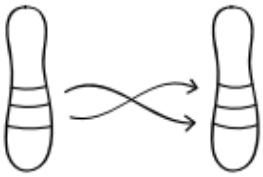
CHROMOSOMAL MUTATIONS

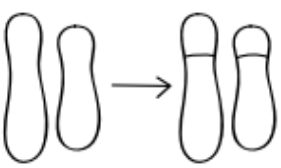


Name each type of chromosomal mutation and describe what is occuring

① 

③ 

② 

④ 

There can also be errors in the NUMBER of chromosomes in the body's cells.

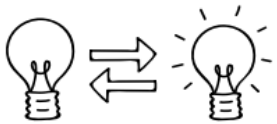
ANEUPLOIDY: Example in HUMANS

POLYPLOIDY: Example in BANANAS

Regulation of GENE EXPRESSION

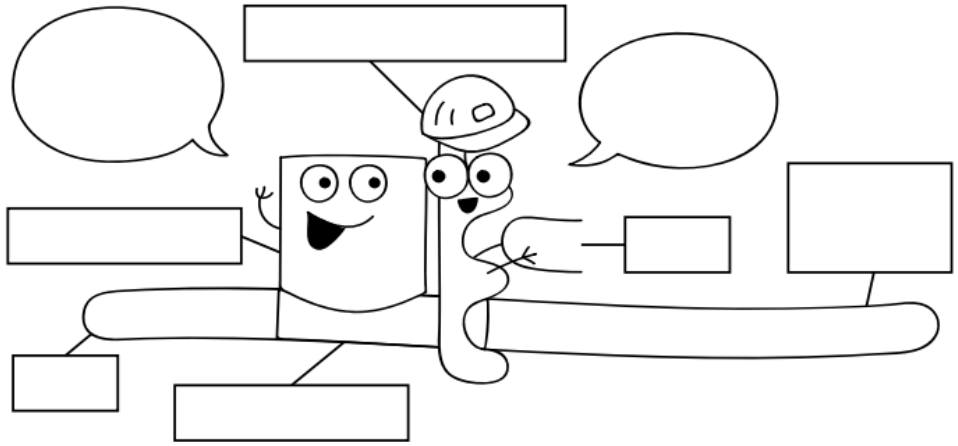
The BIG picture

What is gene expression & why is it important to regulate it?



TRANSCRIPTION FACTORS

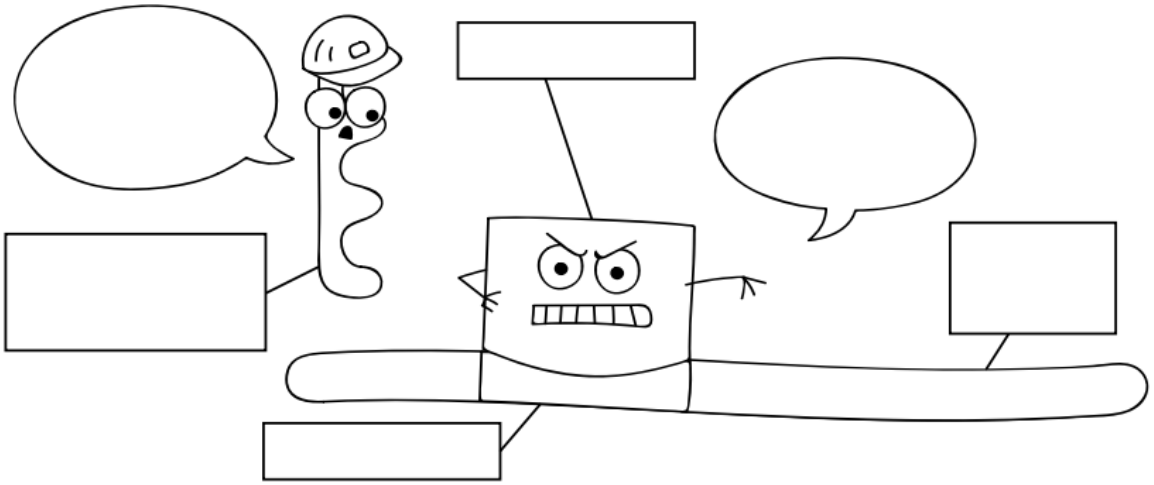
Positive



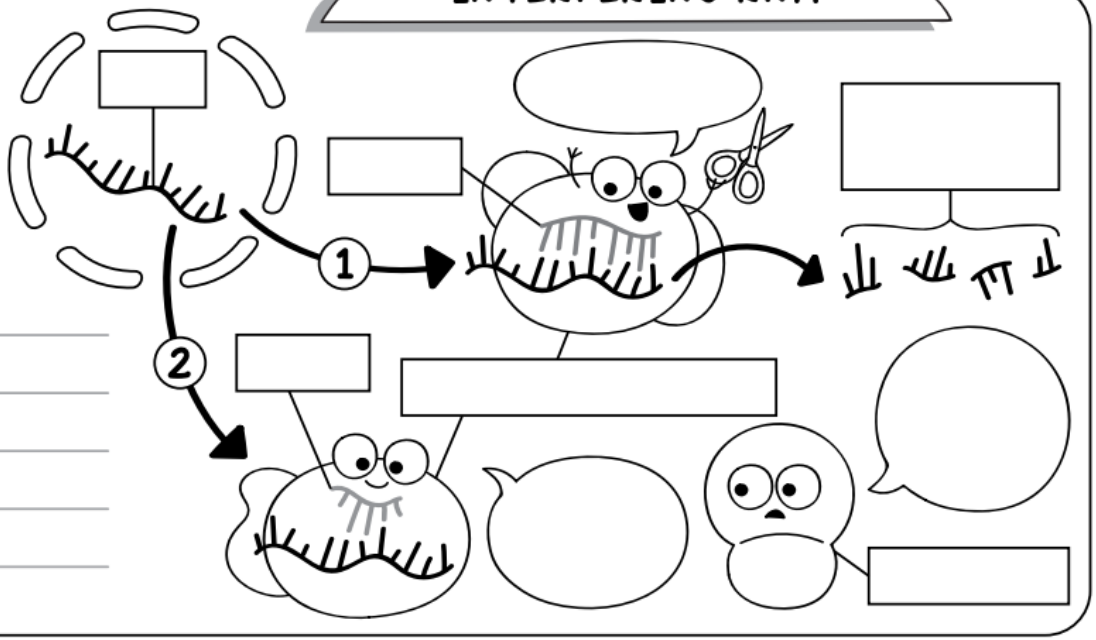
For each mechanism, finish & label the diagram and explain how it affects gene expression

TRANSCRIPTION FACTORS

Negative



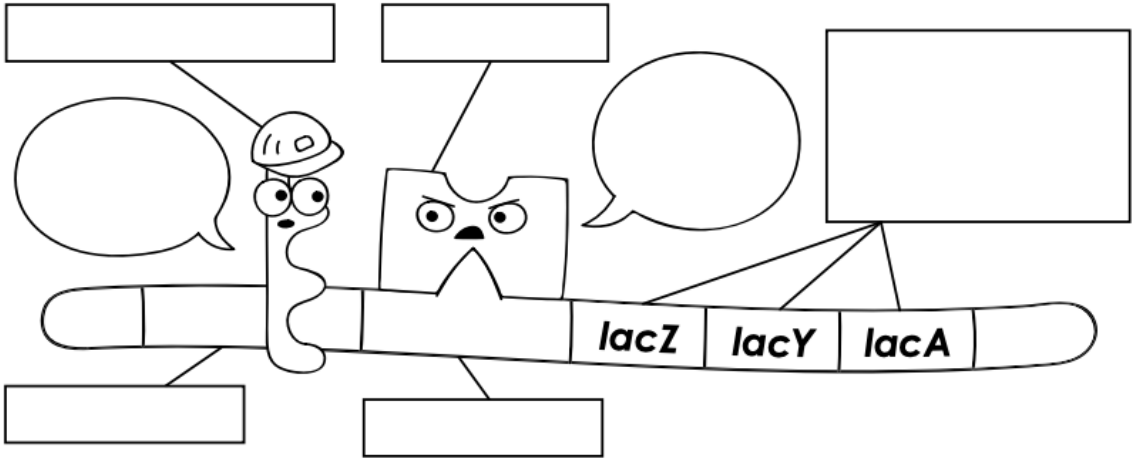
INTERFERING RNA



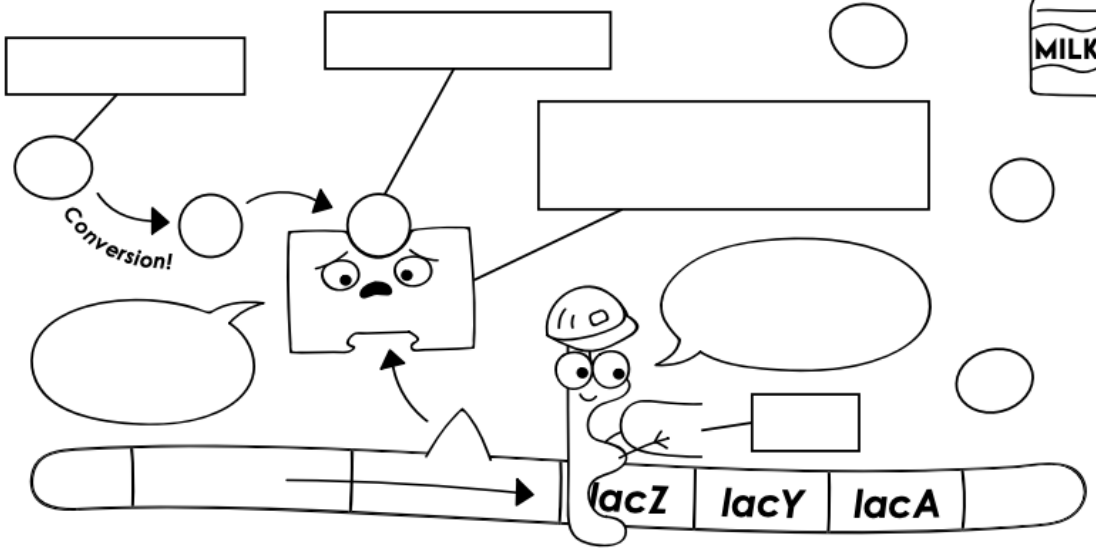
What is an operon? >>>

OPERONS – e.g. The Lac operon

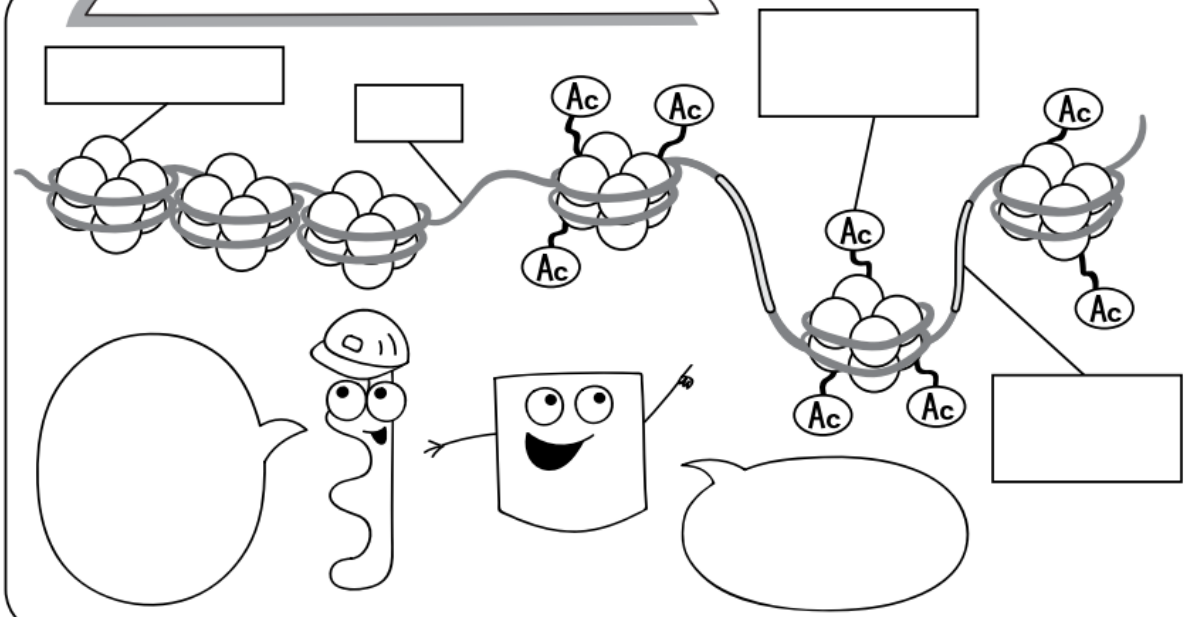
In the absence of lactose:



In the presence of lactose:

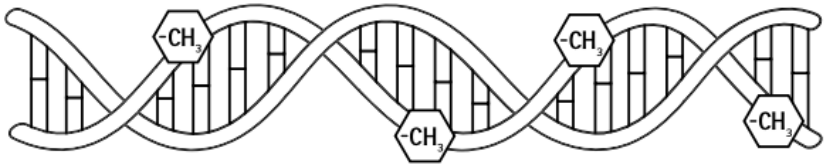


HISTONE ACETYLATION



DNA METHYLATION

Create and use your key to color in the DNA bases so that the methyl groups are only found at CpG sites!



KEY

- ☐ = Aden ne
- ☐ = Thym ne
- ☐ = Cytos ne
- ☐ = Guan ne
- -CH3 = Methyl group

Epigenetics

1. Pick up one strip from each of the body trait plastic bags, and write the DNA strand under the correct heading below.
2. Transcribe the DNA into mRNA.
3. Use the codon chart to figure out what amino acid each strand makes.
4. Use the protein trait chart to figure out the traits for your organism.
5. Draw your organism to show its traits.

<u>Eye Color</u>
DNA:

mRNA:

Amino Acid:

Trait expressed:

<u>Claws</u>
DNA:

mRNA:

Amino Acid:

Trait expressed:

<u>Tail</u>
DNA:

mRNA:

Amino Acid:

Trait expressed:

<u>Eye Shape</u>
DNA:

mRNA:

Amino Acid:

Trait expressed:

Horn Color
DNA:

mRNA:

Amino Acid:

Trait expressed:

Body Color
DNA:

mRNA:

Amino Acid:

Trait expressed:

Organism Drawing:

Original Protein Trait Chart

Eye Color

Phe	Gln	Arg	Lys	Val	**Blue**
Phe	Gln	Met	Ala	Ile	**Green**
Phe	Gln	Met	Ala	Gly	**Orange**

Claws

Val	Pro	Gly	Arg	Gln	**Short**
Val	Pro	Gly	Arg	Thr	**Long**
Val	Pro	Ala	Gln	Val	**No claws**

Tail

Ala	Ala	Tyr	Cys	Ala	**Spikey**
Ala	Ala	Tyr	Leu	Ala	**Curly**
Ala	Ala	Tyr	Glu	Ala	**Straight**

Eye Shape

Leu	Asn	His	Ser	Val	**Almond**
Leu	Asn	His	Ser	Leu	**Circle**
Leu	Asn	His	Ser	Cys	**Teardrop**

Horn Color

Ala	Pro	Cys	Ser	Gln	**Yellow**
Ala	Ser	Cys	Ser	Asp	**Orange**
Ala	Thr	Cys	Pro	Leu	**Red**

Body Color

Leu	His	Tyr	Cys	Arg	**Pink**
Leu	Lys	Tyr	Cys	Cys	**Purple**
Leu	Asn	Tyr	Cys	Gly	**Blue**

Monster Mutations

Your monster is mutating! Decode the mutations in your monster's DNA to determine how the mutations affect your monster. If your DNA strand did not change, write no mutation.

Eye Color
DNA:

mRNA:

Amino Acid:

Trait expressed:

Claws
DNA:

mRNA:

Amino Acid:

Trait expressed:

Tail
DNA:

mRNA:

Amino Acid:

Trait expressed:

Eye Shape
DNA:

mRNA:

Amino Acid:

Trait expressed:

Horn Color
DNA:

mRNA:

Amino Acid:

Trait expressed:

Body Color
DNA:

mRNA:

Amino Acid:

Trait expressed:

Organism 2 Drawing:

Mutations Protein Trait Chart

Eye Color

Phe	His	Arg	Lys	Val	**1 Blue Eye**
Phe	Ser	Asp Acid	Gly	Arg	**3 Brown Eyes**

Claws

Val	Pro	Leu	Val	Gly		**Talons**
Val	Val	Pro	Ala	Gln	Val	**Crab**

Tail

Ala	Cys	Tyr	Ala	Ala	**Scales**
Ala	Ala	STOP			**Fur**

Eye Shape

Leu	Asn	His	Arg	Cys	**Triangle**
Leu	Asn	His	Ile		**Star**

Horn Color

Ala	Ser	Ser	Cys	Ser	Asp	**Rainbow**
Leu	Pro	Cys	Thr	Ala		**Stripes**

Body Color

Ser	His	Tyr	Cys	Arg		**Polka Dots**
Leu	Leu	Asn	Tyr	Cys	Gly	**Checkers**

Reflection Questions:

1. Explain how your mutation(s) did or did not affect your organism.

2. Why are not all mutations necessarily bad?

3. Are mutations always something that you would be able to see? Explain.

4. Why may some genetic mutations not be something that is known to a person until later on in life?

Lesson Review Questions

Lesson 13.1: RNA

1. _____
2. _____
3. _____
4. _____
5. _____

Lesson 13.2: Ribosomes and Protein Synthesis

1. _____
2. _____
3. _____
4. _____
5. _____

Lesson 13.3: Mutations

1. _____
2. _____
3. _____
4. _____
5. _____

Lesson 13.4: Gene Regulation and Expression

1. _____
2. _____
3. _____
4. _____
5. _____

RNA & Protein Synthesis Quiz Review

Terms to Know -

RNA	Messenger RNA	Ribosomal RNA	Transfer RNA
Transcription	Translation	RNA Polymerase	Promoters
Introns	Exons	Polypeptide	Codon
Anticodon	Central Dogma	Amino Acid	

Transcription

- What does RNA stand for?
- How is RNA different from DNA?
- What are the three types of RNA and what is their function in protein synthesis?
    - Be able to identify their structure
- Where does Protein synthesis take place in Eukaryotes and prokaryotes?
- What is the role of RNA Polymerase?
    - What does RNA Polymerase bind to?
- How is RNA “edited”?
- Given a DNA template strand, be able to write BOTH the Complementary DNA strand and the mRNA strand.
    - Know RNA base pairs
- What is the beginning and final product of Transcription?

Translation

- What is the beginning and final product of Translation?
- The genetic code reads three _____ at a time, so that each “word” is three bases long and corresponds to a single _____ _____. Each three letter “word” in mRNA is known as a _____.
    - What is an anticodon and where is it located?
- How does a chain of amino acids know when to stop?
- What is the name of the only START codon?
    - How many STOP codons are there? What are they?
- What is the Central Dogma?
- Given a strand of mRNA, be able to identify the codons, the matching anticodon, and use the codon chart to determine the corresponding amino acid.

Final Exam
Modeling the Central Dogma
Outline

As our final exam you will each be individually completing a project of the entire Central Dogma. This project is going to encompass all of the things we have covered since the change of the quarter. You will be creating a well detailed flipbook/children's book. We will be working on this for 6 days in class (some days are partial class periods), anything you do not finish in those 6 days will become your responsibility to finish on your own time. Also keep in mind that some ALL of the information you need to complete this project will come from your note packets, Doodle Notes, previous work, Edpuzzles or the book.

Content that must be included:

DNA

- Structure of DNA: 3 components of a nucleotide, 4 Bases, Covalent and Hydrogen Bonds, double or single stranded
- Steps of Replication process: Helicase, DNA Polymerase, Ligase,
- Characteristics of Prokaryotic DNA vs. Eukaryotic DNA

RNA

- Structure of RNA: 3 components of a nucleotide, 4 Bases, double or single stranded
- Steps of Transcription: location of synthesis (Prokaryote vs. Eukaryote), RNA Polymerase, Promoters, Introns, Exons, example of DNA template strand being transcribed into mRNA with 6 codons
- Steps of Translation: 3 types of RNA, continue example of mRNA being translated into Amino Acids to form a Polypeptide

Mutations

- Make your own "Monster Mutation" example
    - Using your original DNA strand from above as your original monster trait. Then create a new DNA template strand with a chosen mutation, transcribe to mRNA to determine the new mutated trait.

Other things that must be included:

- Summary/explanation paragraph of each structure/process/phase
- Color
- Labels/drawings
- Neatness/spelling
- **Turn this sheet in with your project on the due date to be graded**

*ALL of the information you need to complete this project will come from your note packets, Doodle Notes, previous work, Edpuzzles or the book. This means that any cutting and pasting from Google will be considered plagiarism. Any form of plagiarism will result in earning a 0 for the project.

Final Exam- Modeling the Central Dogma

Name: _____

Category	Points Possible	Points Earned
Structure of DNA	**10**	
DNA Replication	**15**	
Structure of RNA	**10**	
Process of Transcription	**15**	
Process of Translation	**15**	
Mutation Example	**15**	
Color	**10**	
Neatness/Spelling	**10**	
Total Score	**100**	