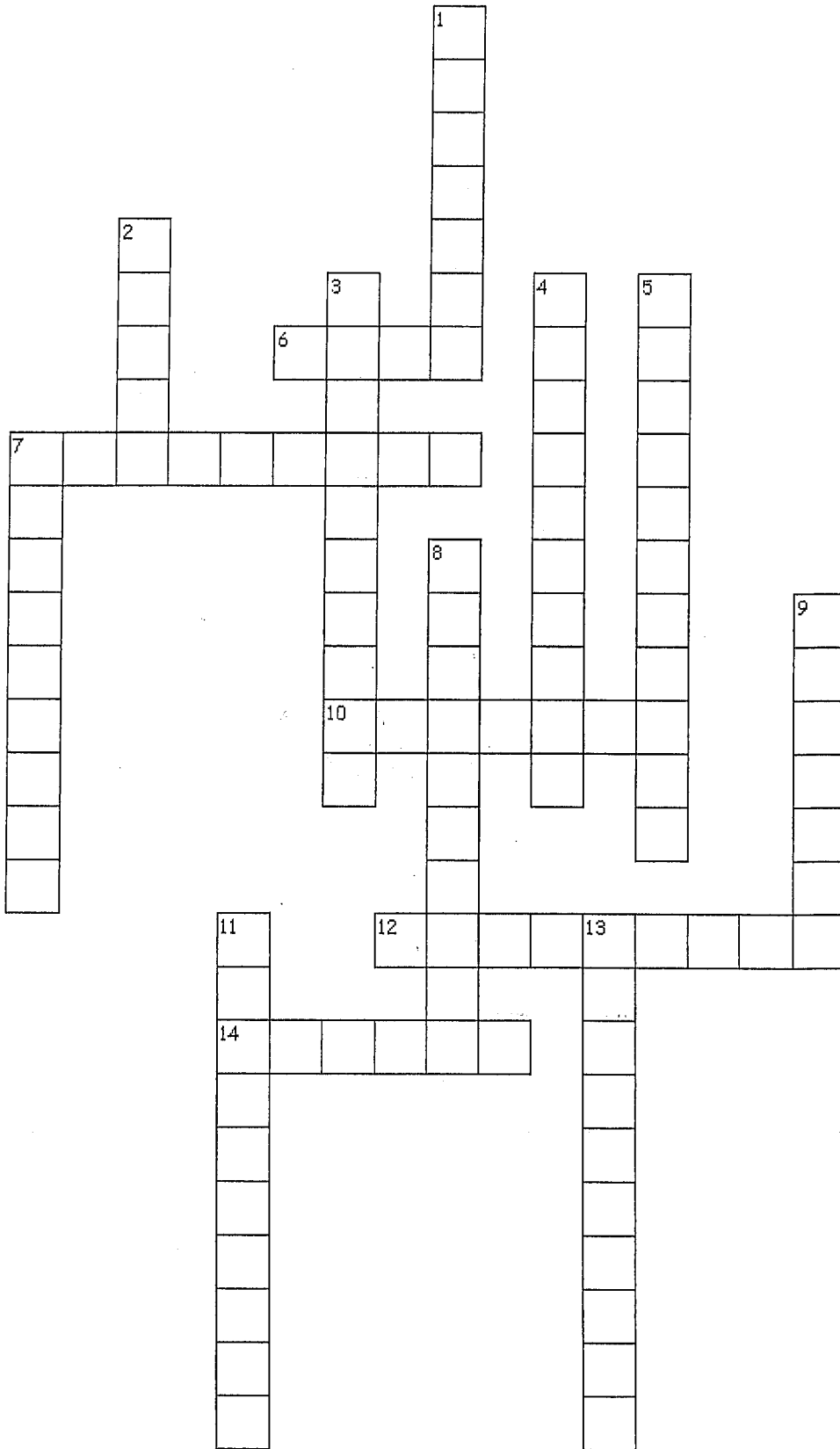


Ch 10 Crossword/ Vocab -



Across

6. a unit of heredity that consists of a segment of nucleic acid that codes for a functional unit of RNA or protein
7. the substance of which eukaryotic chromosomes are composed
10. in eukaryotic cells, a process of cell division that forms two new nuclei, each of which has the same number of chromosomes
12. the life cycle of a cell
14. a group of diseases characterized by uncontrolled growth and spread of abnormal cells

Down

1. a network of microtubules that forms during mitosis and moves chromatids to the poles
2. a growth that arises from normal tissue but that grows abnormally in rate and structure and lacks a function
3. an organelle that contains the centrioles and is the center of dynamic activity in mitosis
4. the period of the cell cycle during which activities such as cell growth and protein synthesis occur without visible signs of cell division
5. the division of the cytoplasm of a cell
7. one of the two strands of a chromosome that become visible during meiosis or mitosis
8. the region of the chromosome that holds the two sister chromatids together during mitosis
9. a type of protein molecule found in the chromosomes of eukaryotic cells but not prokaryotic cells
11. a eukaryotic structural unit of chromatin that consists of DNA wound around a core of histone proteins
13. in a eukaryotic cell, one of the structures in the nucleus that are made up of DNA and protein; in a prokaryotic cell, the main ring of DNA

Gene

Chromosome

Chromatin

Histone

Nucleosome

Chromatid

Centromere

cell cycle

interphase

mitosis

cytokinesis

spindle

centrosome

cancer

tumor

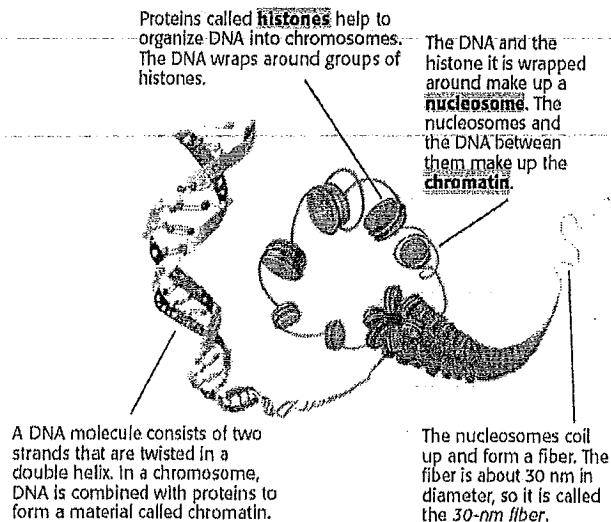
Chapter 10 Cell Growth and Division

I. **REPRODUCTION**- Because _____ cells are more difficult to maintain, cells divide when they grow to a certain size. The size of an organism does not increase by increasing cell size but by increasing the _____.

- A. New cells are needed to help tissues and organs _____. New cells also replace _____ cells. As old cells die and new cells take their place.
- B. A cell's ability to exchange substances is limited by its _____. As a cell gets larger, substances must travel farther to reach where they are needed.
- C. The work of cells is done by _____. As a cell gets larger, more _____ are required to maintain its function.
- D. If the cell gets too large, _____ instructions cannot be copied quickly enough to make the proteins that the cell needs to support itself.

II. **CHROMOSOMES**-chromosomes are the _____ DNA of the cell. The way DNA is stored and read differs between eukaryotes and prokaryotes.

- A. **PROKARYOTES**- Prokaryotic chromosomes also have genes which code for proteins and RNA for the prokaryotic cell functions.
 - 1. A prokaryotic cell has a single _____ molecule of DNA. This loop of DNA contains thousands of genes.
 - 2. A prokaryotic chromosome is condensed through repeated _____ or _____, like a rubber band twisted many times.
- B. **EUKARYOTES**- Eukaryotic DNA is packaged into highly condensed _____ structures to fit in the nucleus with the help of many proteins.



1. The large molecule of DNA is organized into hereditary units called _____ . A _____ is a segment of DNA that codes for the RNA and proteins of a particular trait (ex hair color).
2. The DNA and proteins make up a substance called _____.
3. The first level of packaging is done by a class of proteins called _____ . A group of eight histones come together to form a disc-shaped histone core.
4. The long DNA molecule is wound around a series of histone cores in a regular manner and is called a _____.
5. The string of _____ lines up in a spiral to form a cord that is 30 nm in diameter.
6. During most of a cell's life, its chromosomes exist as _____.
7. As the cell prepares to divide, the chromosomes condense even further ensuring that the extremely long DNA molecules do not get tangled up during cell division.
8. The nucleosome cord forms loops then coil into the final, most highly condensed form of the chromosome.
9. Each of the two thick strands of a fully condensed, duplicated chromosome is called a _____.
10. Each chromatid is made of a single, long molecule of DNA.
11. Identical pairs, called _____ chromatids, are held together at a region called the _____.
12. During cell division, the sister chromatids are separated at the centromere, and one ends up in each _____ cell.
13. Each new cell has the same genetic information as the parent cell.

III. PREPARING FOR CELL DIVISION- The process of cell division involves more than cutting a cell into two pieces. Each new cell must have all of the equipment needed to stay alive. Each new cell will function in the same way as the cells that they replace.

A. Prokaryotes-prokaryotic cell division is more simple than eukaryotic division

1. In prokaryotic cells, the circular DNA molecule is attached to the inner cell membrane.
2. The cytoplasm is divided when a new cell membrane forms between the two DNA copies. Meanwhile the cell continues to grow until it nearly doubles in size.
3. The cell is constricted in the middle, like a long balloon being squeezed near the center.
4. Eventually the dividing prokaryote is pinched into two independent daughter cells, each of which has its own circular DNA molecule.

B. Eukaryotes

1. Eukaryotic cells have many organelles. In order to form two living cells, each daughter cell must contain enough of each organelle to carry out its functions.

- The DNA within the nucleus must also be copied, sorted, and separated.

IV. **EUKARYOTIC CELL CYCLE**-The life of a eukaryotic cell cycles through phases of growth, DNA replication, preparation for cell division, and division of the nucleus and cytoplasm. The _____ is a repeating sequence of cellular growth and division during the life of a cell. The cell cycle is made up of five phases. The first three phases together are known as interphase. The remaining two phases make up cell division.

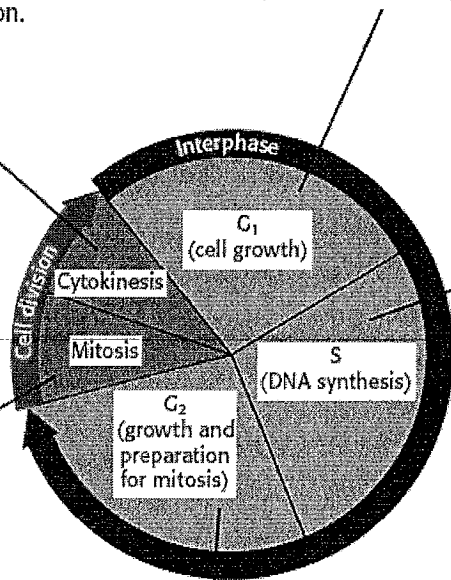
A. _____-During interphase, the cell is not dividing. It is growing and preparing to divide. Different types of cells spend different amounts of time in interphase. Cells that divide often, such as skin cells, spend less time in interphase. Cells that divide seldom, such as nerve cells, spend most of their time in interphase. There are 3 parts of interphase.

- G₁- During the _____ (G₁), a cell grows rapidly as it builds more organelles. For most organisms, this phase occupies the major portion of the cell's life.
- S- During the _____ (S), a cell's DNA is copied. At the end of the S phase, the cell's nucleus has twice as much DNA as it did in the G₁ phase.
- G₂- During the _____ (G₂), the cell continues to grow and prepares to divide. Hollow protein fibers called microtubules are organized in the cytoplasm during G₂.

During the *first gap phase*, or G₁ phase, the cell is growing and producing new organelles. Most cells spend most of their lives in the G₁ phase. A cell leaves the G₁ phase when it is preparing for cell division.

During **cytokinesis**, the organelles and cytoplasm of the cell divide. Two daughter cells form. Each daughter cell contains about half of the cytoplasm and organelles of the original cell.

During **mitosis**, the nucleus of the cell divides and forms two nuclei. Each nucleus contains a complete set of chromosomes.



During the *synthesis phase*, or S phase, the cell's DNA is copied. At the end of the S phase, the cell's nucleus contains twice as much DNA as it did during the G₁ phase.

During the *second gap phase*, or G₂ phase, the cell continues to grow and prepares to divide. Special structures form within the cell that will help it to divide.

B. **STAGES OF MITOSIS**- Mitosis is a continuous process that can be observed in four stages: prophase, metaphase, anaphase, and telophase.

1. **Stage 1: Prophase**

- a) Within the nucleus, chromosomes begin to condense
- b) The nuclear membrane breaks down. Outside the nucleus, a special structure called the spindle forms. The spindle is made up of several spindle fibers.
- c) Cells have an organelle called the _____, which helps assemble the spindle.
- d) In animal cells, the centrosome includes a pair of _____.
- e) Before mitosis, the cell's centrosome is duplicated. During prophase, the centrosomes move to opposite poles of the cell.

2. **Stage 2: Metaphase**

- a) During metaphase, the chromosomes are packaged into their most condensed form.
- b) The nuclear membrane is fully dissolved, and the condensed chromosomes move to the center of the cell and line up along the cell's equator.
- c) Spindle fibers form a link between the poles and the centromere of each chromosome.

3. **Stage 3: Anaphase**

- a) Once all of the chromosomes are lined up, the spindle fibers shorten. The spindle fibers shorten by breaking down the microtubules bit by bit.
- b) _____ chromatids move toward opposite poles as the spindle fibers that are attached continue to shorten. Each pole now has a full set of chromosomes.

4. **Stage 4: Telophase**

- a) A _____ forms around the chromosomes at each pole of the cell.
- b) Chromosomes, now at opposite poles, uncoil and change back to their original _____ form.
- c) The spindle dissolves and the spindle fibers break down and disappear.
- d) Mitosis is complete.

C. **CYTOKINESIS**-During cytokinesis, the cell membrane grows into the center of the cell and divides it into two daughter cells of equal size. Each daughter cell has about half of the parent's cytoplasm and organelles. As mitosis ends, _____ begins. The end result of mitosis and cytokinesis is two genetically identical cells in place of the original cell.

1. **Separating the Cytoplasm**

- a) In animal cells and other cells that lack cell walls, the cell is pinched in half by a belt of protein threads.
- b) In plant cells and other cells that have rigid cell walls, the cytoplasm is divided by a cell plate.

V. **CONTROLS**-Cell growth and division depend on protein signals and other environmental signals. Cell division is highly controlled. Signals from surrounding cells or even from other organs can also regulate cell growth and division. Environmental conditions, such as availability of nutrients, the amount of light and temperature, also affect the cell cycle.

VI. **CHECKPOINTS**-Feedback signals at key checkpoints in the cell cycle can _____ or _____ the next phase of the cell cycle. During the cell cycle, a cell undergoes an inspection process to ensure that the cell is ready for the next phase in the cell cycle. There are three main checkpoints in the cell cycle—G1 checkpoint, G2 checkpoint, mitosis checkpoint.

A. _____ Before the cell copies its DNA, the cell checks its surroundings. If conditions are favorable and the cell is healthy and large enough, the cell enters the synthesis phase. If conditions are not favorable, the cell goes into a resting period. Certain cells, such as some nerve and muscle cells, remain in this resting period forever

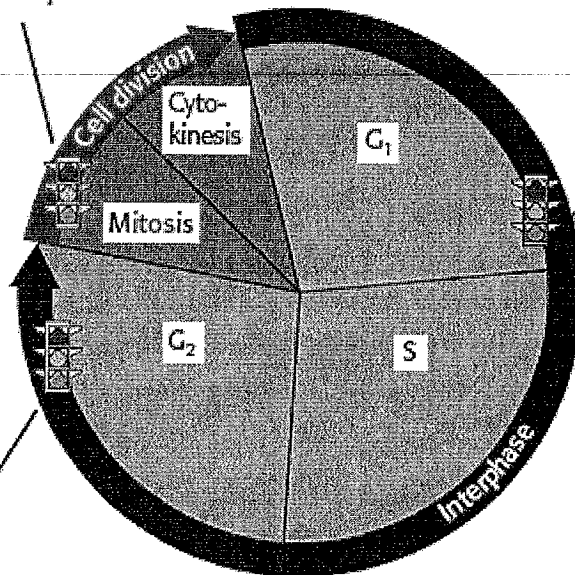
B. _____ - Before mitosis begins, the cell checks for any mistakes in the copied DNA. _____ correct any mistakes. This checkpoint ensures that the DNA of the daughter cells will be identical to the DNA of the original cell. If the cell passes the G2 checkpoint, then the cell may begin to divide. Once past this checkpoint, proteins help to trigger mitosis.

C. _____ - During the metaphase stage of mitosis, chromosomes line up at the equator. At this point, the cell checks that the _____ are properly attached to the spindle fibers. Without this checkpoint, the sister chromatids may not separate properly giving one daughter cell too many genes and one not enough

The *metaphase checkpoint* ensures that genetic material is evenly split between the daughter cells. At this point, the cell checks to make sure that the chromosomes are properly attached to the spindle fibers.

The *G₁ checkpoint* determines whether a cell's DNA is replicated. Before a cell copies its DNA, it checks its surroundings. If conditions are right and the cell is healthy and large enough to divide, the S phase begins.

The *G₂ checkpoint* determines whether mitosis can begin. Before mitosis begins, the copied DNA is checked for errors. Enzymes correct any mistakes. In addition, proteins double-check that the cell is large enough to divide.



VII. **CANCER**-cancer is _____ cell growth and division that can result in masses of cells that invade and destroy healthy tissues. Cancer cell reproduction continues without the normal feedbacks. The defective cell divides and produces more defective cells. Eventually, these cells form a mass called a _____.

A. Development

1. A _____ tumor does not spread to other parts of the body and can often be removed by surgery.
2. A _____ tumor invades and destroys nearby healthy tissues and organs.
3. _____ tumors, or cancers, can break loose from their tissue of origin and grow throughout the body. This process is called _____. Once a cancer has metastasized, it becomes difficult to treat.

B. Treatment

1. Some cancers can be treated by using drugs that kill the fast-growing cancer cells.
2. Because drugs are chemicals, this method of treatment is called _____, or "chemo" for short.
3. Some cancers can be treated by surgery to remove of the affected organ.
4. In _____ therapy, high-energy rays are focused on an area in order to destroy cancerous cells.

C. Usually, when cancer has metastasized, _____ (the likelihood of survival) is poor.

D. Prevention

1. The best way to prevent cancer is to avoid things that can cause cancer (_____)
2. Ultraviolet radiation in sunlight can damage genes that control the cell cycle (skin cancer)
3. Chemicals in cigarette smoke also affect how cell growth and division is regulated.
4. Large amounts of alcohol consumption have been linked to liver cancers
5. Teenage exposure cell phones has been linked to brain cancer (NOT A JOKE)

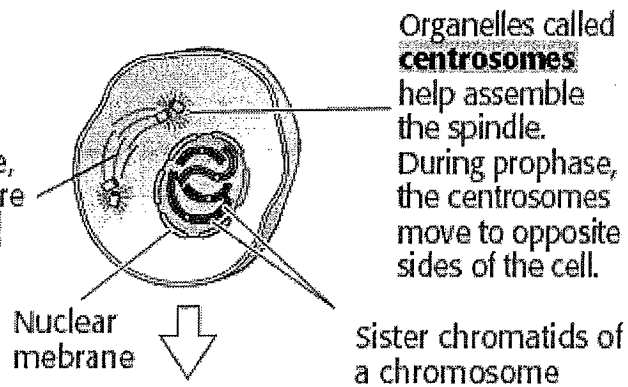
Type of tumor	Description
Benign	<ul style="list-style-type: none"> • does not spread to other parts of the body • most can be removed through surgery
Malignant	<ul style="list-style-type: none"> • invades nearby healthy tissue • pieces of tumor may break off and travel to other parts of the body (metastasis) • can be more difficult to treat than benign tumors

THE STAGES OF MITOSIS

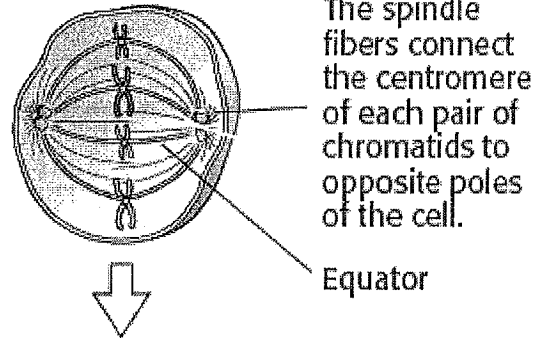
There are four main stages of mitosis, as shown in the figure below.

The first stage of mitosis is *prophase*. During this stage, the chromosomes begin to condense. The nuclear membrane breaks down.

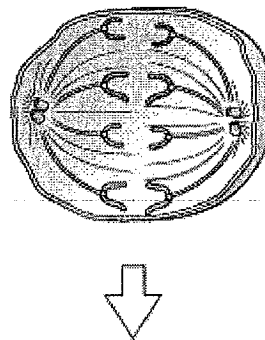
During prophase, a special structure called a **spindle** forms.



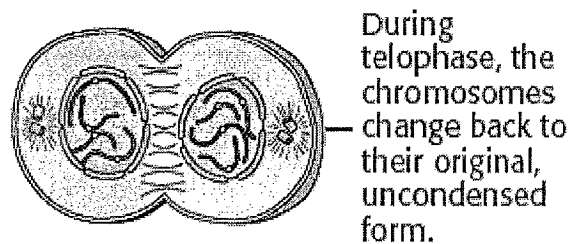
The second stage of mitosis is *metaphase*. During this stage, the chromosomes line up along the equator of the cell.



The third stage of mitosis is *anaphase*. During this stage, the spindle fibers shorten. The chromatids are pulled to opposite sides of the cell.



The final stage of mitosis is *telophase*. During this stage, a new nuclear envelope forms at each pole. The spindle fibers break down and disappear.



1. How is a cell's size related to its need for nutrients? How does this relationship make larger cells harder to maintain?

2. Fill in the blanks below using the terms *chromatin*, *nucleosomes*, *histones*, and *DNA*.

chromosomes			

3. Name two things that happen when a cell prepares to divide.

BELLRINGER

ANSWER:

1. What happens during the G₁ phase of the cell cycle?

2. What two processes make up cell division?

3. What role do spindles play in mitosis?

4. Fill in the blank spaces in the table below.

Stage	Description
	sister chromatids move to opposite sides of the cell
	chromosomes condense; nuclear membrane breaks down
	new nuclear envelopes form around each set of chromosomes; chromosomes uncoil
	chromosomes line up along the equator of the cell

5. How is cytokinesis in plant cells different from cytokinesis in animal cells?

Bellringer: Day M T W Th F Date _____	Question _____
Answer _____	

1. How is cancer related to the cell cycle?

2. Where can signals that regulate the cell cycle come from? Name three sources.

3. Explain what happens at each of the three checkpoints in the eukaryotic cell cycle.

4. How do feedback signals affect the cell cycle?

5. Give two differences between benign tumors and malignant tumors.

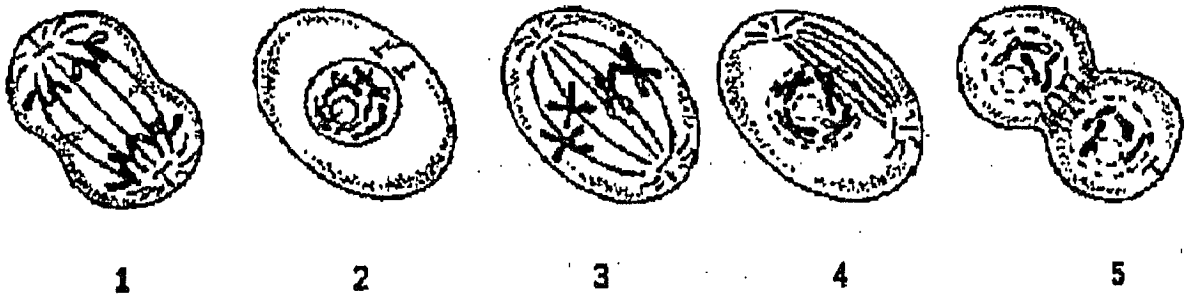
6. Give two examples of things that can make cancer more likely.

Bellringer: Day M T W Th F Date _____ Question _____

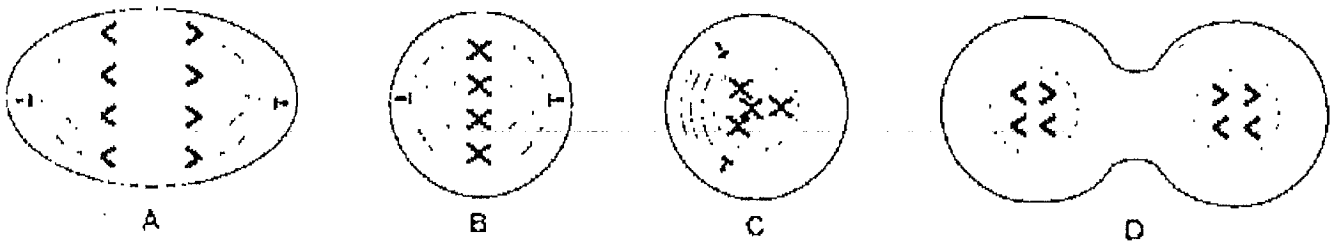
Answer _____

CHAPTER 10 TEST REVIEW

- 1) Why do cells divide?
- 2) What does the chromosome of a bacterium look like?
- 3) What is the region of a chromosome where two sister chromatids are held together called?
- 4) what are chromatids?
- 5) What occurs as the chromosome condenses?
- 6) In order to fit within the cell, how does DNA compact itself? Make sure to mention histones
- 7) How do prokaryotes (bacteria) go through cell division? What occurs? Is a cell wall formed?
- 8) Each cell occupies most of its time in what mitotic stage?
- 9) What occurs after cytokinesis is completed?
- 10) What is the correct sequence of the cell cycle?
- 11) When cells are not dividing, what phase do they remain in?
- 12) What occurs during the synthesis (S) phase?
- 13) what are the first three phases of the cell cycle collectively known as?
- 14) What does mitosis actually accomplish?
- 15) The phase of mitosis that is characterized by the arrangement of all chromosomes along the equator of the cell is called



- 16) These are not ordered. Name the phase they are in and place them in the correct chronological order.

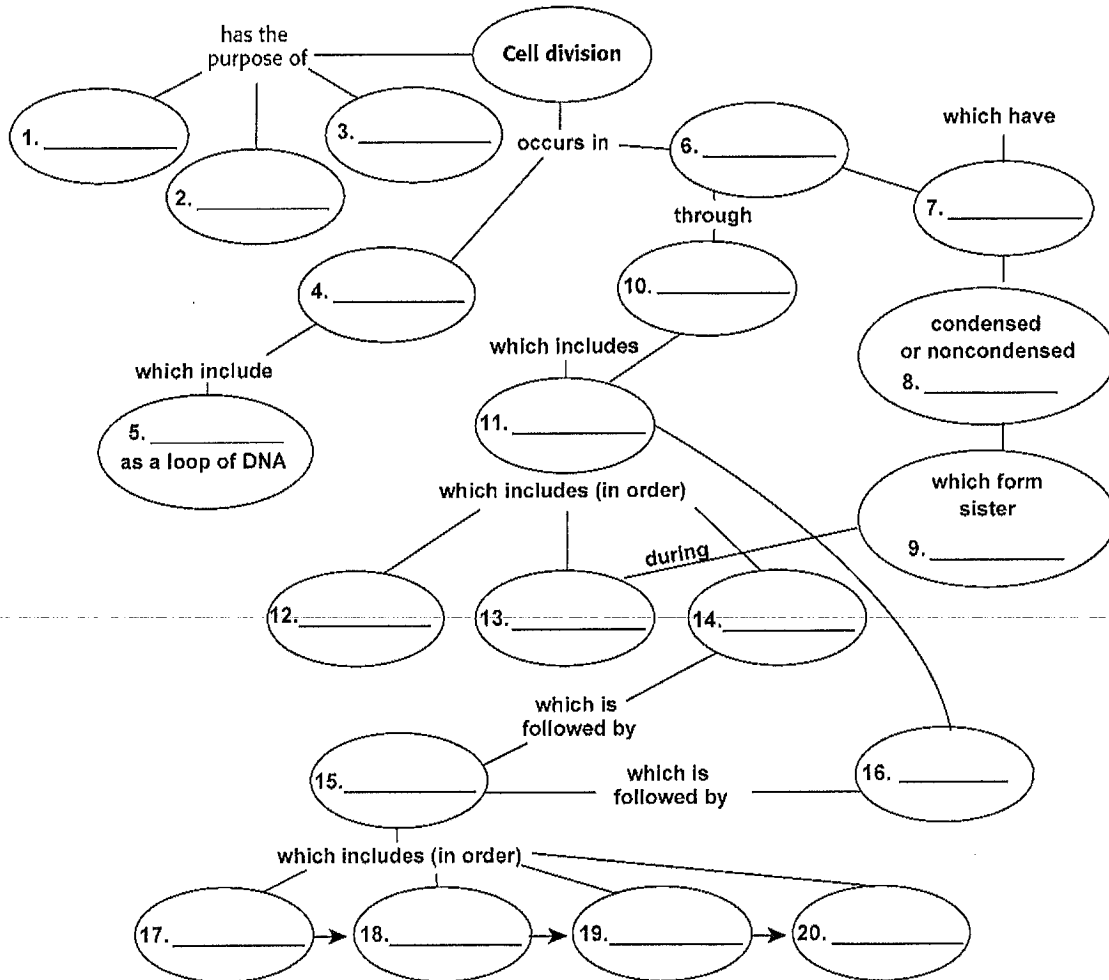


- 17) What stages are each of the drawing is and what order should they be in? At what point in the above diagram do centrosomes centerate.
- 18) how is genetic information divided in the two new cells?
- 19) What is different between the cytokinesis of plant and animal cells

Concept Mapping Ch 10

Using the terms and phrases provided below, complete the concept map showing the principles of cell division.

- | | | |
|----------------|----------------------|--------------|
| anaphase | G ₁ phase | prokaryotes |
| the cell cycle | G ₂ phase | prophase |
| chromatids | growth | replacement |
| a chromosome | interphase | S phase |
| chromosomes | metaphase | telophase |
| cytokinesis | mitosis | wound repair |
| eukaryotes | nucleosomes | |



Number of Cells Resulting from Mitosis

In the human body, the rate of mitosis is about 25 million (2.5×10^7) cells produced per second. By using this rate, you can calculate the number of cells produced by mitosis in a given amount of time.

Procedure

1. Calculate the number of cells produced by mitosis in the time given. For example, to find the number of cells produced in 3 min, determine how many seconds are in 3 min (because the rate is given in seconds).

$$\frac{60 \text{ seconds}}{1 \text{ minute}} \times 3 \text{ minutes} = 180 \text{ seconds}$$

2. Multiply the rate of mitosis by the time (in seconds) given in the problem (180 s).

$$\frac{2.5 \times 10^7 \text{ cells}}{\text{second}} \times 180 \text{ seconds} = 4.5 \times 10^9 \text{ cells}$$

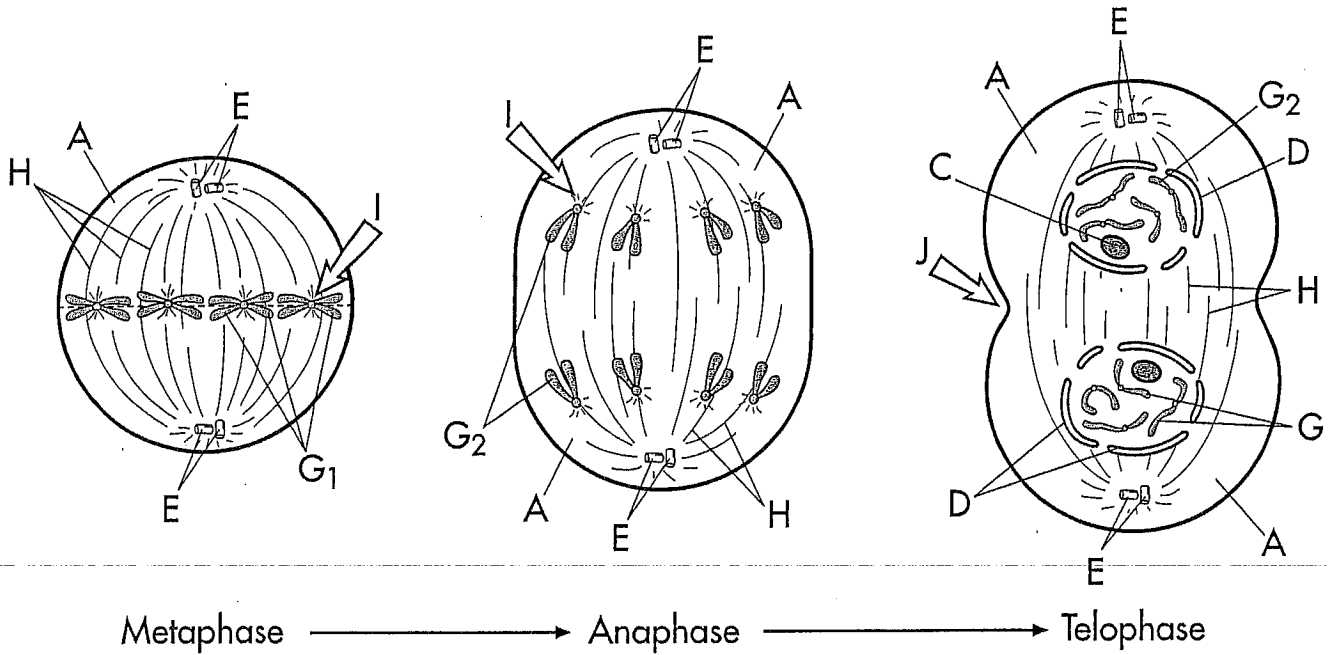
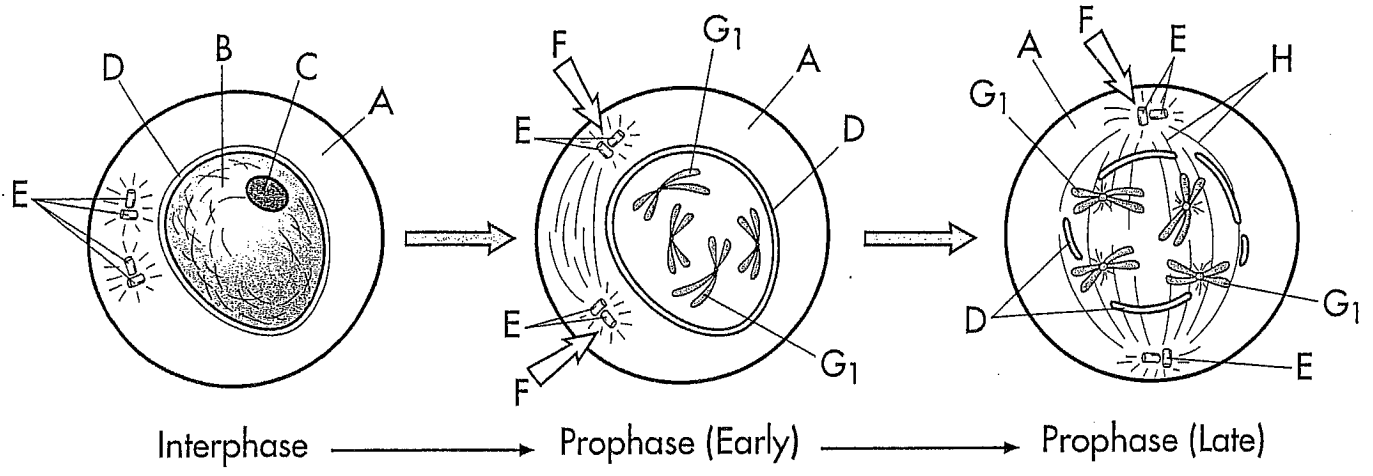
$$4.5 \times 10^9 \text{ cells} = 4,500,000,000 \text{ cells} = 4.5 \text{ billion cells}$$

Analysis

1. Calculate the number of cells that would be produced in 1 h.

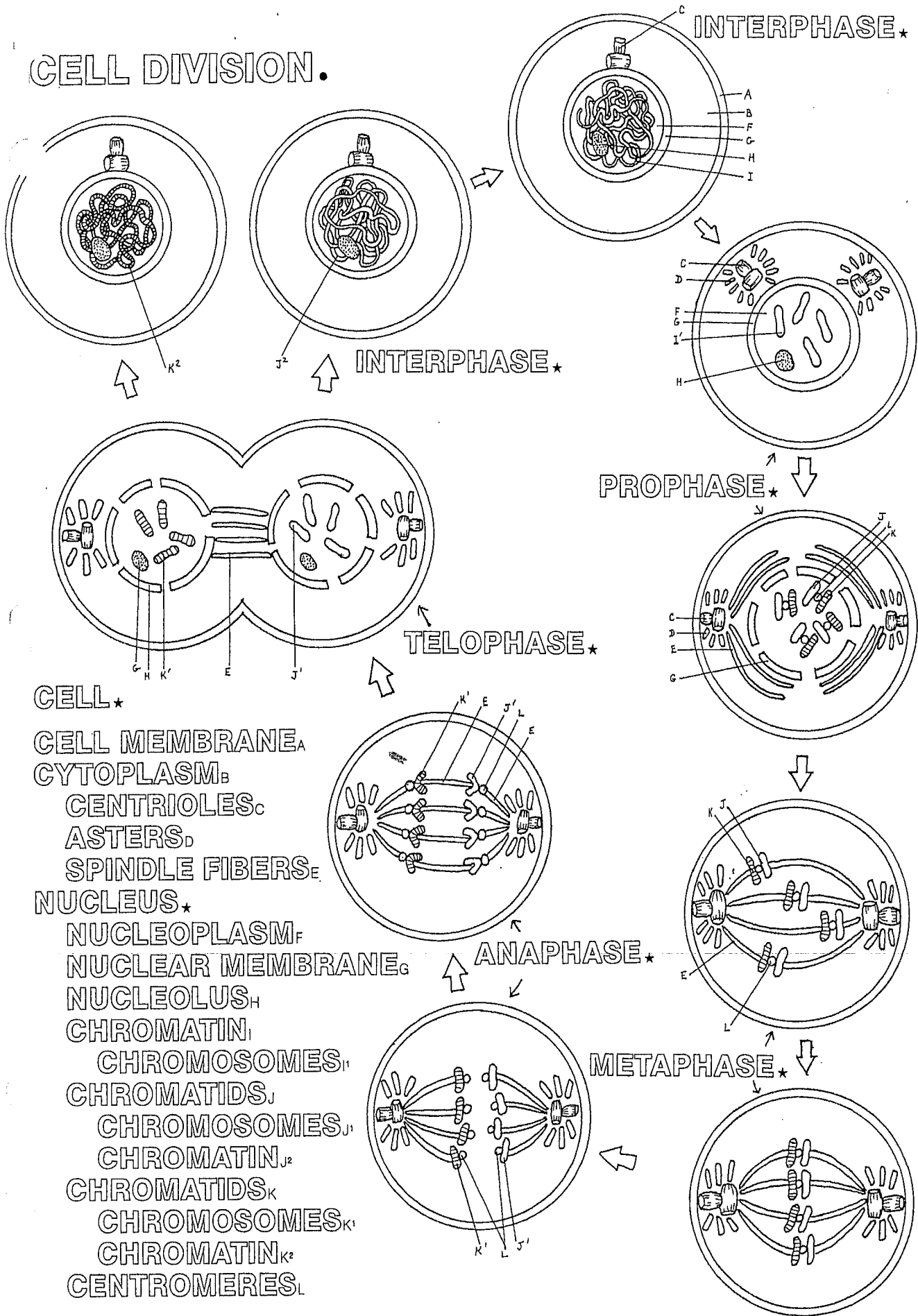
2. Calculate the number of cells that would be produced in 1 day.

3. **Critical Thinking** Identify factors that might increase or decrease the rate of mitosis.

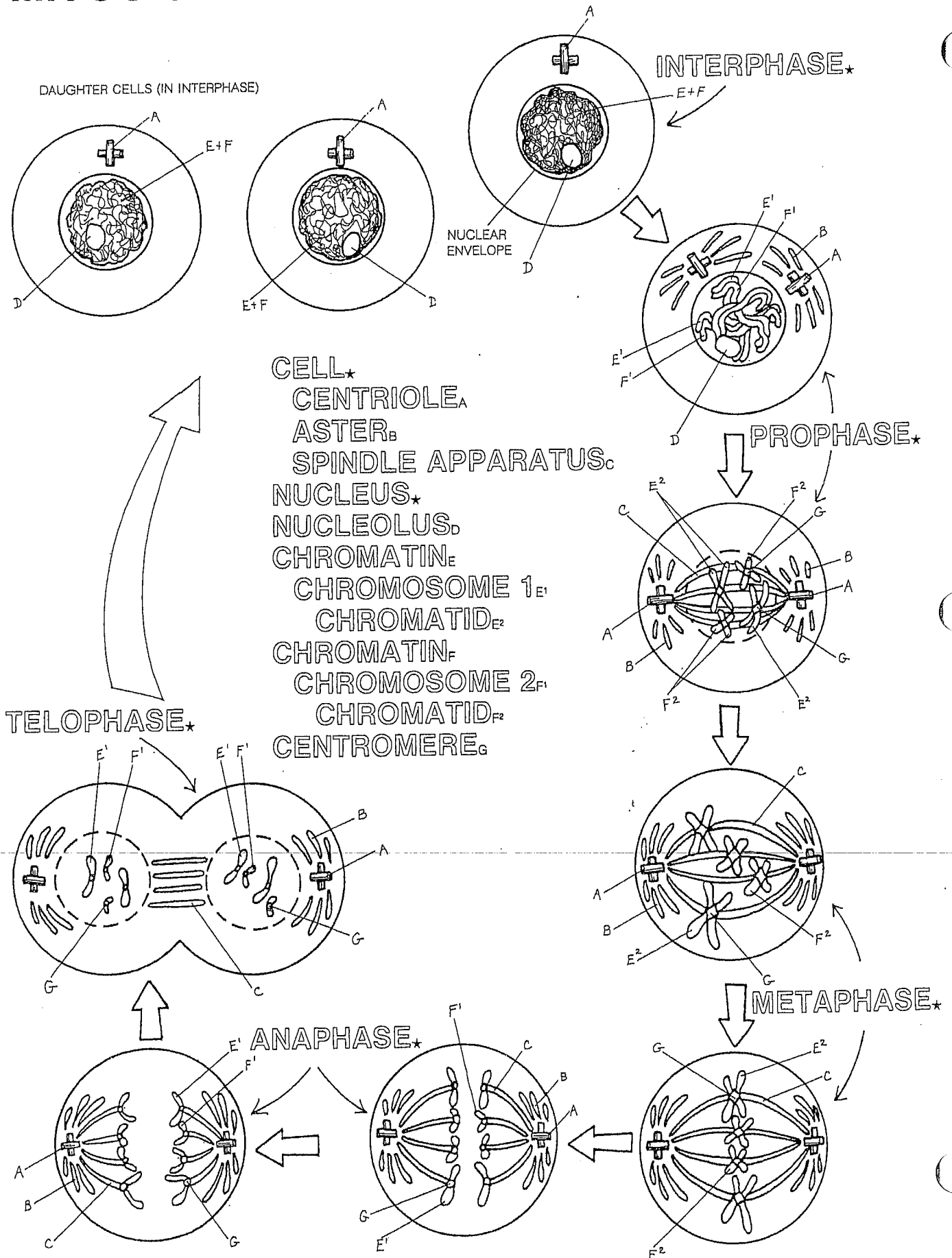


- | Mitosis | | |
|-----------------------------|----------------------------------|-------------------------|
| ○ Cytoplasm.....A | ○ CentriolesE | ○ Spindle FibersH |
| ○ Nucleus (Chromatin).....B | ○ AstersF | ○ Kinetochores.....I |
| ○ Nucleolus.....C | ○ ChromatidsG ₁ | ○ Cleavage Furrow.....J |
| ○ Nuclear MembraneD | ○ Chromosomes.....G ₂ | |

CELL DIVISION.



MITOSIS



Mitosis Flip-Book Project

Purpose: For students to create a visual aid to help them understand the process of mitosis

Materials: 10-20 sheets of paper, or a small pad at least 30 pages long
markers, coloured pencils, etc
stapler or tape to bind the book
textbook, or good diagram of stages of mitosis, for reference

Preparation: Cut each sheet of paper into quarters or eighths. The paper must all be the same size.

Method:

1. You can make your books as detailed as you want, as long as you realize you'll be drawing a lot of very similar pictures.
2. To make a good flip-book, each successive picture should vary a tiny bit from the preceding picture. When you flip the book, the animation should be fairly smooth. There should be at least **30** pages in total.
3. Imagine mitosis as a smooth process. Mitosis doesn't happen in 4 or 5 static frames, the way it's depicted in textbooks. Emphasize the movement of chromosomes.
4. Use the textbook diagrams to help draw the cell in mitosis. Remember the :
 - changes to chromosomes,
 - the nuclear membrane,
 - spindle fibres,
 - cell membrane
5. Make sure each phase is labeled on one hand side for the entire portion of that stage

Assessment:

- Flip books analyzed for the correct depiction of the five phases (i.e., chromosome placement, presence of nuclear membrane)
- All the phases must be labeled along with the correct structures in the phases. Structures should not be labelled

Summary of Mitosis:

- Write an outline that describes each step of mitosis. This outline should describe the steps that you have done in your flip book.
- Do not put your name on the flip-book or summary. Use only the science number on the back

SCIENCE NUMBER ONLY _____

Mitosis Flip Book Peer Grading Rubric

The flip book must include all of the following. Your grading scale will be out of 4 total points.

- 4 – exceeds the standard, 3 – meets the standard
2 – meets some of the standard, 1 – meets none of the standard

Name:

1. _____ Do they have all 6 phases of mitosis in their flip book? Can you see the centrioles, chromosomes, & spindle fibers throughout the flip book?
2. _____ Does their flip book show a smooth transition to each phases (make sure it looks similar to the animations that we saw in class on the computer)? Did they include 20-25 pages?
3. _____ Did they include a lab report that outlined the 6 phases? Does their description match the details they have in their flip book?

Comments:

SCIENCE NUMBER ONLY _____

Mitosis Flip Book Peer Grading Rubric

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Comments

Chromosome Package Model

DNA is condensed to reduce the space that it occupies in the cell. In eukaryotic cells, the linear DNA molecule is condensed by being wrapped around a core of proteins.

Procedure

1. Scrunch a 1 m length of kite string into a wad. Cover this wad with a piece of plastic wrap.
2. Wind another 1 m length of string tightly and uniformly around a paper clip. Cover this shape with another piece of plastic wrap.

Analysis

1. Identify what the string, the plastic wrap, and the paper clip represent in each model.

Model 1

Model 2

2. Compare the volumes of space that the two models occupy.

3. Describe an object that would be more effective than a paper clip as a core to wrap the string around. Explain your answer.

Mitosis

A single fertilized human egg cell will divide to form two cells. These two cells will each divide into two cells. In time, millions of cells are produced. The division of nuclear material in which each new nucleus obtains the same number of chromosomes and the same nuclear code as the original nucleus is called mitosis. Mitosis occurs in four phases. There is an interphase between each mitosis.

In this investigation, you will

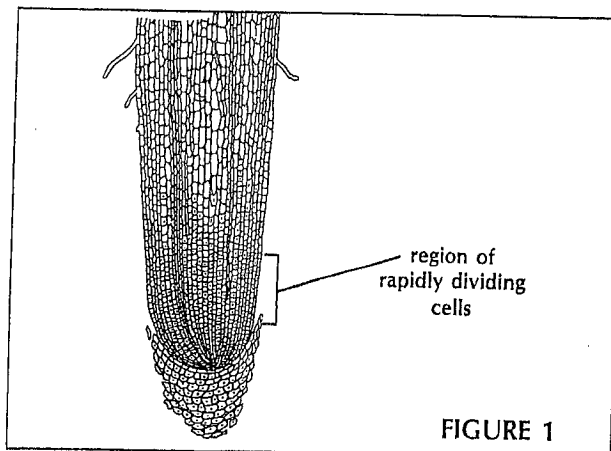
- locate cells in prepared onion root slides that are in the process of dividing by mitosis.
- identify cells in interphase and in each of the four stages of mitosis in the onion root tips by comparing them with diagrams.
- study the changes which occur in a cell as it undergoes mitosis.

Materials

microscope
prepared slides of onion root tip (*Allium*), longitudinal section

Procedure

- Locate with a microscope the region of rapidly dividing cells on the prepared slide of onion root tip as shown in Figure 1. After locating the cells under low power, switch to high power.
- Locate cells that appear to be in the various stages of mitosis. Use Figure 2 as a guide.
- Identify and label the following stages by using the brief description provided. Write the correct stage name on the lines provided in Figure 2.



- Interphase*—cell contains easily seen nucleus and nucleolus—chromosomes appear as fine dots within nucleus
- Prophase*—cell nucleus enlarged—nucleolus no longer visible—chromosomes appear as short strands within nucleus
- Metaphase*—chromosomes long and thin strands—chromosomes lined up along cell center and look like "spider on a mirror"
- Anaphase*—two sets of separate chromosomes can be seen—look as if they are being pulled apart from one another
- Telophase*—chromosomes appear at opposite ends of cell—middle of cell has line across center that divides it almost into two new cells
- Daughter cells*—appear as cells in interphase but smaller and side by side—actually start of new interphase

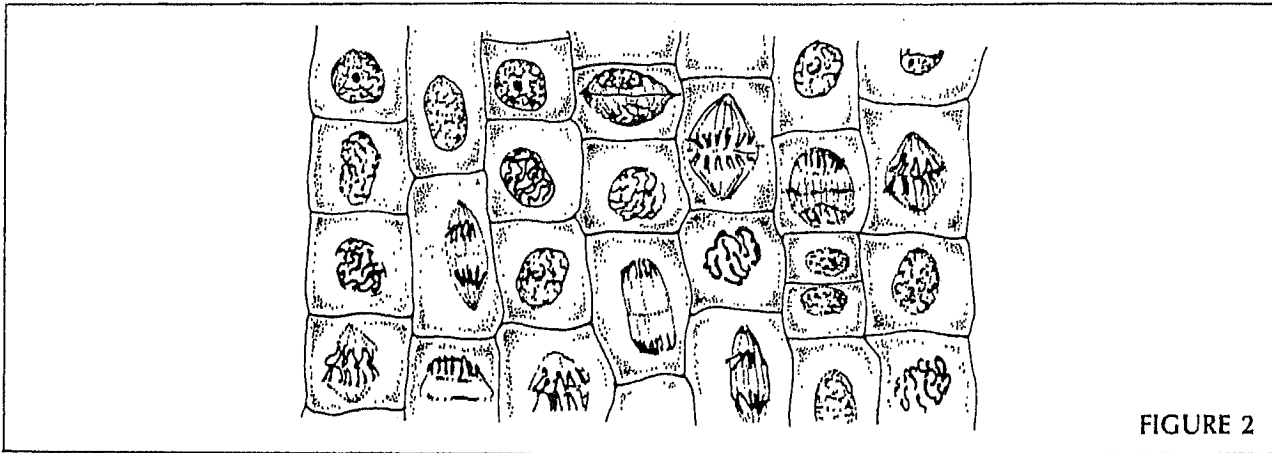
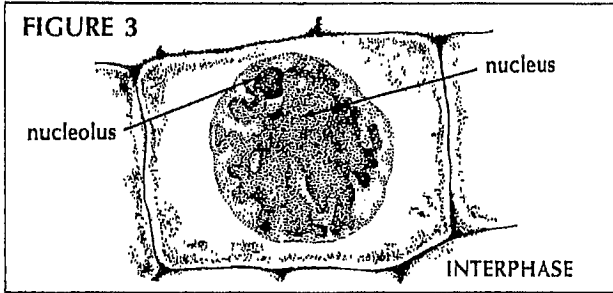


FIGURE 2

● Answer the following questions about each of the phases of mitosis.

somes during interphase? _____

(b) What other important events occur during interphase? _____



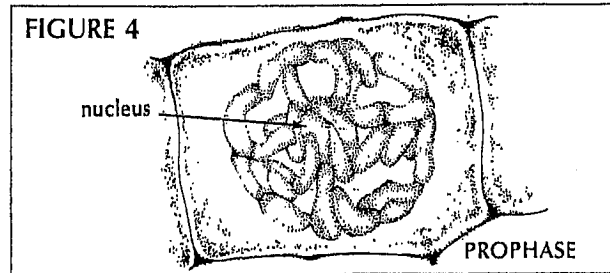
Interphase

● Locate cells resembling Figure 3. Answer questions 1-3 while observing these cells.

1. Describe the contents of a nucleus during interphase. _____
2. Are a nucleolus and nuclear membrane present in the cell? _____
3. Are distinct rod-shaped structures called chromosomes easily observed in the nucleus at this time? _____

● Use your text for reference while answering questions 4-6.

4. Are chromosomes present in cells during interphase? _____
5. What term is used to describe nuclear contents during interphase? _____
6. (a) What important event occurs to chromo-



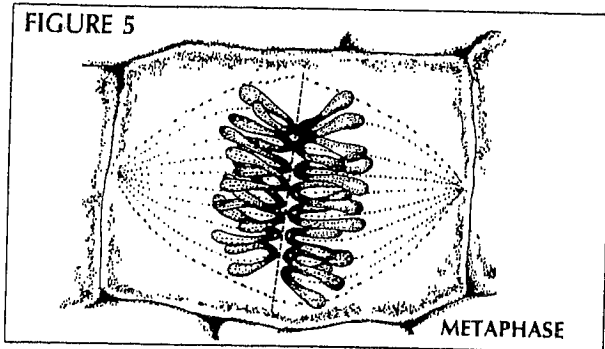
Prophase

● Locate cells resembling Figure 4. Answer questions 7 and 8 while observing these cells.

7. Are chromosomes now visible during prophase? _____
8. Describe the changes that have occurred to the nucleolus and nuclear membrane from interphase to prophase. _____

● Use your text for reference while answering question 9.

9. Explain why chromosomes can now be observed but were not observable during interphase. _____



Metaphase

• Locate cells resembling Figure 5. Answer questions 10 and 11 while observing these cells.

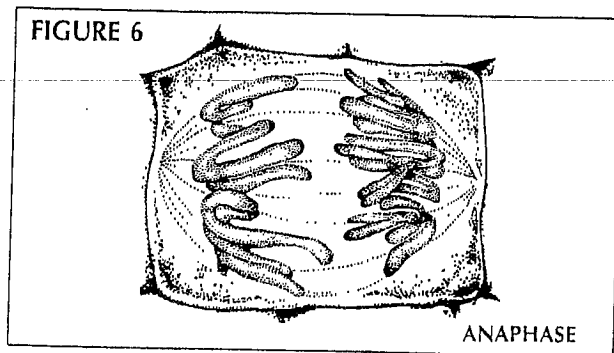
10. Describe where the chromosomes are now located in relation to the cell. _____

11. Can evidence of chromosome duplication (replication) now be observed? _____

• Use your text for reference while answering questions 12 and 13.

12. What are the fibers called that become visible during this phase? _____

13. What term is used to describe the structure at which each fiber attaches to a chromosome? _____



Anaphase

• Locate cells resembling Figure 6. Answer questions 14 and 15 while observing these cells.

14. In metaphase, chromosome pairs were lined up along the cell's center. Describe what is occurring to each chromosome pair during anaphase. _____

15. Toward what area of the cell are the chromosomes being directed? _____

• Use your text for reference while answering question 16.

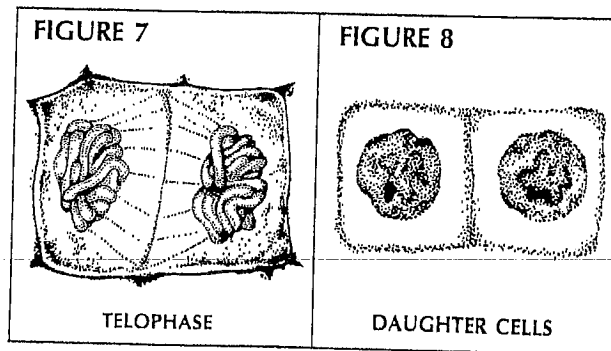
16. What structure is responsible for the movement of chromosomes during this phase? _____

Telophase

• Locate cells resembling Figure 7. Answer question 17 while observing these cells.

17. What cell parts begin to reappear during this phase? (See question 8.) _____

18. Describe the location of the chromosomes now compared to where they were during metaphase. _____



Daughter Cells

• Locate cells resembling Figure 8. Answer questions 19 and 20 while observing these cells.

19. How many cells have now formed from an original cell? _____

20. Explain how the number of chromosomes found in each daughter cell compares to the number found in the original cell before mitosis. (HINT: Read introduction.) _____

Analysis

1. The term "mitosis" comes from the Greek word meaning "thread." Explain why this word may be helpful in describing this process of nuclear division. _____

2. Explain how the process of mitosis helps an organism to grow in size. _____

3. Complete Figure 9 to show the structures visible during each stage of mitosis. Draw in and/or label the structures listed below on the appropriate diagram. Be sure to label each animal cell with the correct mitosis stage name.

- (a) *Interphase*: draw and label *nuclear membrane*, *nucleolus*, *chromatin*, *centriole*.
- (b) *Prophase*: label *disappearing nuclear membrane*, *disappearing nucleolus*, *original chromosomes* (shaded), *chromosome copies* (unshaded).
- (c) *Metaphase*: draw in the two chromosome pairs as they would appear during metaphase. Label *chromosomes*, *spindle fibers*.
- (d) *Anaphase*: draw in the two chromosome pairs as they separate in anaphase. Label *centromeres*.
- (e) *Telophase*: label *reforming nuclear membrane*, *reforming nucleolus*, *pinching in of cell membrane*.
- (f) *Interphase*: draw in and label *nucleus*, *nucleolus*, *nuclear membrane*, and *chromatin* in each cell.

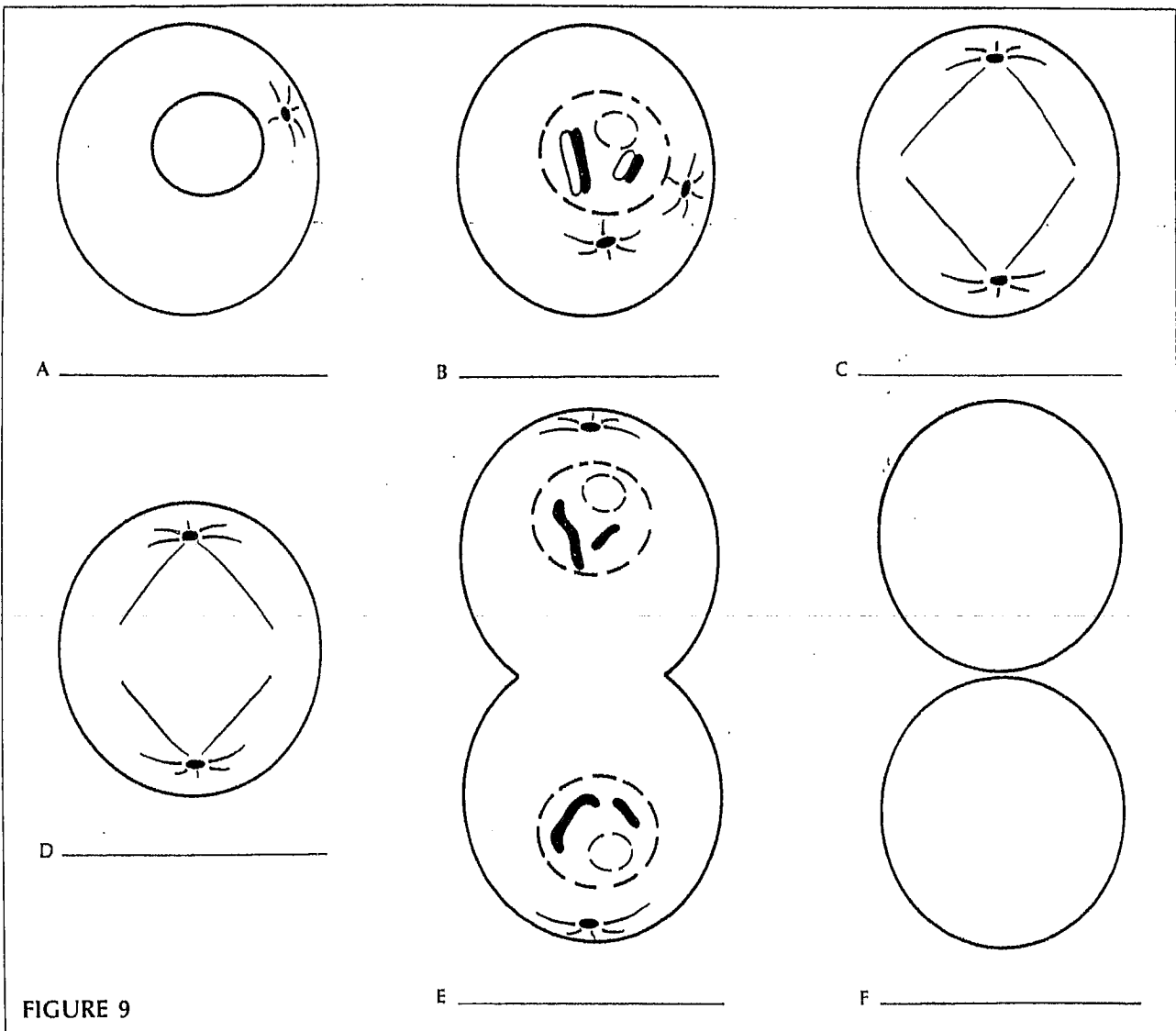


FIGURE 9

UNDERSTANDING MITOSIS

Let us study mitosis of a typical animal cell. This cell has four chromosomes. Follow what happens step-by-step.

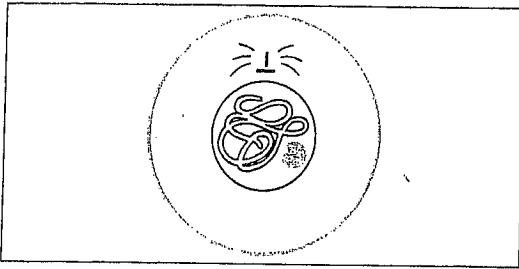


Figure A

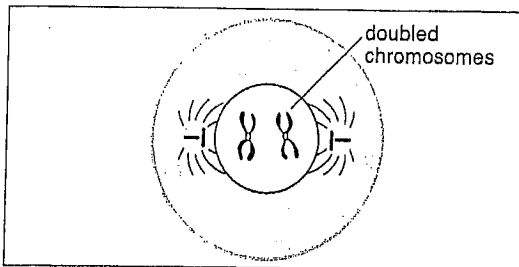


Figure B

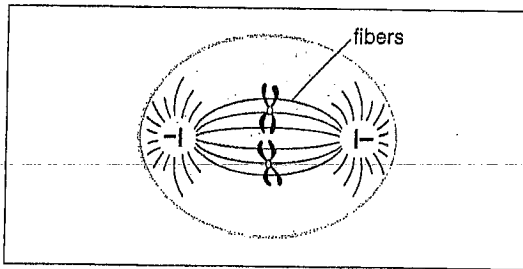


Figure C

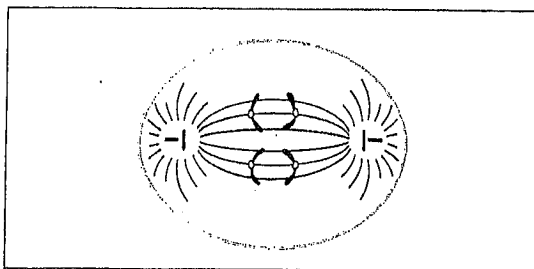


Figure D

- The cell is getting ready to divide.
- The chromosome material is duplicating itself. It does not look like chromosomes—not yet.

- The chromosome pairs coil, becoming short and thick. They can be seen clearly. Count them.
- The nuclear membrane disappears.
- Spindle fibers form in the cytoplasm. The spindle fibers attach to the chromosomes and to both ends of the cell.
- The two sets of chromosomes line up at the center of the cell.

- The chromosomes of each pair separate and move to opposite ends of the cell.

- The cell begins to pinch in two.

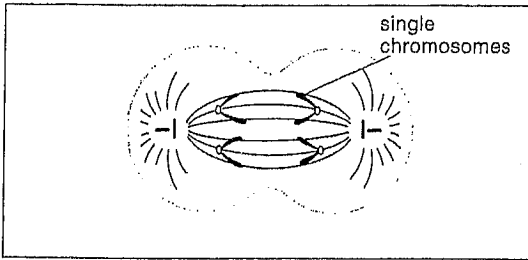


Figure E

- A new nuclear membrane forms in each daughter cell.
- The chromosomes uncoil.

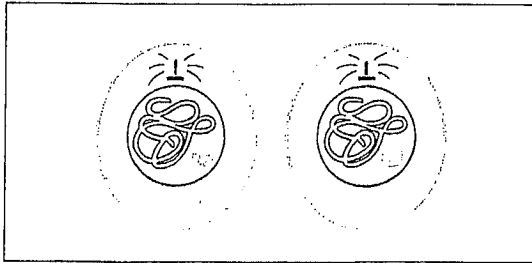
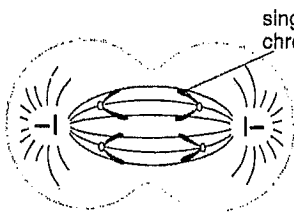


Figure F

- The cell has divided and there are now two daughter cells. Each daughter cell is exactly alike.

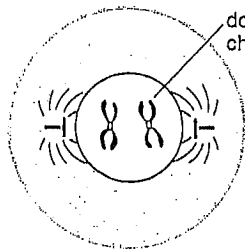
NOW TRY THIS

Study the diagrams below. In the spaces provided, number the diagram from 1 to 5 to show the correct order of the stages of mitosis.



single
chromosomes

Figure G



doubled
chromosomes

Figure H

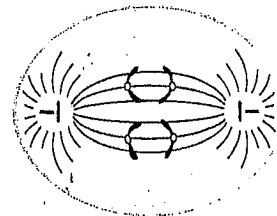
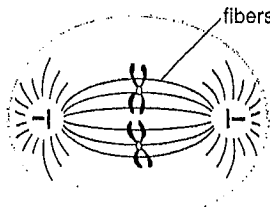


Figure I



fibers

Figure J

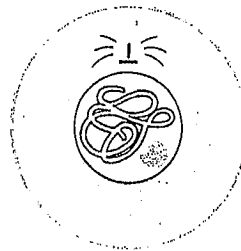


Figure K

Plant cells also reproduce by cell division. Like animal cells, plant cells make copies of themselves and carry out mitosis. However, in plant cells, a new cell wall and new cell membrane form down the middle of the cell. They form a wall between the two new nuclei. Two daughter cells are formed, one on each side of the new cell wall.

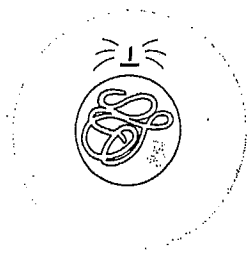


Figure L

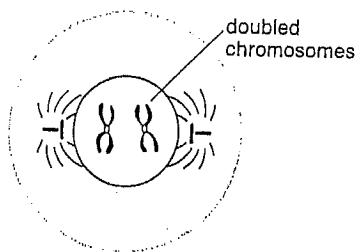


Figure M

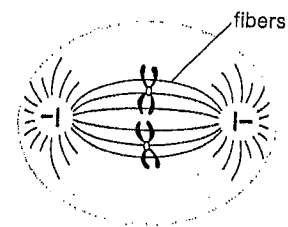


Figure N

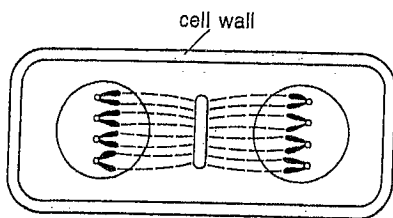


Figure O

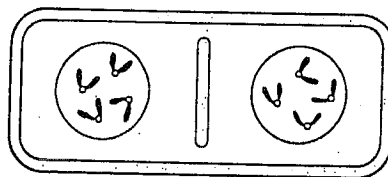


Figure P

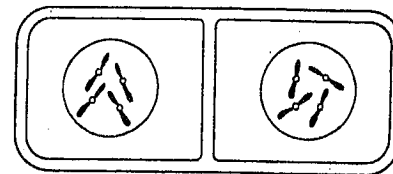


Figure Q

Using Figures M-R, answer the following questions.

1. Is plant or animal cell division shown in the diagram? _____
2. How do you know? _____
3. What is happening in Figure O? _____

4. What is happening in Figure P? _____

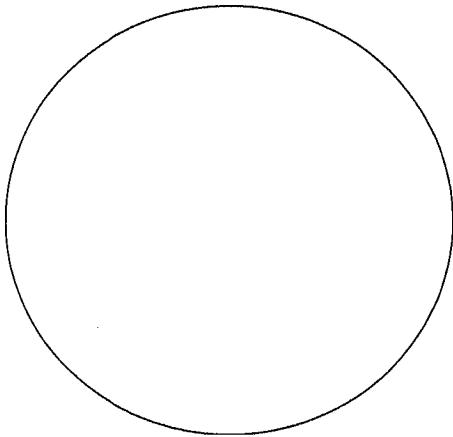
5. What do the slashed lines around the chromosomes in Figure N represent?

Whitefish Cells

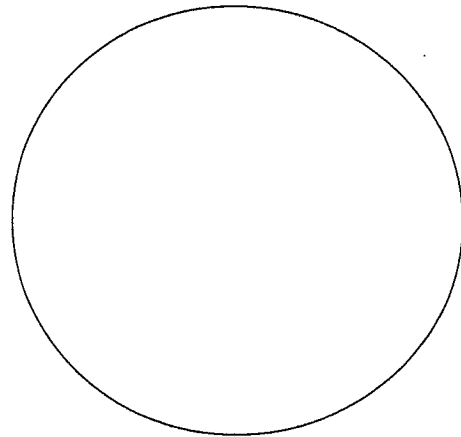
As an embryo develops, its cells divide rapidly. Few of these cells remain in a resting state, so when observing them, you will see groups of these cells in various stages of division.

Procedure

1. Place a slide of whitefish cells on the stage of a microscope. Examine the cells under low power. Do all of the cells look alike? If not, how do they differ? Draw several representative cells.
2. Carefully switch to high power. Slowly scan the slide, and look for obvious differences between cells. Pay particular attention to the appearance of the nuclei.
3. Make a sketch of each distinct pattern of cells that you see.



Object _____ Mag _____



Object _____ Mag _____

Analysis

1. **Describe** any differences you observed in the nuclei of these cells.

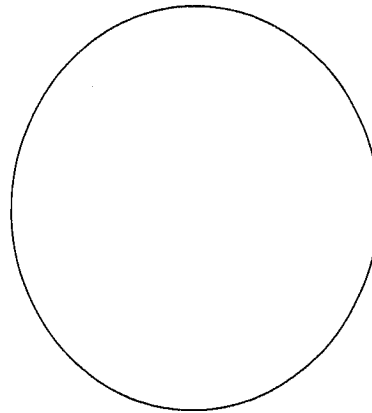
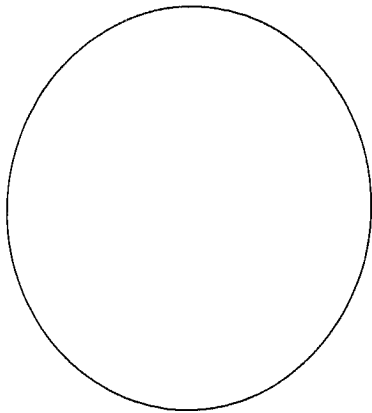
2. **Determine** whether all the cells you observed had a distinct nucleus. Explain.

NAME _____
OBJECT _____

OBJECT _____

TOTAL MAGNIFICATION _____

TOTAL MAGNIFICATION _____

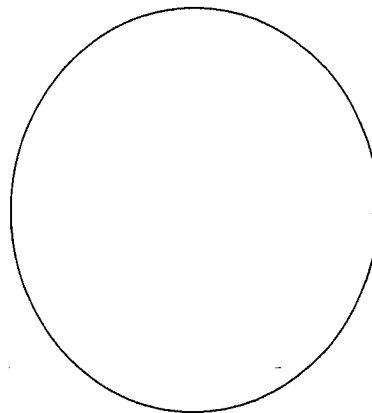
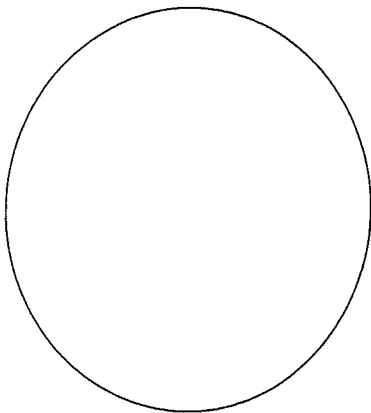


OBJECT _____

OBJECT _____

TOTAL MAGNIFICATION _____

TOTAL MAGNIFICATION _____

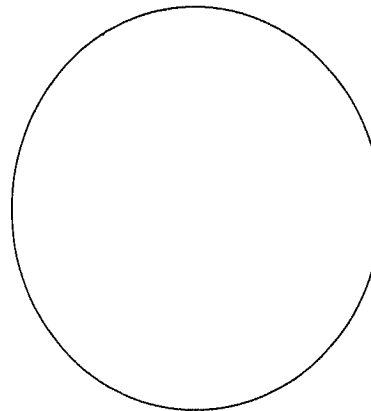
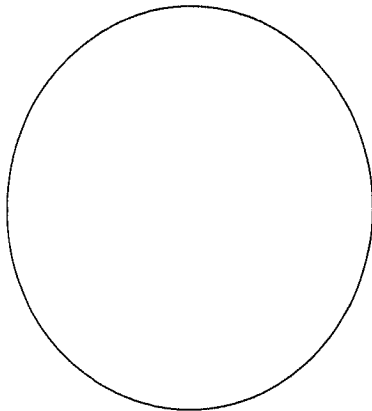


OBJECT _____

OBJECT _____

TOTAL MAGNIFICATION _____

TOTAL MAGNIFICATION _____



Mitosis in Plant Cells

OBJECTIVES

- **Examine** the dividing root-tip cells of an onion.
- **Identify** the phase of mitosis that each cell in an onion root tip is undergoing.
- **Determine** the relative length of time each phase of mitosis takes in onion root-tip cells.

MATERIALS

- compound light microscope
- prepared microscope slide of a longitudinal section of *Allium* (onion) root tip

Procedure

IDENTIFY THE PHASES OF MITOSIS

1. **CAUTION: Follow safety rules**
2. **CAUTION: Handle glass slides and cover slips with care.** Look at the meristem area of the slide on low power. Focus the microscope as needed.
3. Examine the meristem carefully. Choose a sample of about 50 cells. Look for a group of cells that appear to have been actively dividing at the time that the slide was made. The cells will appear to be in rows, so it should be easy to keep track of them. The dark-staining bodies are the chromosomes.
4. For each of the cells in your sample, identify the stage of mitosis. Use the data table on the next page to show how long each phase of mitosis lasts. Record your observations in the data table.

Relative Duration of Each Phase of Mitosis

Phase of mitosis	Tally marks	Count	Percentage of all cells	Time (min)
Prophase				
Metaphase				
Anaphase				
Telophase				

CALCULATE THE RELATIVE LENGTH OF EACH PHASE

5. When you have classified each cell in your sample, count the tally marks for each phase and fill in the "Count" column.

Which phase of mitosis had the most cells? _____

Which phase of mitosis had the least cells? _____

6. Find the percentage of all cells that were found in each phase. (Hint: see the formula below.) Divide the number of cells in a phase by the total number of cells in your sample. Then multiply by 100. Enter these figures in the "Percentage" column.

$$\text{Percentage} = \frac{\text{number of cells in phase}}{\text{total number of cells in sample}} \times 100\%$$

7. The percentage of the total cells in each phase (the numbers you just calculated) can be used to estimate how long each phase lasts. For example, imagine 25% of the cells are in prophase. If that is the case, then prophase takes 25% of the total time of mitosis. Mitosis in onion cells takes about 80 min. Using this information and the percentages you have just determined, calculate the time for each phase. Record it in your data table.

$$\text{Duration of phase (in minutes)} = \frac{\text{percentage}}{100} \times 80 \text{ min}$$

8. Use the table on the following page to record the data for the whole class. Collect and add the counts for each phase of mitosis for the entire class. Fill in the percentage and time information by using the data.

Class Data

Phase of mitosis	Count	Percentage of all cells	Duration (min)
Prophase			
Metaphase			
Anaphase			
Telophase			

Analyze and Conclude

1. **Identifying Structures** What color are the chromosomes stained?

2. **Recognizing Relationships** How can you tell the difference between early and late anaphase?

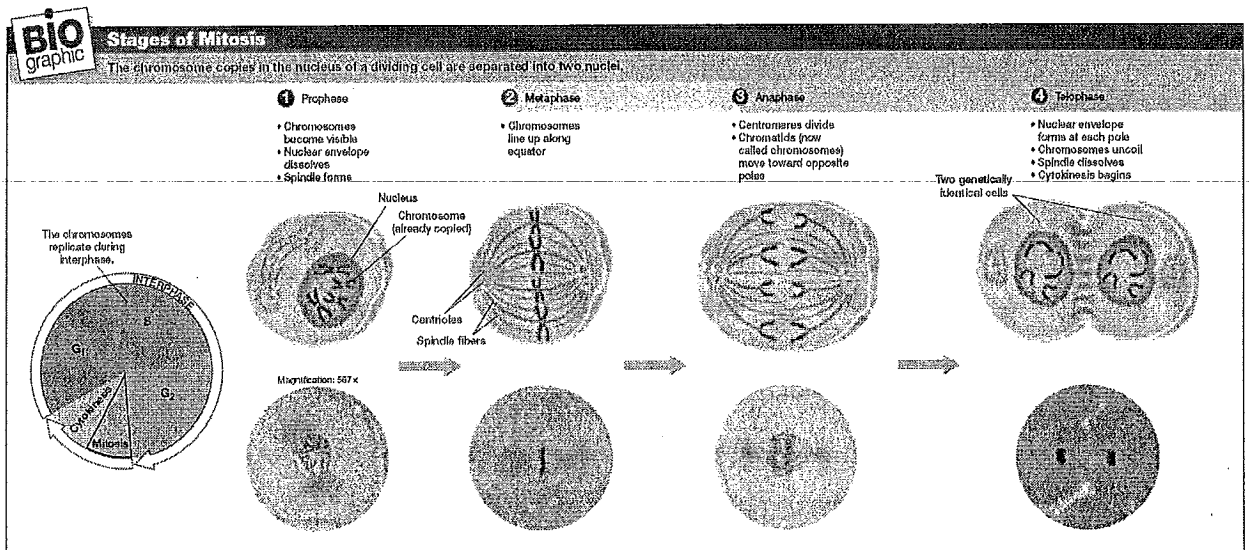
3. **Scientific Methods Making Systematic Observations** According to your data table, which phase takes the least amount of time? _____

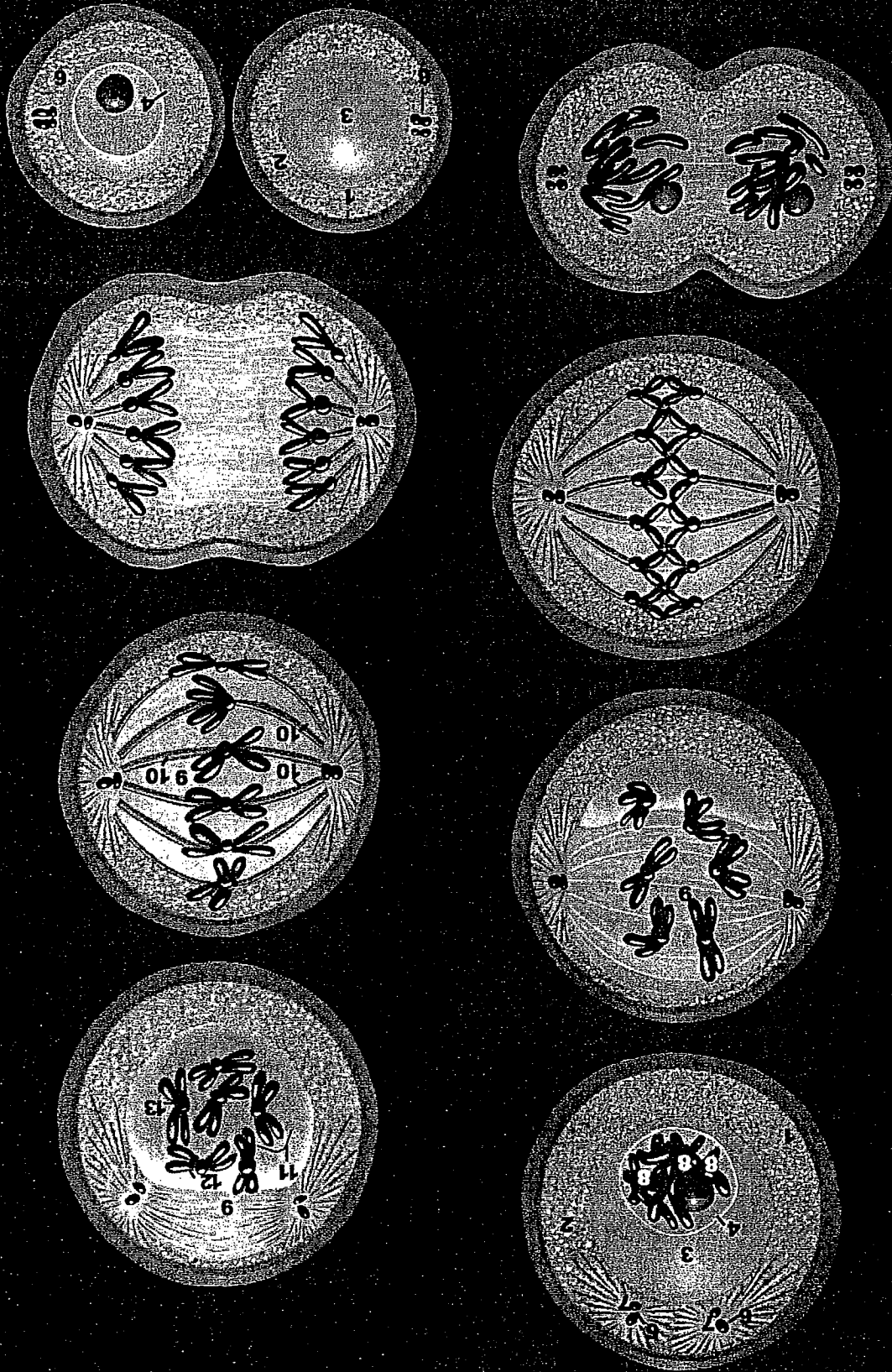
Which phase of mitosis lasts the longest? _____

Why might this phase require more time than other phases of mitosis?

4. **Critiquing Procedures** Do you remember how you calculated the time in each phase? You assumed that the percentage of time in any phase is equal to the percentage of the number of cells in that phase. Why might this not be true for very small samples of cells?

5. Cancerous tissue is composed of cells undergoing uncontrolled, rapid cell division. How could you develop a procedure to identify cancerous tissue by counting the number of cells undergoing mitosis?

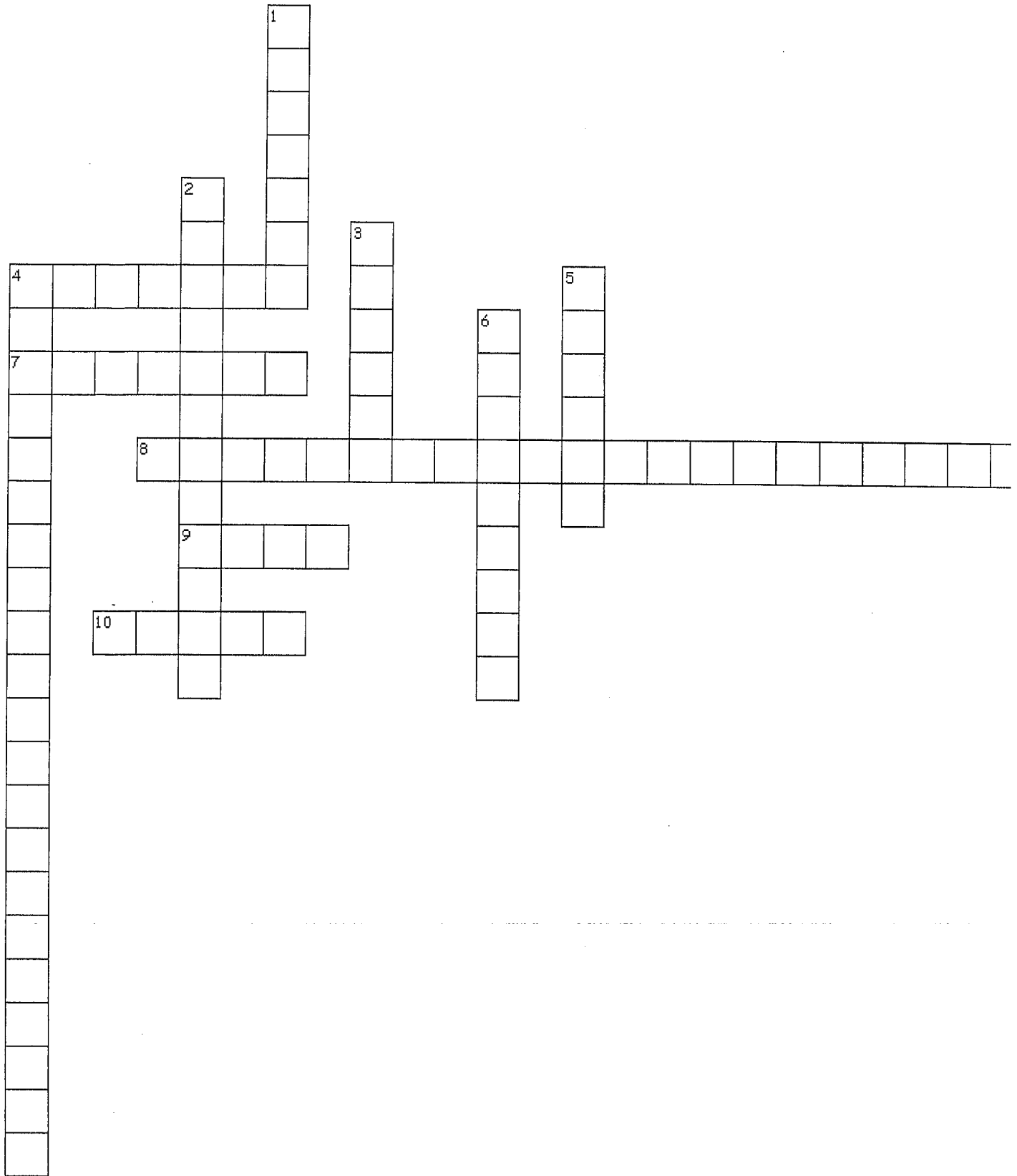




MITOSIS



Ch 11 Crossword/ Vocab



Across

4. describes a cell, nucleus, or organism that has only one set of unpaired chromosomes
7. a process in cell division during which the number of chromosomes decreases to half the original number by two divisions of the nucleus, which results in the production of sex cells
8. the random distribution of the pairs of genes on different chromosomes to the gametes
9. a mature egg cell
10. the male gamete (sex cell)

Down

1. a cell that contains two haploid sets of chromosomes
2. the exchange of genetic material between homologous chromosomes during meiosis
3. a haploid reproductive cell that unites with another haploid reproductive cell to form a zygote
4. chromosomes that have the same sequence of genes, that have the same structure, and that pair during meiosis
5. the cell that results from the union of gametes
6. all of the events in the growth and development of an organism until the organism reaches sexual maturity

CHAPTER 11 VOCAB

Gamete

Zygote

Diploid

Haploid

homologous chromosomes

meiosis

crossing over

independent assortment

life cycle

sperm

ovum

somatic cell

Mitosis

chromosome

chromatid

Chapter 11 Meiosis and Sexual Reproduction

I. **ASEXUAL REPRODUCTION**- In asexual reproduction, a single parent passes a complete copy of its genetic information to each of its offspring. An individual formed by asexual reproduction is genetically _____ to its parent.

A. Prokaryotes reproduce asexually by a kind of cell division called _____.

B. Many unicellular eukaryotes also reproduce asexually.

1. Some multicellular eukaryotes, such as starfish, go through _____. _____ is reproduction in which the body breaks into several pieces. Some or all of these fragments regrow missing parts and develop into complete adults.
2. Other animals, such as the hydra, go through _____. In _____, new individuals split off from existing ones.
3. Some plants, such as potatoes, can form whole new plants from parts of stems. Other plants can reproduce from roots or leaves. (_____)
4. Some crustaceans, such as water fleas, reproduce by _____. _____ is a process in which a female makes a viable egg that grows into an adult without being fertilized by a male.

Type of asexual reproduction	Description	Example of an organism that can reproduce this way
Binary fission	An organism splits in half.	prokaryotes, such as bacteria
Fragmentation	An organism breaks into several pieces, each of which may grow into a complete organism.	starfish
Parthenogenesis	An unfertilized female sex cell grows into an adult.	water flea
Budding	An individual splits off from an existing organism.	potato

II. **SEXUAL REPRODUCTION**-In sexual reproduction, two parents give genetic material to produce offspring that are genetically different from their parents.

A. Most eukaryotic organisms reproduce _____.

B. Each parent produces a reproductive cell, called a _____. A gamete from one parent fuses with a gamete from the other. The resulting cell, called a _____, has a combination of genetic material from both parents. This is called fertilization. . Not all cells of eukaryotes can sexually reproduce.

III. GERM CELLS AND SOMATIC CELLS

- A. The cells of a multicellular organism are often specialized for certain functions.
- B. Cells that are specialized for sexual reproduction are called _____ . Only germ cells can produce _____ .
- C. Other body cells are called _____ cells. Somatic cells do not undergo _____ reproduction.

IV. ADVANTAGES OF SEXUAL REPRODUCTION

- A. Asexual reproduction is the simplest, most _____ method of reproduction.
- B. Asexual reproduction allows organisms to produce many offspring in a short period of time without using energy to make gametes or to find a mate.
- C. There is very little genetic variation.
- D. Sexual reproduction, in contrast, produces genetically _____ individuals.

V. **CHROMOSOME NUMBER**- Each chromosome has thousands of genes that play an important role in determining how an organism develops and functions. Each species has a characteristic number of chromosomes. (humans= _____)
If an organism has too many or too few chromosomes, the organism may not develop and function properly.

VI. HAPLOID AND DIPLOID CELLS

- A. The symbol _____ is used to represent the number of chromosomes in one set.
- B. A cell, such as a somatic cell, that has two sets of chromosomes is _____ . (2n)
- C. A cell is _____ if it has one set of chromosomes.(n)
- D. Gametes (sperm and eggs) are _____ cells.(n)
- E. Human gametes have 23 chromosomes, so $n = 23$. The diploid number in somatic cells is written as $2n$. Human somatic cells have 46 chromosomes ($2n = 46$).

VII. HOMOLOGOUS CHROMOSOMES- Homologous chromosomes are chromosomes that are similar in size, in shape, and in kinds of genes. Each diploid cell has pairs of chromosomes made up of two homologous chromosomes. Each chromosome in a homologous pair comes from one of the two parents. Homologous chromosomes can carry different forms of genes.

VIII. AUTOSOMES AND SEX CHROMOSOMES

A. _____ are chromosomes with genes that do not determine the sex of an individual.

B. Sex chromosomes have genes that determine the sex of an individual.

1. In humans and many other organisms, the two sex chromosomes are referred to as the X and Y chromosomes.
2. The genes that cause a zygote to develop into a _____ are located on the Y chromosome.
3. Human males have one X chromosome and one Y chromosome (XY), and human _____ have two X chromosomes (XX).

IX. STAGES OF MEIOSIS- During meiosis, a diploid cell goes through two divisions to form _____ haploid cells. _____ cells undergo meiosis to produce gametes (sex cells=egg or sperm) In meiosis I, homologous chromosomes are separated. In meiosis II, the sister chromatids of each homologue are separated.

A. **MEIOSIS I-** Meiosis begins with a diploid cell that has copied its chromosomes.

1. During prophase I, the chromosomes condense, and the nuclear envelope breaks down. Homologous chromosomes pair. Chromatids exchange genetic material in a process called crossing-over.
2. In metaphase I, the spindle moves the pairs of homologous chromosomes to the equator of the cell. The homologous chromosomes remain together.
3. In anaphase I, the homologous chromosomes separate. The spindle fibers pull the chromosomes of each pair to opposite poles of the cell. But the chromatids do not separate at their centromeres. Each chromosome is still made of two chromatids. The genetic material, however, has recombined.
4. During telophase I, the cytoplasm divides (cytokinesis), and two new cells are formed. Both cells have one chromosome from each pair of homologous chromosomes.

B. **Meiosis II**

1. Meiosis II begins with the two cells formed at the end of telophase I of meiosis I.

2. The chromosomes are not copied between meiosis I and meiosis II.
3. In prophase II, new spindles form.
4. During metaphase II, the chromosomes line up along the equators and are attached at their centromeres to spindle fibers.
5. In anaphase II, the centromeres divide. The chromatids, which are now called chromosomes, move to opposite poles of the cell.
6. During telophase II, a nuclear envelope forms around each set of chromosomes. The spindle breaks down, and the cell goes through cytokinesis.
7. The result of meiosis is four haploid cells.

X. COMPARING MITOSIS AND MEIOSIS- _____

makes new cells that are used during growth, development, repair, and asexual reproduction. _____ makes cells that enable an organism to reproduce sexually and happens only in reproductive structures.

- A. _____ produces two genetically identical diploid cells.
- B. _____ produces four genetically different haploid cells. The haploid cells produced by meiosis contain half the genetic information of the parent cell.
- C. If you compare meiosis and mitosis, they may appear similar but they are very different.
 1. In prophase I of meiosis, every chromosome pairs with its homologue. A pair of homologous chromosomes is called a _____.
 2. As the tetrads form, different homologues exchange parts of their chromatids in the process of crossing-over. The pairing of homologous chromosomes and the crossing-over do not happen in _____.

Process	Description	Function
Mitosis	produces two genetically identical diploid cells	makes new cells for growth, development, repair, and asexual reproduction
Meiosis	produces four genetically different haploid cells	makes sex cells (gametes) for sexual reproduction

XI. **GENETIC VARIATION**-Genetic variation is advantageous for a population. Genetic variation can help a population survive a major environmental change. Genetic variation is made possible by _____ reproduction. Three key contributions to genetic variation are crossing-over, independent assortment, and random fertilization

A. CROSSING-OVER

1. During prophase I, homologous chromosomes line up next to each other.
2. Each homologous chromosome is made of two sister _____ attached at the centromere.
3. Crossing-over happens when one arm of a chromatid crosses over the arm of the other chromatid. – The chromosomes break at the point of the crossover, and each chromatid re-forms its full length with the piece from the other chromosome.
4. Thus, the sister chromatids of a homologous chromosome no longer have identical genetic information.

B. INDEPENDENT ASSORTMENT

1. During metaphase I, homologous pairs of chromosomes line up at the equator of the cell.
2. The two pairs of chromosomes can line up in either of two equally probable ways.
3. This random distribution of homologous chromosomes during _____ is called independent assortment.

C. RANDOM FERTILIZATION

1. Fertilization is a random process that adds genetic variation.
2. The zygote that forms is made by the random joining of two gametes.
3. Because _____ of an egg by a sperm is random, the number of possible outcomes is squared.

XII. DIPLOID LIFE CYCLE-In diploid life cycles, meiosis in germ cells of a multicellular diploid organism results in the formation of haploid gametes.

A. Most animals have a diploid life cycle. Most of the life cycle is spent in the _____ state. Somatic cells= $2n$

B. All of the cells except the gametes are _____.

C. A diploid germ cell in a reproductive organ goes through meiosis and forms gametes. The gametes, the sperm and the egg, join during fertilization. The result is a diploid _____. This single diploid cell goes through mitosis and eventually gives rise to all of the cells of the adult, which are also diploid.

D. MEIOSIS AND GAMETE FORMATION

1. Male animals produce gametes called sperm. A diploid germ cell goes through meiosis I. Two cells are formed, each of which goes through meiosis II.
2. The result is four haploid cells.

3. The four cells change in form and develop a tail to form four sperm.
4. Female animals produce gametes called eggs, or ova (singular, ovum). A diploid germ cell begins to divide by meiosis. Meiosis I results in the formation of two haploid cells that have unequal amounts of cytoplasm.
5. One of the cells has nearly all of the cytoplasm. The other cell, called a polar body, is very small and has a small amount of cytoplasm.
6. The polar body may divide again, but its offspring cells will not survive.
7. The larger cell goes through meiosis II, and the division of the cell's cytoplasm is again unequal.
8. The larger cell develops into an ovum. The smaller cell, the second polar body, dies. – Because of its larger share of cytoplasm, the mature ovum has a rich storehouse of nutrients.

XIII. HAPLOID LIFE CYCLE- In haploid life cycles, meiosis in a diploid zygote results in the formation of the first cell of a multicellular haploid individual.

- A. The _____ life cycle happens in most fungi and some protists.
- B. The _____, the only diploid structure, goes through meiosis immediately after it is formed and makes new haploid cells.
- C. The haploid cells divide by mitosis and give rise to multicellular haploid individuals.

XIV. ALTERNATION OF GENERATIONS- Plants and most multicellular protists have a life cycle that alternates between a haploid phase and a diploid phase called alternation of generations.

- A. In plants, the multicellular diploid phase in the life cycle is called a _____. Spore-forming cells in the sporophyte undergo meiosis and produce spores.
- B. A spore forms a multicellular _____.
- C. The gametophyte is the haploid phase that produces gametes by _____. The gametes fuse and give rise to the diploid phase.

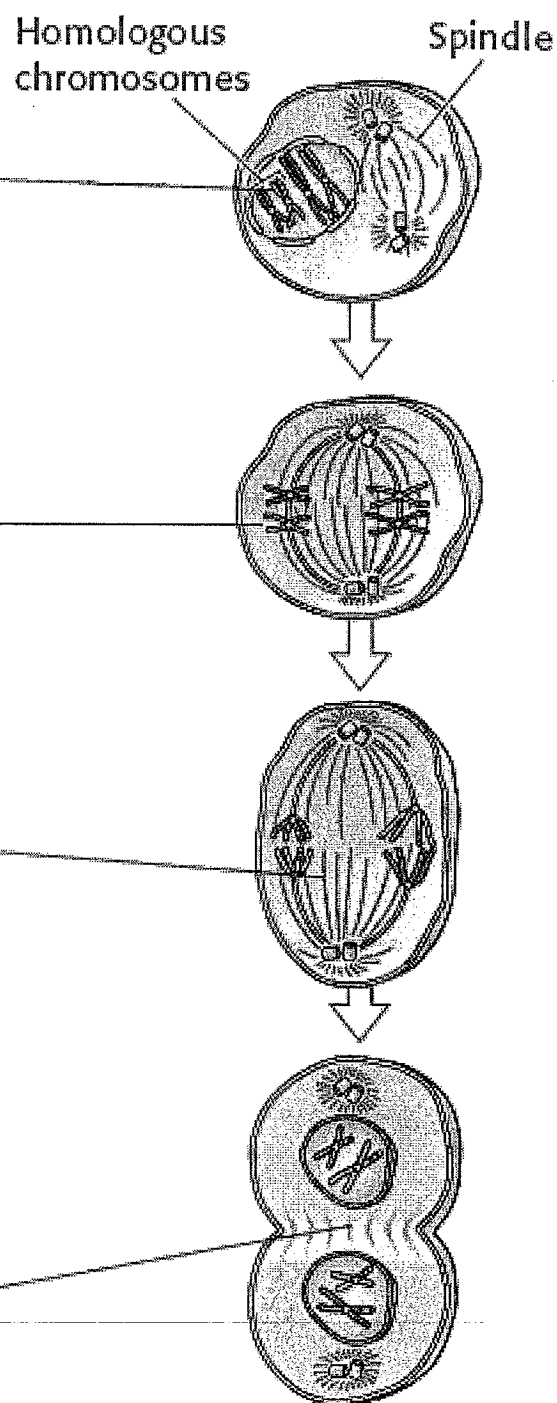
Meiosis I

Meiosis I begins with a cell that has copied its chromosomes. The first stage of meiosis I is prophase I. During prophase I, the chromosomes condense. Homologous chromosomes pair up. The membrane around the nucleus breaks down.

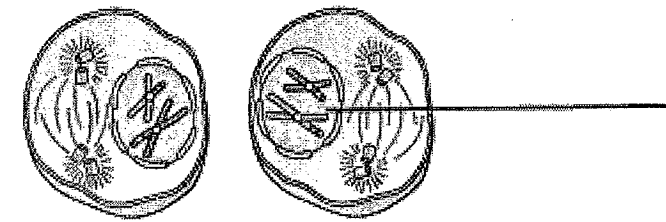
The second stage of meiosis I is metaphase I. During metaphase I, the pairs of homologous chromosomes move to the equator of the cell.

The third stage of meiosis I is anaphase I. During anaphase I, the homologous chromosomes separate. The spindle fibers pull one chromosome from each pair to each pole of the cell.

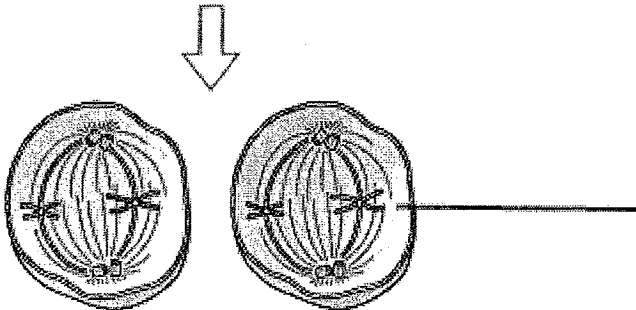
The fourth stage of meiosis I is telophase I. During telophase I, the cytoplasm divides (cytokinesis). Two new cells form. Each cell contains one chromosome from each pair of homologous chromosomes.



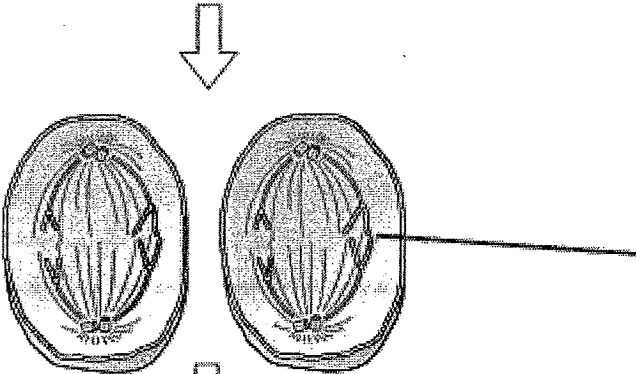
Meiosis II



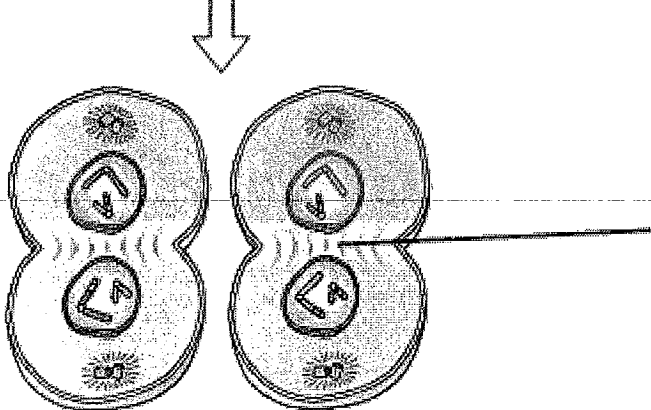
Meiosis II begins with the two cells formed at the end of meiosis I. The chromosomes are not copied at the end of meiosis I. The first stage of meiosis II is prophase II. During prophase II, a new spindle forms.



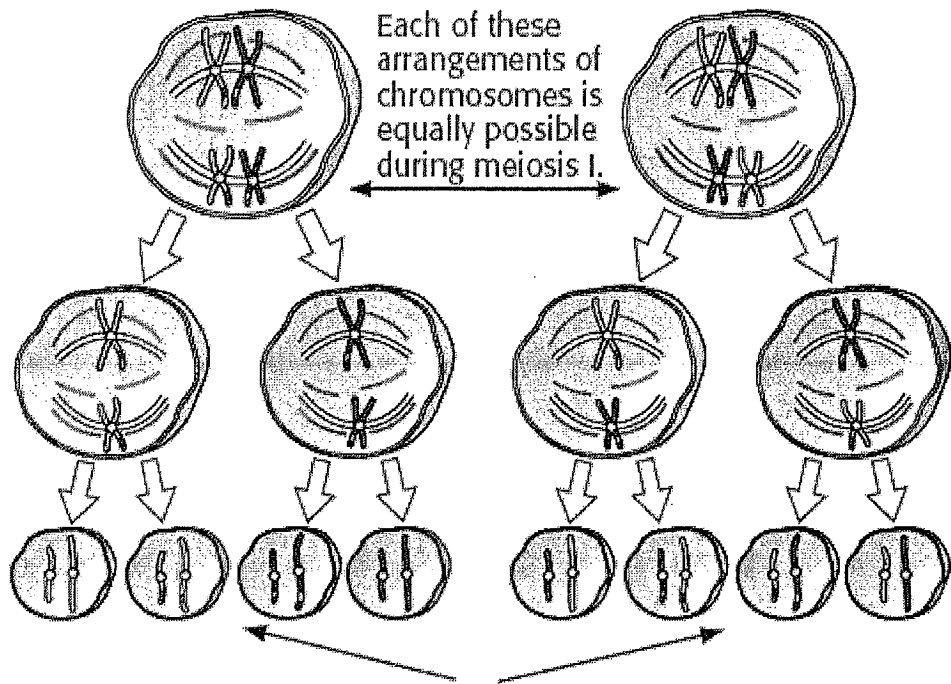
The second stage of meiosis II is metaphase II. During metaphase II, the chromosomes move to the equators of the cells.



The third stage of meiosis II is anaphase II. During anaphase II, the centromeres divide and the chromatids in each chromosome separate. The spindle fibers pull one chromatid from each pair to the pole of each cell.



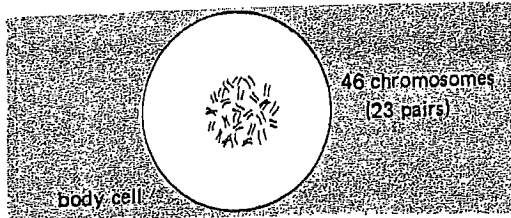
The fourth stage of meiosis II is telophase II. During telophase II, the cytoplasm in each cell divides (cytokinesis). Four new haploid cells form. Each cell contains one chromatid from each pair of homologous chromosomes.



The alleles that each gamete contains depend on how the chromosomes were arranged at the beginning of meiosis. Different arrangements of chromosomes produce gametes with different alleles.

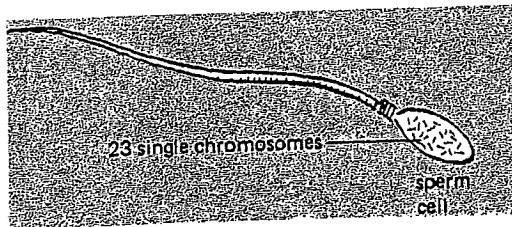
ONLY HALF THE STORY!

Body cells are produced by mitosis. But sperm and egg cells do not form this way. Reproductive cells are formed by meiosis. Each gamete has only half the usual number of chromosomes. But when the sperm and egg join, the zygote has the full number of chromosomes.



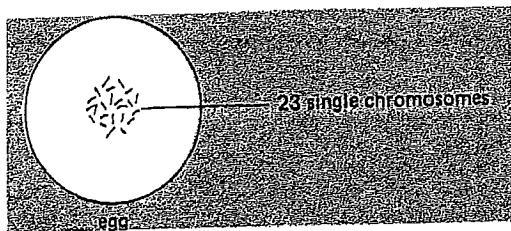
A human body cell has 46 chromosomes. The chromosomes are paired. So there are 23 pairs.

Figure B



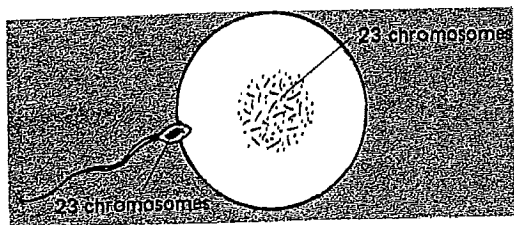
Each human sperm cell has 23 single chromosomes.

Figure C



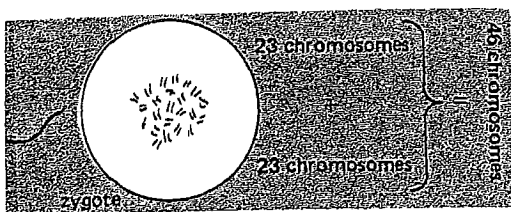
Each human egg cell has 23 single chromosomes.

Figure D



Fertilization links the gamete chromosomes.

Figure E



The zygote, then has a total of 46 chromosomes. 23 are from the mother, 23 are from the father.

The zygote starts to divide after fertilization. It divides by mitosis. It divides over and over again as it develops.

Figure F

MEIOSIS

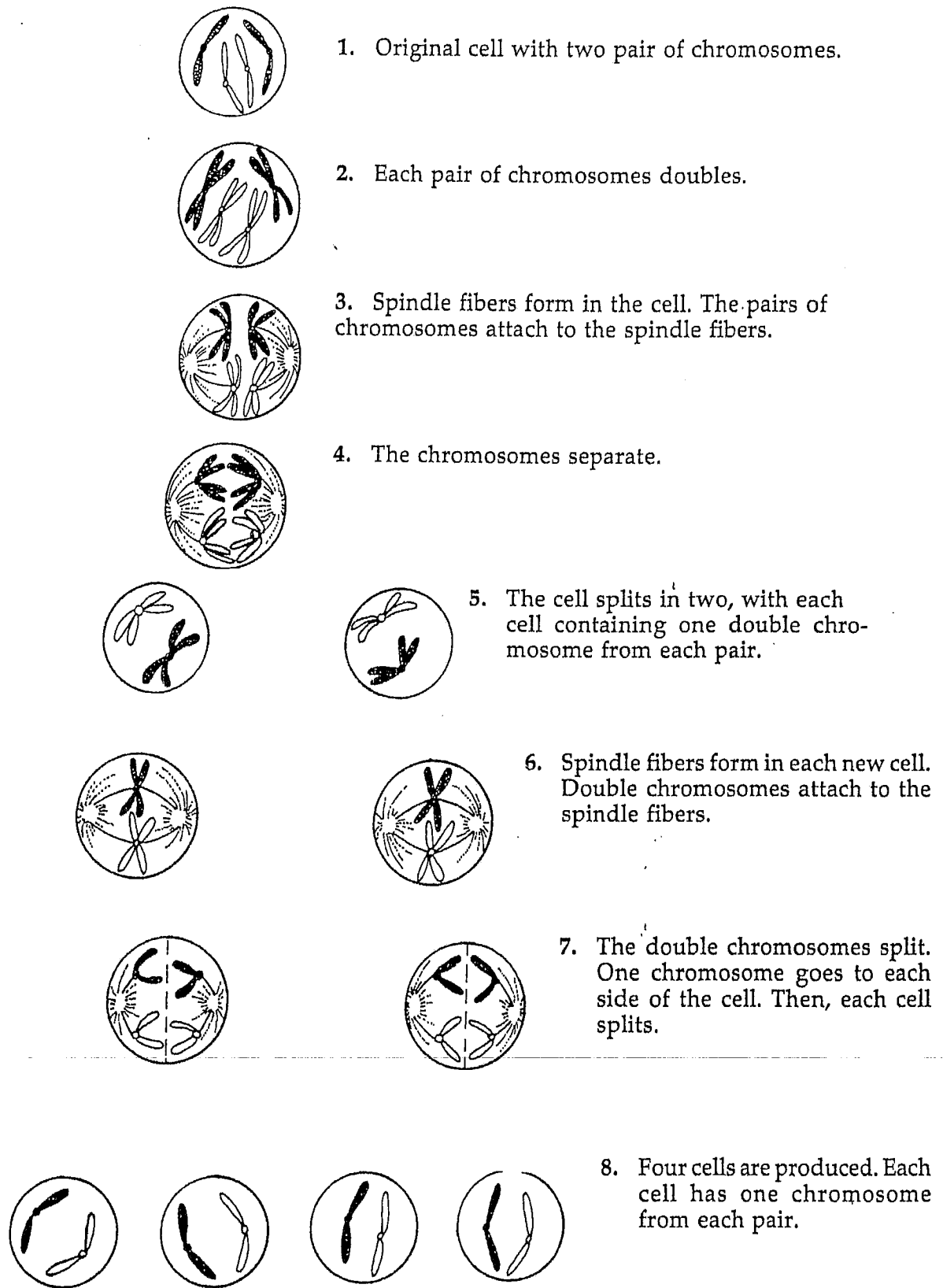
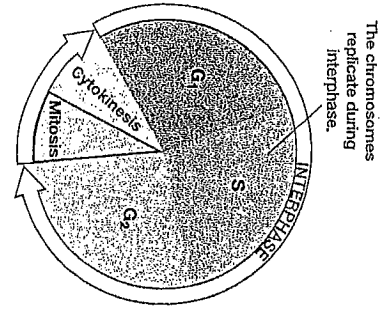


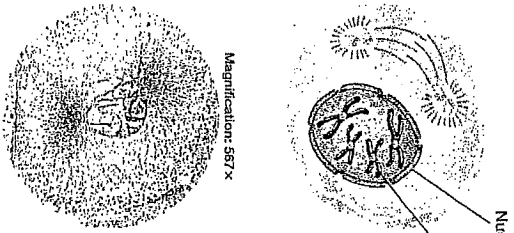
Figure A

Stages of Mitosis

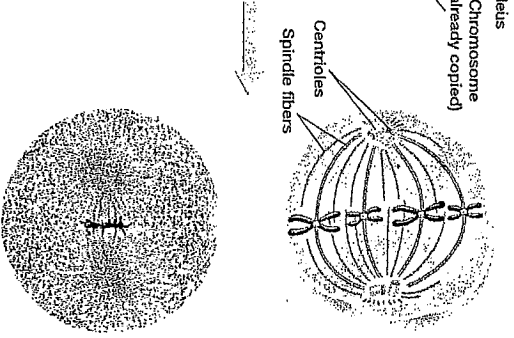
The chromosome copies in the nucleus of a dividing cell are separated into two nuclei.



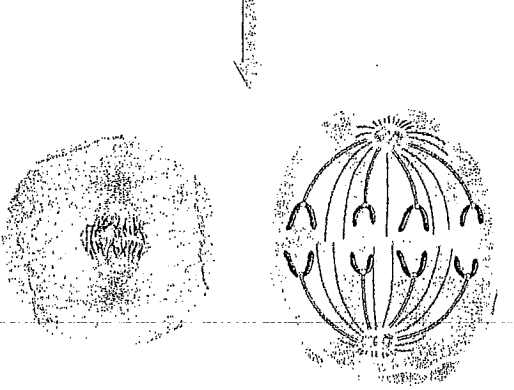
- 1 Prophase**
- Chromosomes become visible
 - Nuclear envelope dissolves
 - Spindle forms



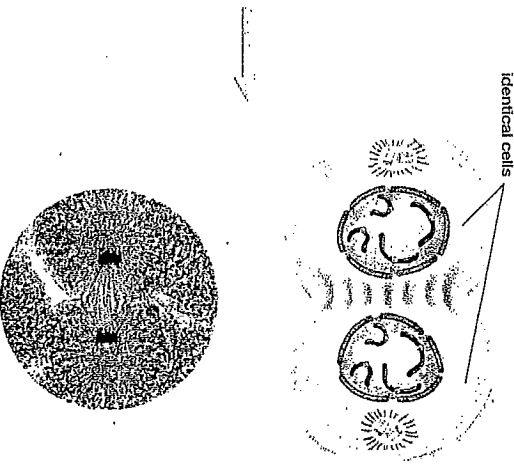
- 2 Metaphase**
- Chromosomes line up along equator



- 3 Anaphase**
- Centromeres divide
 - Chromatids (now called chromosomes) move toward opposite poles



- 4 Telophase**
- Nuclear envelope forms at each pole
 - Chromosomes uncoil
 - Spindle dissolves
 - Cytokinesis begins

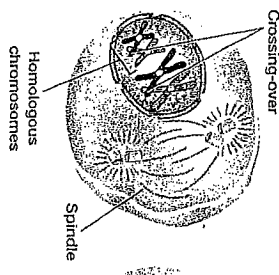


Stages of Meiosis

Four cells are produced, each with half as much genetic material as the original cell.

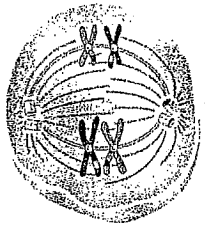
- 1 Prophase I**

Chromosomes become visible. The nuclear envelope breaks down. Crossing-over occurs.



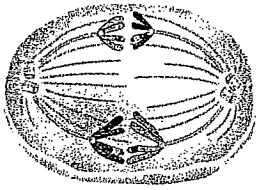
- 2 Metaphase I**

Pairs of homologous chromosomes move to the equator of the cell.



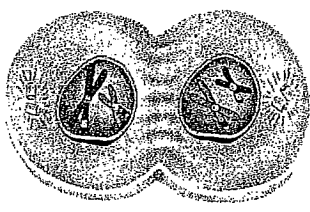
- 3 Anaphase I**

Homologous chromosomes move to opposite poles of the cell.



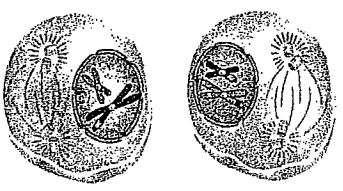
- 4 Telophase I and cytokinesis**

Chromosomes gather at the poles of the cell. The cytoplasm divides.



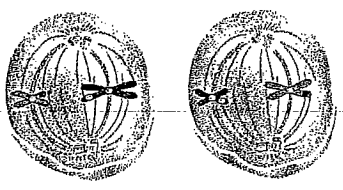
- 5 Prophase II**

A new spindle forms around the chromosomes.



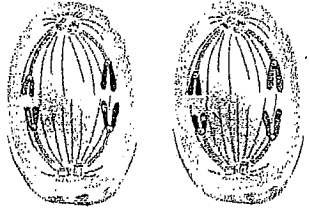
- 6 Metaphase II**

Chromosomes line up at the equator.



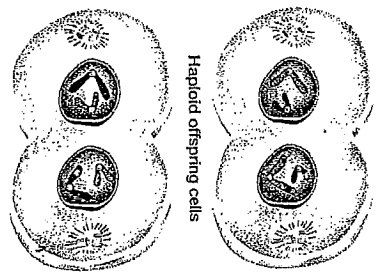
- 7 Anaphase II**

Centromeres divide. Chromatids move to opposite poles of the cell.



- 8 Telophase II and cytokinesis**

A nuclear envelope forms around each set of chromosomes. The cytoplasm divides.



1. How are gametes and zygotes related?

2. What is one thing that all types of asexual reproduction have in common?

3. What would happen if the gametes of sexually reproducing organisms were diploid instead of haploid? Explain your answer.

4. How many chromosomes does a gamete of a dog have? Explain your answer.

5. Give two differences between sexual reproduction and asexual reproduction.

Bellringer: Day M T W Th F Date _____ Question _____

Answer _____

1. Describe the difference between what happens during anaphase I and what happens during anaphase II.

2. Fill in the blank spaces in the table below.

Stage of meiosis	Description
	Chromosomes condense, homologous chromosomes pair up, and crossing-over occurs.
	Cytokinesis occurs, and two new cells form.
	Pairs of sister chromatids move to the equators of the two cells.
	Cytokinesis occurs, and four new cells form.

3. Give two differences between meiosis and mitosis.

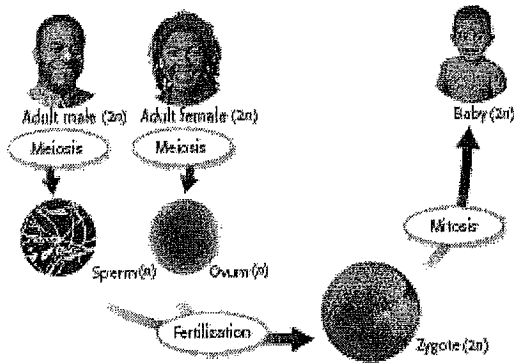
4. What are three processes that contribute to genetic variation during sexual reproduction?

5. Why is sexual reproduction helpful to a species?

Bellringer: Day M T W Th F Date _____ Question _____

Answer _____

1. Label the haploid and diploid cells in the figure below.



2. What type of life cycle does the figure above show? Explain your answer.

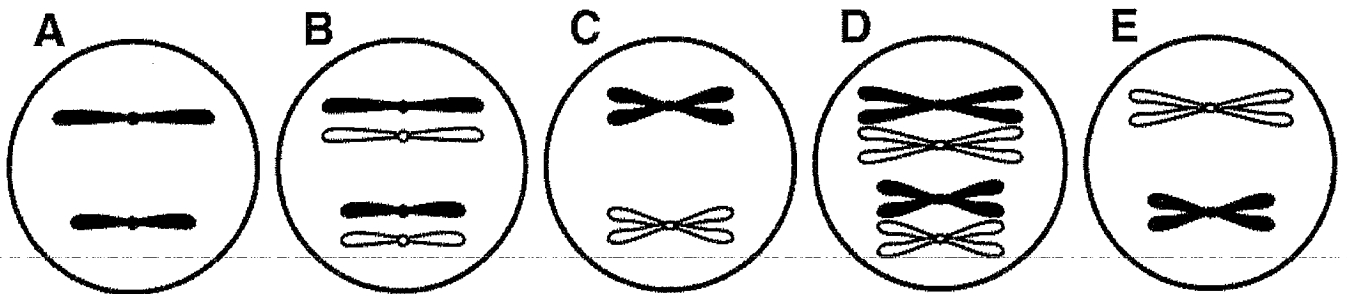
3. A particular plant's diploid number of chromosomes is 50. Describe the number of chromosomes in one of the plant's cells during its sporophyte phase and during its gametophyte phase. (use the phrase alternation of generations)

4. By what process do the spores of a plant form? By what process do the gametes form?

Bellringer: Day M T W Th F Date _____ Question _____
Answer _____

CH 11 REVIEW

1. What is the most simple method of reproduction?
2. What is binary fission?
3. What is asexual and sexual reproduction? What is the difference?
4. What is budding? Fragmentation? Binary Fission?
5. What zygote sex chromosome combination do females develop from?
6. Homologous chromosomes are pairs of chromosomes containing genes that code for _____
7. What # of autosomes and sex chromosomes do humans have?
8. In humans, the male determines the sex of the child because males have _____
9. What is haploid and diploid? Where do you find these in humans?
10. Finish the simily-diploid : somatic cell :: haploid :
11. Separation of homologues occurs during _____
12. Crossing over only takes place in _____
13. Label these stages and put them in order:



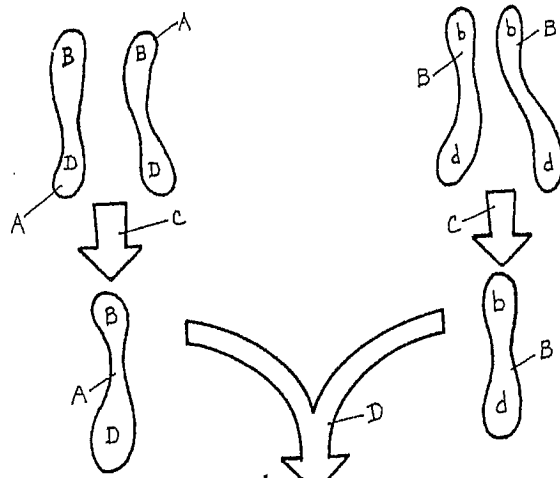
14. What is the difference between anaphase I of mitosis and anaphase I of meiosis?
15. _____ why does crossing over occur?
16. When does crossing over occur?
17. What provides for NEW genetic combinations?
18. What is an ovum?
19. What is alternation of generations? What is the haploid life cycle? What is a diploid life cycle?

CHROMOSOME CROSSOVERS.

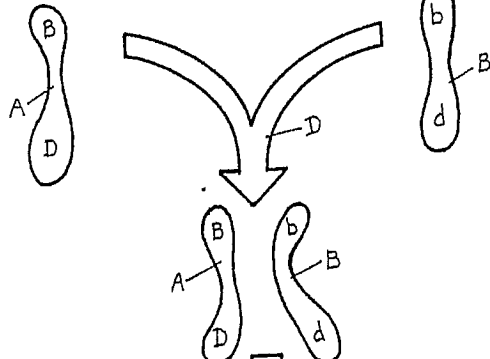
CHROMOSOME/CHROMATID*
 PATERNAL (HOMOZYGOUS
 DOMINANT)^A
 MATERNAL (HOMOZYGOUS
 RECESSIVE)^B
 MEIOSIS.
 FERTILIZATION.

TETRAD FORMATION.
 NON-CROSSING OVER:
 CROSSING OVER.
 RECOMBINANT CHROMOSOMES*
 PATERNAL PORTION^{A'}
 MATERNAL PORTION^{B'}

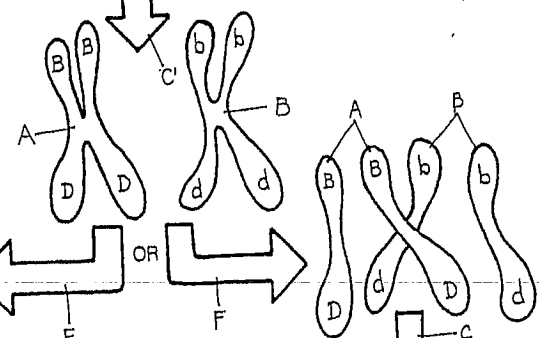
GENOTYPE/
CHROMOSOMES*



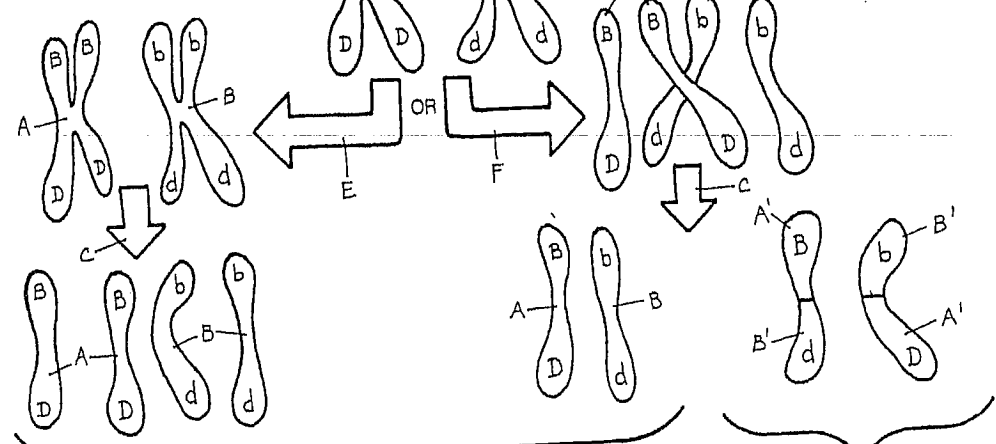
GAMETES/
CHROMOSOMES*



GENOTYPE/
CHROMOSOMES*



GAMETES/
CHROMOSOMES*



84%

16%

PERCENTAGE OF
TOTAL GAMETES_H

H

H

Chromosome Combinations

When a sperm and egg fuse, two sets of chromosomes are combined. In this lab, you will model this cross between two sets of chromosomes.

Procedure

1. Write "F1F2 × M1M2" on a sheet of paper. F1 and F2 represent the father's chromosomes. M1 and M2 represent the mother's chromosomes.
2. Determine all of the possible chromosome combinations in the zygote that forms from the fusion of the gametes with the chromosomes that you wrote in step 1.

Analysis

1. **Calculate** the number of chromosome combinations that are possible in the zygote.

2. List all of the possible chromosome combinations.

3. Why can the offspring of 2 parents have a phenotype (appearance) significantly different from either parent? Ex- why can two parents with black hair have a blond child?

Chromosome Simulation

The hereditary material of the non-dividing or interphase cell is contained in a compact body, the nucleus. Most nuclei divide (reproduce) by a process called mitosis. Near the nucleus in animal cells are two small bundles of rods, the centrioles, which lie at right angles to each other.

As division begins, the centrioles separate and move to opposite poles of the cell. As the centrioles move, they are surrounded by a system of microtubules, the asters. At the same time the nuclear membrane disintegrates and the nuclear material condenses and coils to form visible chromosomes. Each chromosome is divided lengthwise into two sister chromatids which are joined at a constriction called the centromere. Microtubules connect the centromeres of each chromosome to the centrioles, and the chromosomes then move to the equatorial plane of the cell (equidistant from the centrioles). The sister chromatids separate and are then called daughter chromosomes.

The daughter chromosomes begin moving toward opposite centrioles. When the chromosomes stop moving, a reorganization takes place which usually involves cytoplasmic division and nuclear reformation. This produces two interphase (daughter) cells. During the interphase, each chromosome reproduces itself; thus, new sister chromatids are present for the next division.

ASSEMBLY

Each team should obtain 60 beads of each color, four magnetic centromeres, two centrioles, a plastic bag, and four pieces of string 75 cm (30") long. Assemble four units (two of each color) like the unit illustrated in Figure 1. Bring the centromeres of two units of the same color together so they attract and link to form a chromosome with two parallel chromatids (Fig. 2).

INTERPHASE. Put the two chromosomes in the plastic bag (nuclear membrane). Place the bag near the center of your work space to represent the nucleus, and position the two centrioles near the nucleus at right angles to each other (Fig. 3).

PROPHASE. Separate the two centrioles and tape them down about 50 cm to each side of the nucleus (Fig. 4), pointing toward the nucleus. Dump the chromosomes from the bag and put the bag aside. The arms of each chromosome should be twisted as shown in Figure 4. Form a loop at one end of each string. Draw one loop tightly around each centromere of a chromatid as shown in Figure 5, and then thread the strings of sister chromatids through opposite centrioles.

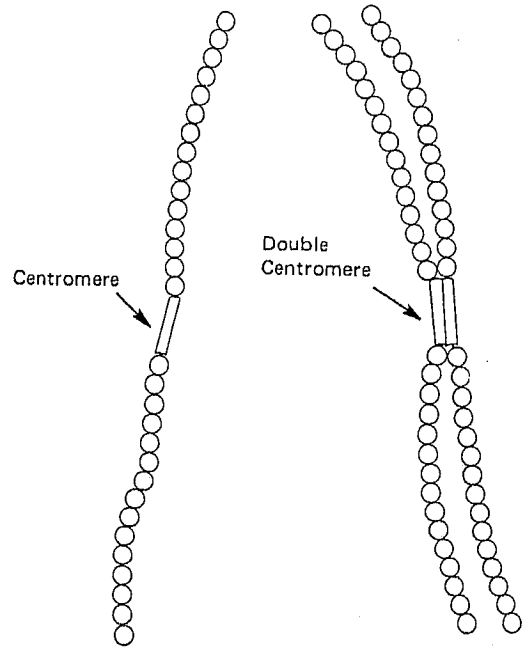


FIGURE 1

FIGURE 2

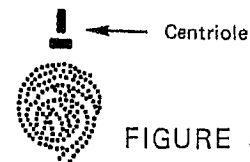


FIGURE 3

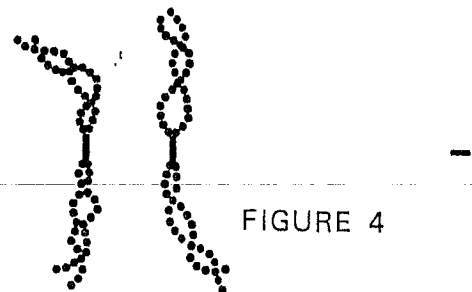


FIGURE 4

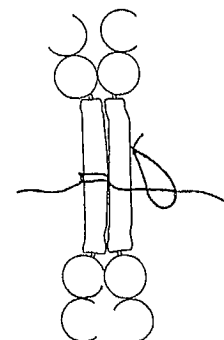


FIGURE 5

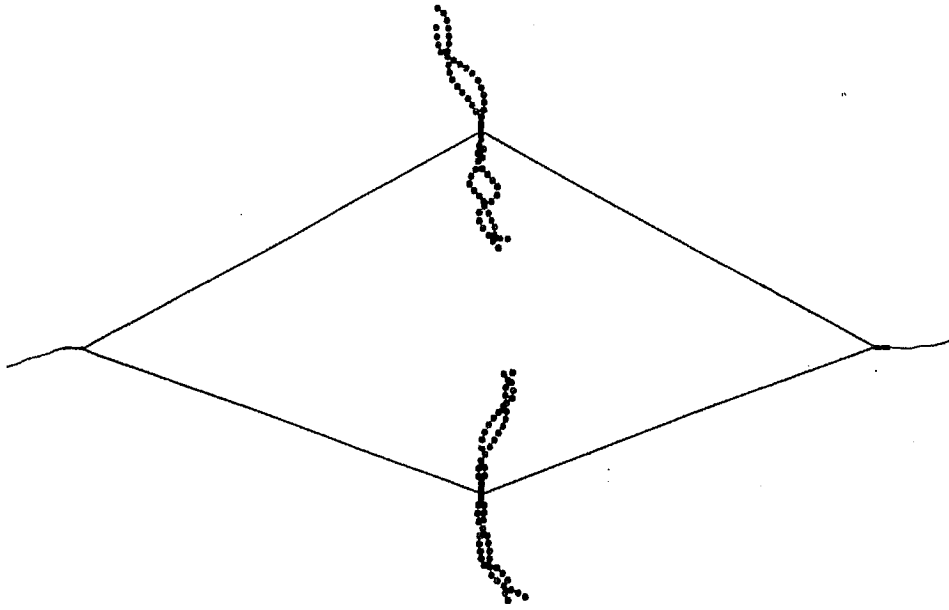


FIGURE 6

METAPHASE. Pull gently on the strings to bring the chromosomes to the midpoint between the centrioles (Fig. 6).

ANAPHASE. Continue pulling the strings until the centromeres are separated (Fig. 7). When the centromeres separate, the chromatids become daughter chromosomes. Continue pulling the chromosomes toward the centrioles.

TELOPHASE. Remove the strings. Pile the two chromosomes together near each centriole (Fig. 8). A nuclear membrane would now form and division of the cytoplasm would occur, completing cell division.

REVIEW

Repeat the above procedure several times until you are familiar with the major events of mitosis.

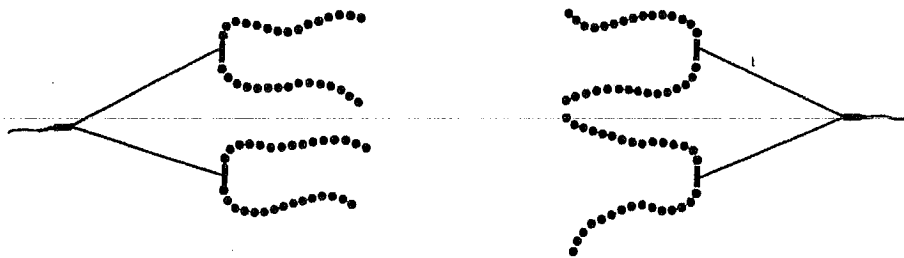


FIGURE 7



FIGURE 8

Chromosome Simulation

Meiosis is a fundamental step in the sexual reproductive cycle of most organisms. It is a sequence of two nuclear divisions resulting in reduction of the chromosome number by half. Early in meiosis, pairing of homologous (like) chromosomes occurs. While they are paired, the homologous chromosomes may exchange segments, a process called crossing-over. In this exercise you will work with a pair of homologous chromosomes.

ASSEMBLY

Each team should obtain 60 beads of each color (120 total), four magnetic centromeres, four centrioles, a plastic bag, and four pieces of string 75 cm (30") long. Assemble four units (2 of each color) like the unit illustrated in Figure 1. Bring the centromeres of two units of the same color together so they attract and link to form a chromosome with two parallel chromatids.

INTERPHASE: Put the two chromosomes in the plastic bag (nuclear membrane). Place the bag near the center of your work space to represent the nucleus, and position the two centrioles near the nucleus at right angles to each other.

FIRST DIVISION: REDUCTION DIVISION

PROPHASE I: Although the chromosomal events of prophase I occur within the nuclear membrane, to simulate these events the plastic bag must be discarded. Dump the chromosomes onto your work space and entwine them as shown in Figure 2. Note that the chromatids of each chromosome remain parallel. To simulate crossing-over, detach a chromatid section from each chromosome at some point (e.g., A of Fig. 2) and exchange them. (The sections must be of equal length.) Separate the two centrioles and tape them down about 50 cm to each side of the nucleus (Fig. 2). Form a loop at one end of each string. Draw a loop tightly around the double centromere of each chromosome as shown in Figure 3, and then thread the strings through opposite centrioles.

METAPHASE I: Position the chromosomes near the midpoint between the centrioles and at right angles to the strings (Fig. 4).

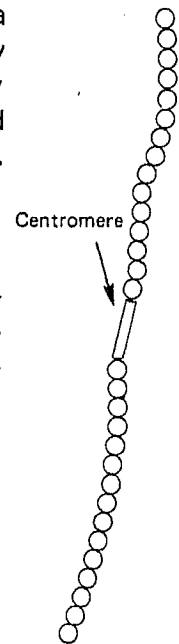


FIGURE 1

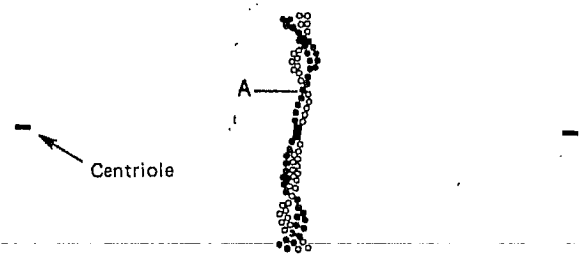


FIGURE 2

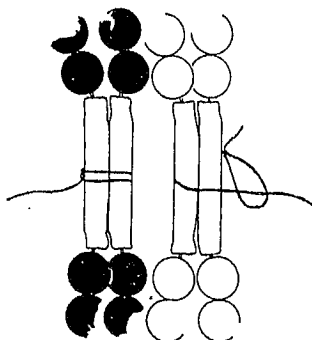


FIGURE 3

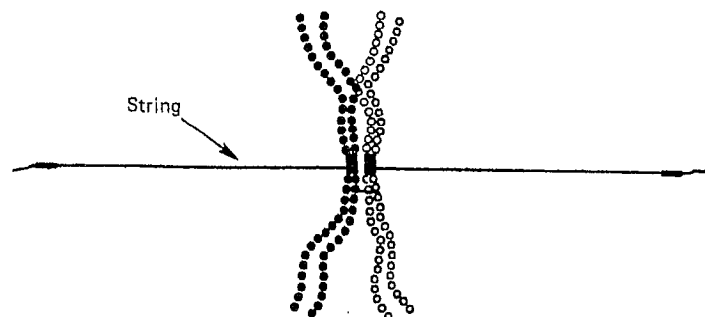


FIGURE 4

ANAPHASE I: Pull gently on the strings, separating the chromosomes and pulling them toward opposite centrioles (Fig. 5).

TELOPHASE I: Remove the strings. Pile each chromosome near its centriole and place a second centriole near the first, at right angles to it (Fig. 6). Formation of a nuclear membrane and division of the cytoplasm often occurs at this time to produce two cells (Fig. 6).

SECOND DIVISION: "MITOTIC" DIVISION (The following procedures apply to both chromosome groups produced by the first division.)

PROPHASE II: Separate the two centrioles and tape them down about 50 cm to each side of the chromosome group (Fig. 8). Form a loop at one end of each string. Draw a loop tightly around each centromere of a chromatid as shown in Figure 7 and then thread the strings of sister chromatids through opposite centrioles (Fig. 8).

METAPHASE II: Pull gently on the strings to bring the chromosome to the midpoint between the centrioles (Fig. 8).

ANAPHASE II: Continue pulling the strings until the centromeres are separated and the daughter chromosomes are pulled toward the centrioles (Fig. 9).

TELOPHASE II: Remove the strings. Pile each chromosome near its centriole (Fig. 10). Formation of a nuclear membrane and division of the cytoplasm would occur at this time.

REVIEW

Repeat the above procedure several times until you are familiar with the major events of meiosis.

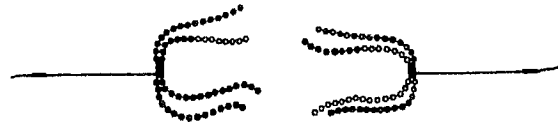


FIGURE 5



FIGURE 6

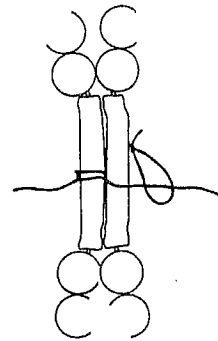


FIGURE 7

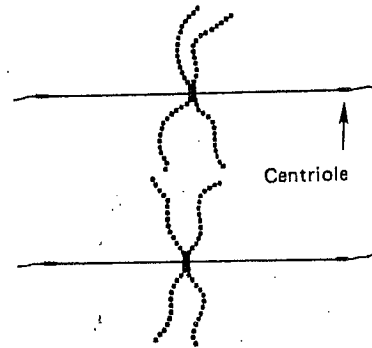


FIGURE 8

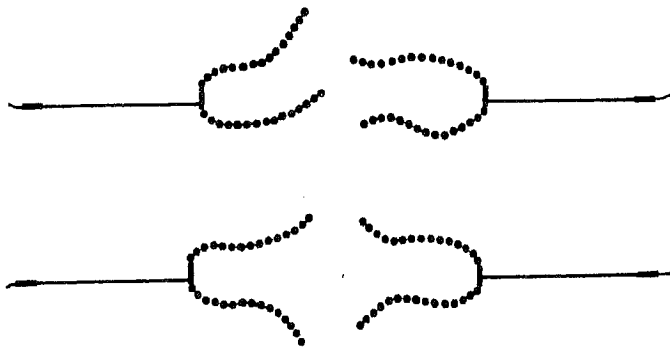


FIGURE 9

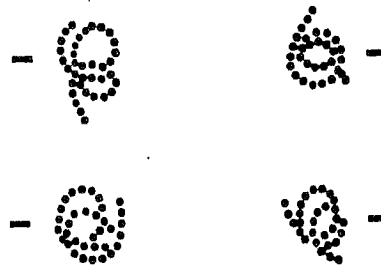


FIGURE 10

Crossing-over & Chromosome Aberrations

In this exercise you will work with a pair of homologous chromosomes. Consider the beads to be genes. Genes on a given chromosome tend to be inherited together and are said to be linked. However, these linkage groups can be disrupted or rearranged in various ways during meiosis. Some examples follow.

ASSEMBLY

Each team should obtain 60 beads of each color and four magnetic centromeres. Assemble four units (two of each color) like the unit illustrated in Figure 1. Bring the centromeres of two units of the same color together so they attract and link to form a chromosome with two parallel chromatids as shown in Figure 2.

CROSSING-OVER

Entwine the chromatids of the chromosome pair somewhat as shown in Figure 3. Detach chromatid sections in areas corresponding to A, B, and C of Figure 3 and exchange the sections. Notice that the sections exchanged must be of equal lengths. Untangle the chromosomes and record the results by shading in the appropriate sections of Figure 4. The exchange of genetic material between homologous chromosomes is termed *crossing-over*. Compare your results with the results of other groups. If you find differences, try to determine how they occurred. If such an exchange occurs between nonhomologous chromosomes, it is termed *translocation*.

For the next exercise reassemble the chromosomes in their original condition.

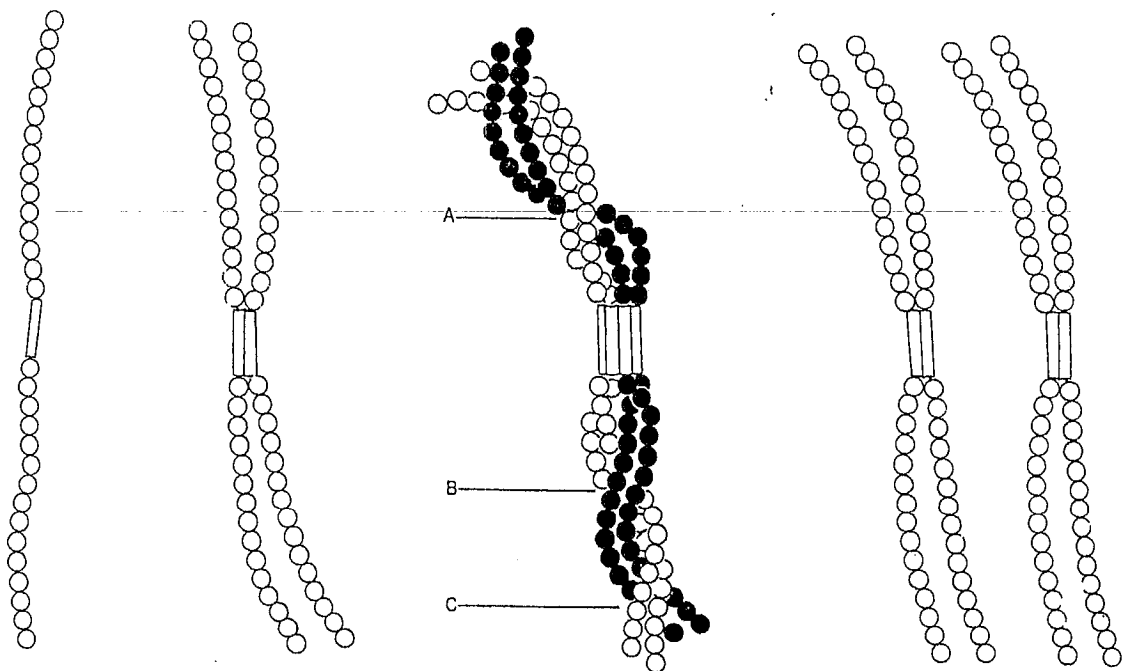


FIGURE 1

FIGURE 2

FIGURE 3

FIGURE 4

DELETION AND DUPLICATION

Remove a portion of a chromatid. The loss of a chromatid portion is termed *deletion*. Reproductive cells which have deletions may die or give rise to defective offspring. Why would a loss of genes cause such effects? _____

Attach the deleted portion to the end of another chromatid. This results in a chromatid with double the number of genes for some traits and is an example of one type of *duplication*. Diagram the results of deletion and duplication on Figure 5 by marking out the deletion and drawing in the duplication.

For the next exercise reassemble the chromosomes in their original condition.

INVERSION

Use a ballpoint pen to mark the beads on one chromatid as shown in Figure 6. (If necessary, mark the letters on masking tape and attach to the beads.) Form a loop in the chromatid as shown in Figure 7. Detach the ends of the chromatid where they overlap and exchange the ends. Straighten out the chromatid with gene A again uppermost. Record the new sequence of genes on Figure 8. What has happened to the sequence of the genes that were within the loop? _____

A change in the sequence of genes in a linkage group is termed an *inversion*.

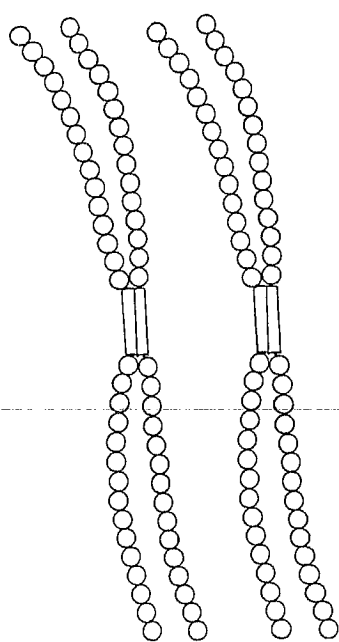


FIGURE 5

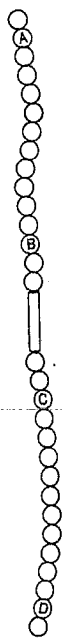


FIGURE 6

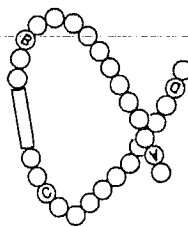


FIGURE 7



FIGURE 8

Meiosis Model

OBJECTIVES

- **Model** the stages of meiosis.
- **Describe** the events that occur in each stage of the process of meiosis.
- **Compare** your meiosis model to meiosis stages in a set of prepared slides of lily anther microsporocytes.

MATERIALS

- pop beads(40)
- marker
-
- plates (8) labeled with each stage
- centrosome (plastic)
- scissors

Procedure

BUILD A MODEL

1. Work in a team of two (not 4). Review the stages of meiosis I and meiosis II. Study what happens in each stage. Pay particular attention to the way the chromosomes look and act.
2. Work with your partner to design a model of a cell nucleus. Use the plate as the cell. Omit other structures
3. Label each of the eight plates with one stage of meiosis, like "Prophase II."
4. Using your model plan that you designed in step 2, you or your partner will make a set of models for the four stages of meiosis I. The other team member will make a set of models for the four stages of meiosis II. (each person must make 4)
5. Finish making your set of models. Then, position the plates in two horizontal rows. The top row is for the stages of meiosis I. The bottom row is for the stages of meiosis II. What are the differences between the corresponding stages.

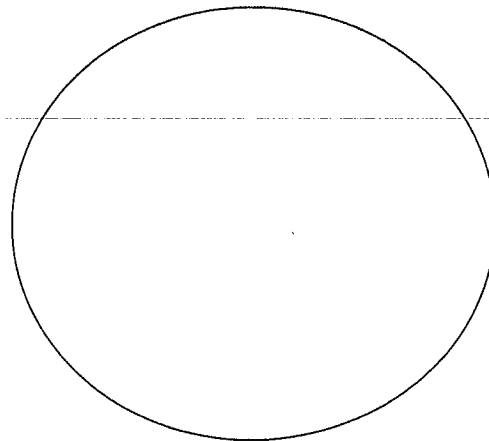
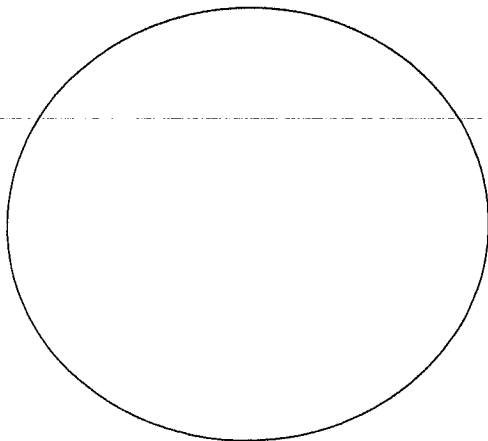
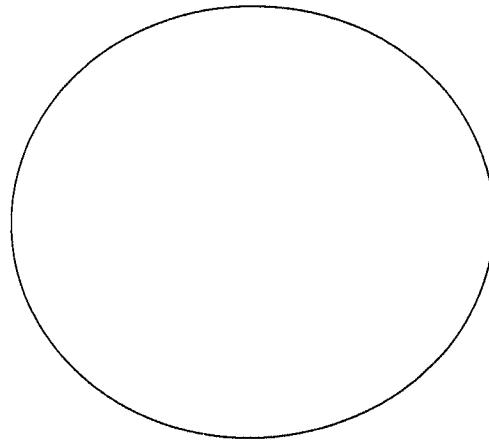
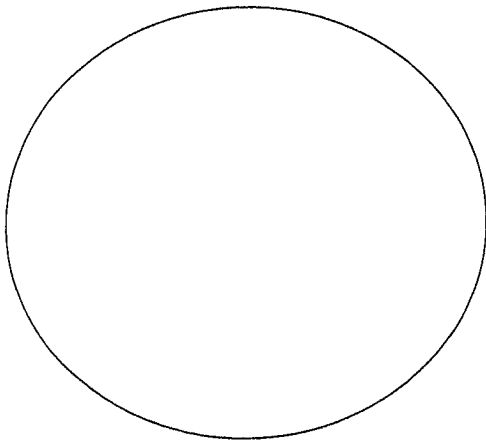
Questions

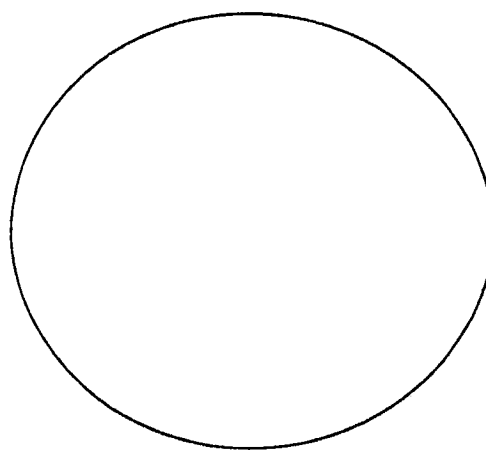
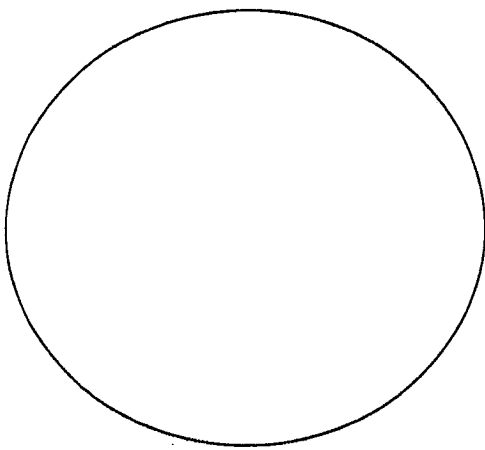
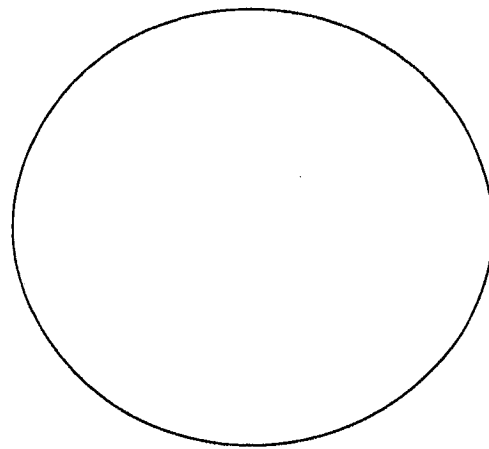
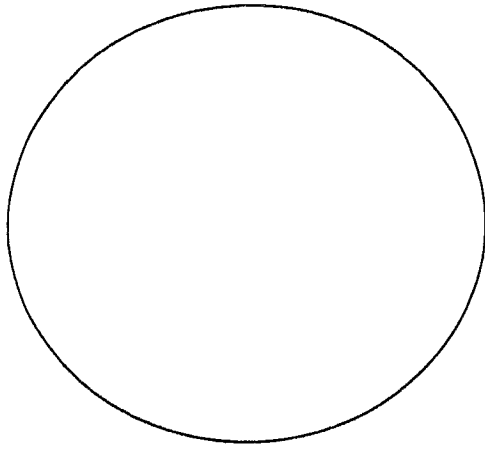
1. Identify and label each stage of meiosis as a haploid stage or a diploid stage.

Prophase I	Metaphase I	Anaphase I	Telephase I

Prophase 2	Metaphase 2	Anaphase 2	Telephase 2

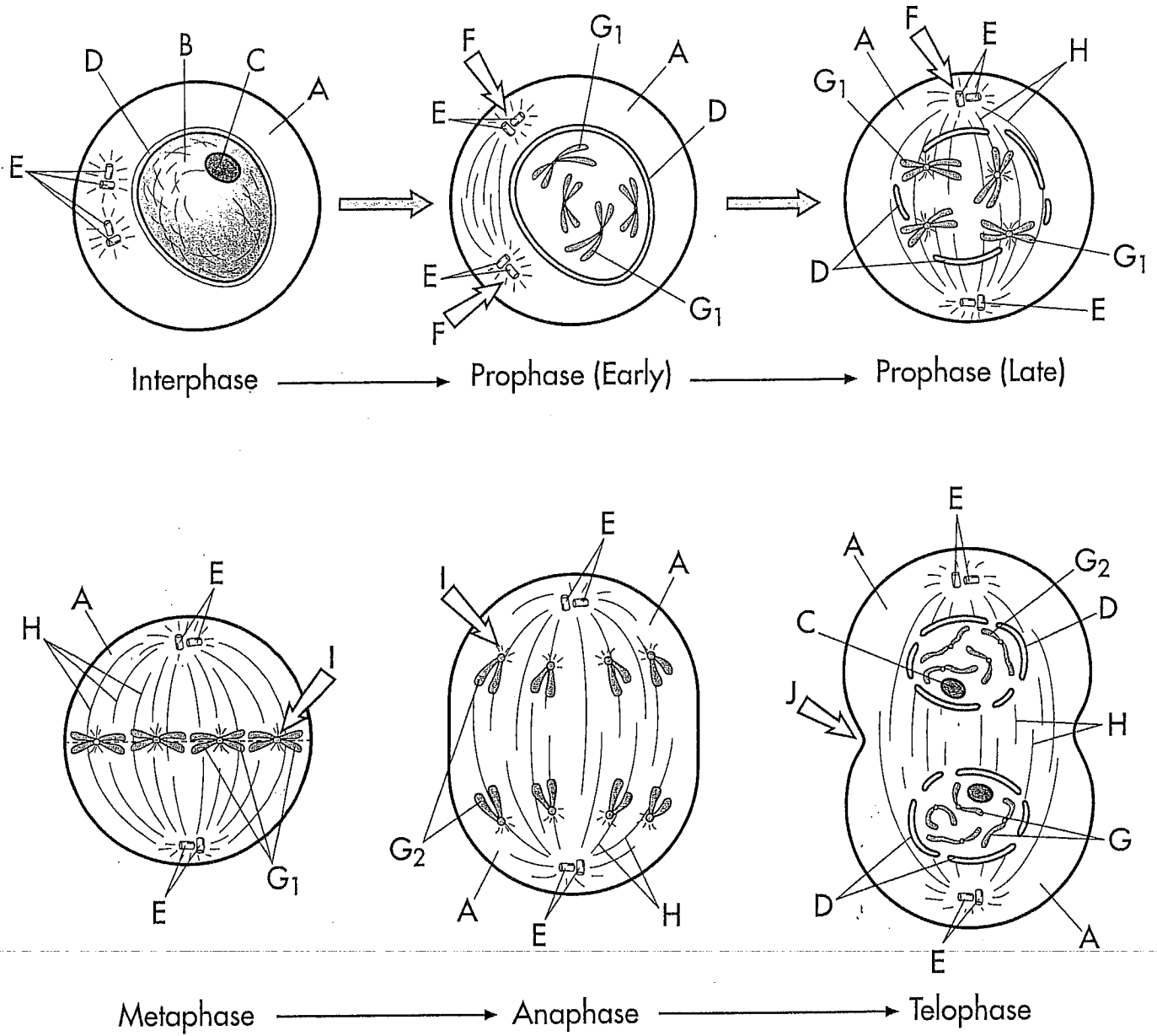
2. Draw AND LABEL each stage of meiosis below.





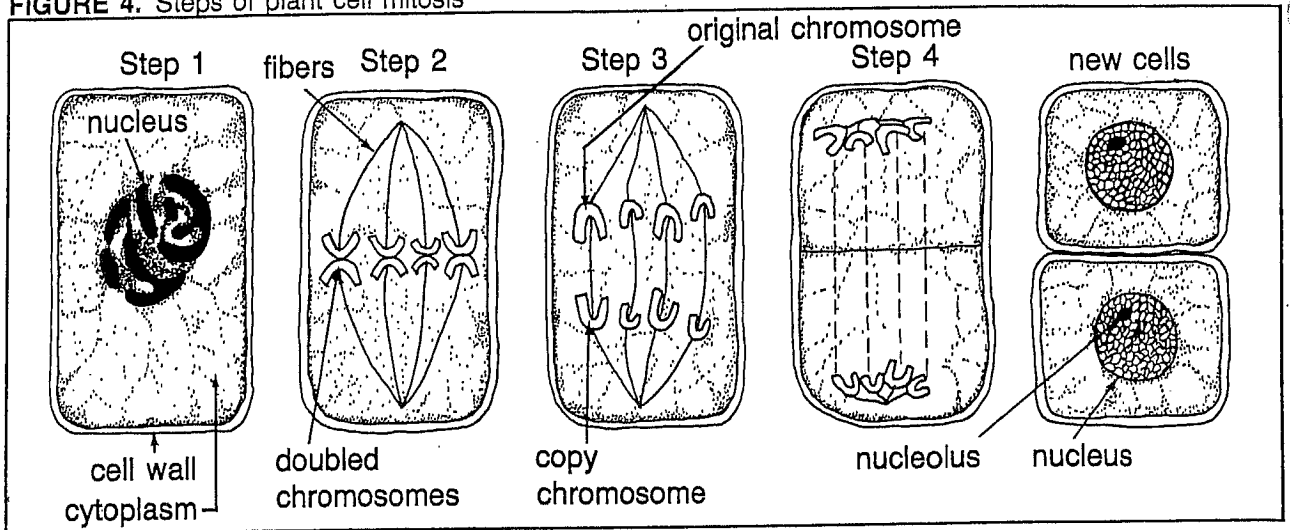
2. How are anaphase I and anaphase II different?

3. Based upon what you saw in other people's work, evaluate your model. How could you improve your model?



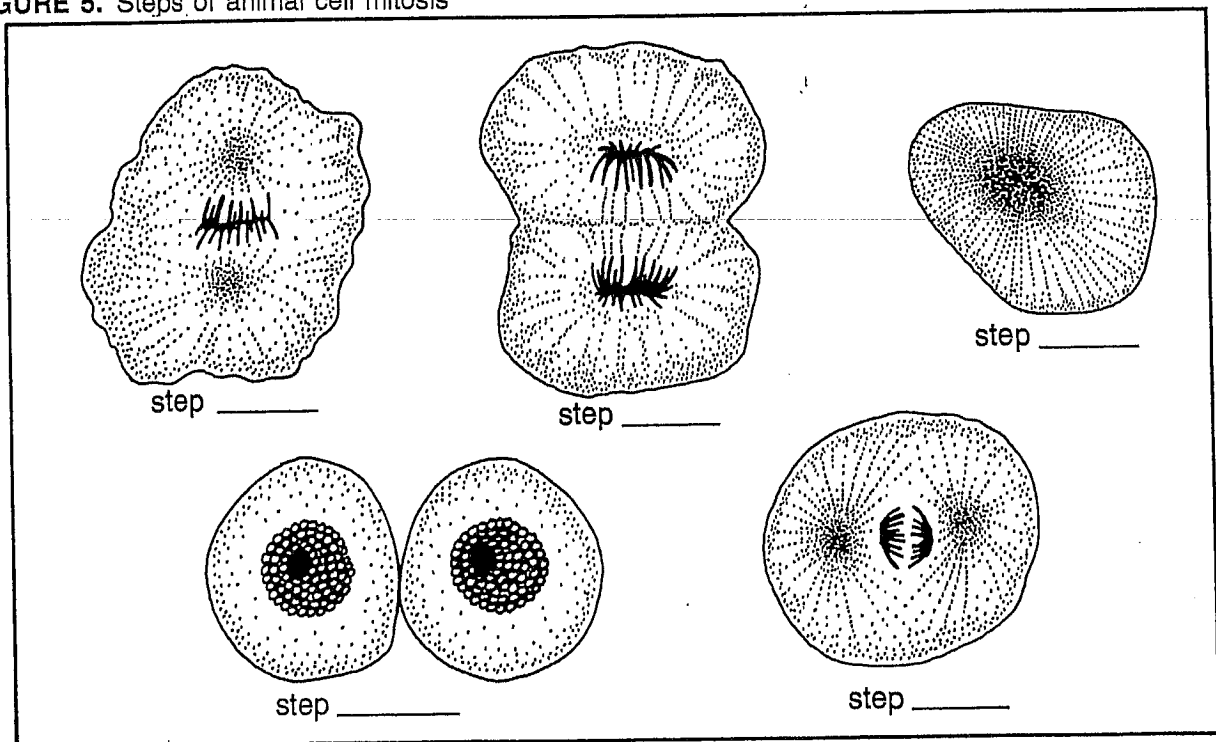
- | Mitosis | | |
|-----------------------------|----------------------------------|-------------------------|
| ○ Cytoplasm.....A | ○ CentriolesE | ○ Spindle FibersH |
| ○ Nucleus (Chromatin).....B | ○ AstersF | ○ Kinetochore.....I |
| ○ Nucleolus.....C | ○ ChromatidsG ₁ | ○ Cleavage Furrow.....J |
| ○ Nuclear MembraneD | ○ Chromosomes.....G ₂ | |

FIGURE 4. Steps of plant cell mitosis



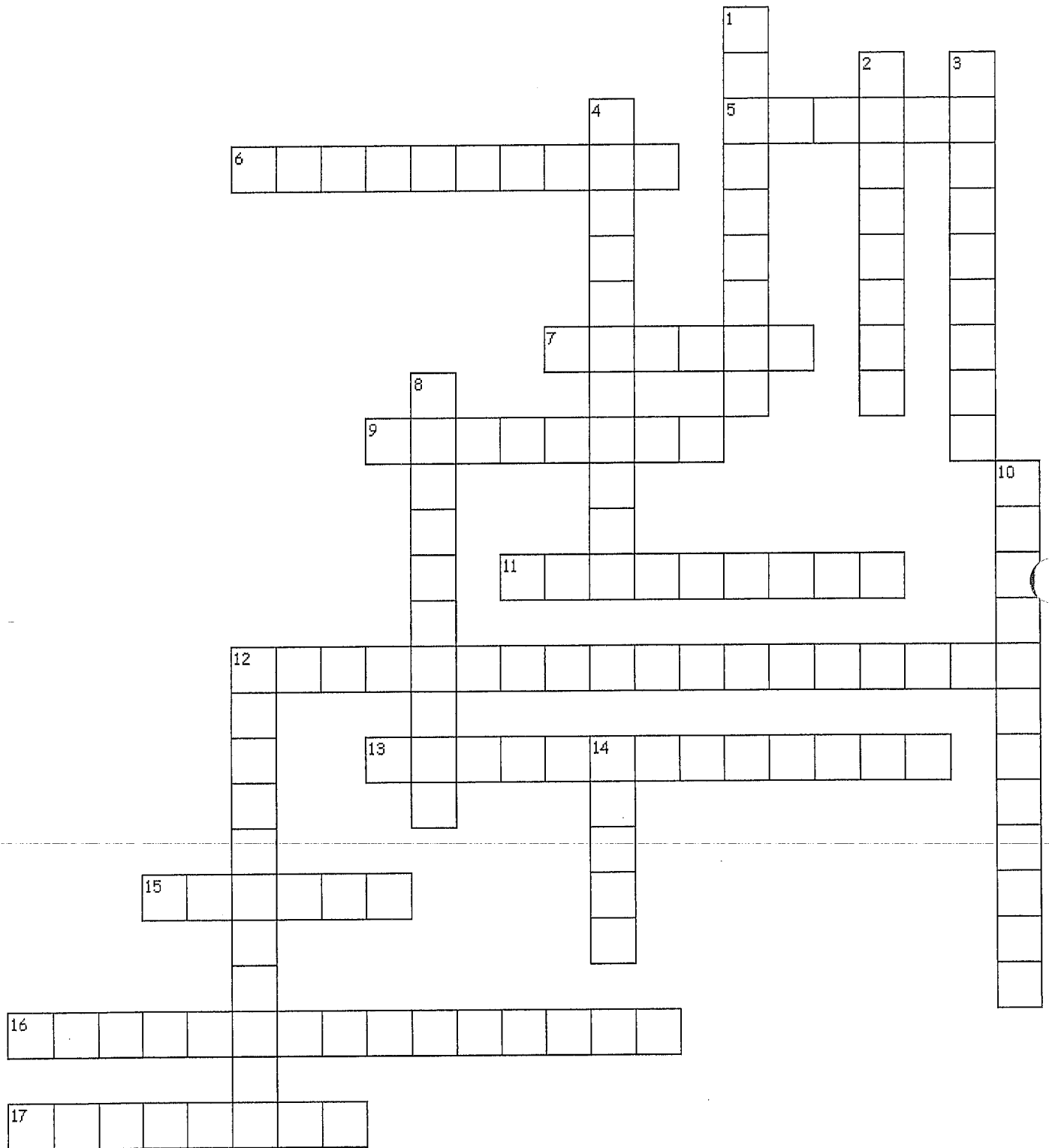
6. Arrange your models in the order in which mitosis occurs. Note how your models differ from those shown in Figure 1. Your models show dividing plant cells.
7. Compare your models with the drawings of the animal cells in Figure 5.
8. Write the number of the step of mitosis below each drawing of the animal cells.

FIGURE 5. Steps of animal cell mitosis





Ch 12 Crossword/ Vocab



Across

5. one of two or more alternative forms of a gene, each leading to a unique trait
6. the entire group of offspring produced by a given group of parents
7. in genetics, describes two or more genes that tend to be inherited together
9. describes an allele that is fully expressed whenever the allele is present in an individual
11. the detectable trait or traits that result from the genotype of an individual
12. a character that is influenced by more than one gene
13. a graphic used to predict the results of a genetic cross
15. the offspring of a cross between parents that have contrasting traits
16. an inherited disease or disorder that is caused by a mutation in a gene or by a chromosomal defect
17. a specific combination of alleles in an individual

Down

1. a recognizable inherited feature or characteristic of an organism
2. a diagram that shows the occurrence of a genetic trait in several generations of a family
3. describes an allele that is expressed only when there is no dominant allele present in an individual
4. a condition in which both alleles for a gene are fully expressed
8. describes an individual that carries two identical alleles of a gene
10. describes an individual that carries two different alleles of a gene
12. the likelihood that a specific event will occur
14. a genetically determined characteristic

CHAPTER 12 VOCAB

Character

Trait

Hybrid

Generation

Allele

Dominant

Recessive

Genotype

Phenotype

Homozygous

Heterozygous

Punnett square

Probability

Pedigree

genetic disorder

polygenic character

codominance

Chapter 12 Mendel and Heredity

I. **MENDEL'S BREEDING EXPERIMENTS-** Modern genetics is based on Mendel's explanations for the patterns of heredity in garden pea plants.

- A. A monk named Gregor Mendel did breeding experiments in the 1800s with the garden pea plant.
- B. The science of heredity and the mechanism by which traits are passed from parents to offspring is called genetics.
- C. Most of Mendel's experiments involved crossing different types of pea plants. In this case, the word cross means "to mate or breed two individuals."

II. **MENDEL'S FIRST EXPERIMENTS** - Mendel's first experiments used monohybrid crosses and were carried out in three steps.

- A. A _____ cross is a cross that is done to study one pair of contrasting traits..
- B. Each step in Mendel's experiments involved a new generation of plants. A _____ is a group of offspring from a given group of parents.
- C. Plants that self-pollinate for several generations produce offspring of the same type. Such a plant is said to be _____ for a given trait.
- D. The first group of parents that are crossed in a breeding experiment are called the _____, or P generation. The offspring of the P generation is called the first _____ generation, or F1 generation.
- E. Mendel allowed the F1 generation to self-pollinate and produce new plants. He called this offspring the _____ generation, or F2 generation.

III. **RATIOS IN MENDEL'S RESULTS-** For each of the seven characters that Mendel studied, he found a similar 3-to-1 ratio of contrasting traits in the F2 generation.

IV. **EXPLAINING MENDEL'S RESULTS-** Mendelian theory explains simple patterns of inheritance..

- A. Different traits result from different versions of genes. Each version of a gene is called an _____.

- B. Each allele can lead to a unique _____.
- C. An allele that is fully expressed whenever it is present is called _____.
- D. An allele that is not expressed when a dominant allele is present is called _____.
- E. A recessive allele is expressed only when there is no _____ allele present.

V. **RANDOM SEGREGATION OF ALLELES**- In modern terms, the law of segregation holds that when an organism produces gametes, each pair of alleles is separated and each gamete has an equal chance of receiving either one of the alleles. Chance decides which alleles will be passed on.

VI. **GENOTYPE DETERMINES PHENOTYPE**- The combination of genes an individual has (_____) determines what an organism looks like (_____)

- A. A _____ allele is shown as a capital letter. This letter usually corresponds to the first letter of the word for the trait.
- B. A _____ allele is shown as a lowercase letter.
- C. The set of specific combinations of alleles that an individual has for a character is called the _____.
- D. The detectable trait that results from the genotype's set of alleles is called the _____.
- E. If an individual has two identical alleles of a certain gene, the individual is _____ for the related character.
- F. If an individual has two different alleles of a certain gene, the individual is _____ for the related character.

VII. **MENDEL'S SECOND EXPERIMENTS**- Mendel went from his monohybrid crosses (purple or white flower color) to _____ crosses where he examined how 2 traits are passed together. A _____ cross involves two characters, such as seed color and seed shape.

- A. Mendel used dihybrid crosses in his second experiments and found that the inheritance of one character did not affect the inheritance of another character.
- B. Genes are said to be _____ when they are close together on chromosomes. Scientists now know that many genes are linked to each other as parts of chromosomes.
- C. Genes that are located close together on the same chromosome will NOT separate _____.
- D. The only genes that follow Mendel's law of independent assortment are those that are far apart.

VIII. USING PUNNETT SQUARES-A Punnett square shows all of the genotypes that could result from a given cross.

- A. A Punnett square is a model that predicts the likely outcomes of a genetic cross.
- B. The combination of letters in each box represents one possible _____ in the offspring.
- C. In a monohybrid homozygous cross, all of the offspring will be _____ (Yy) and will express the dominant trait.
- D. In a monohybrid heterozygous cross the genotypic ratio will be 1 YY : 2 Yy : 1 yy. The _____ ratio will be 3 : 1.

IX. USING PROBABILITY- A Punnett square is a visual way to determine probability. Probability is the likelihood that a specific event will occur. Probability can be expressed in words, as a decimal, as a percentage, or as a fraction.

X. USING A PEDIGREE- A pedigree is a diagram that shows how a trait is inherited over several generations of a family. Pedigrees can be used to help a family understand a genetic disorder.

XI. MANY GENES, MANY ALLELES- The Mendelian inheritance pattern is rare in nature; other patterns include polygenic inheritance, incomplete dominance, multiple alleles, and codominance.

- A. A character that is influenced or affected by more than one gene is called a _____ character. Eye color, height, and skin color are examples of polygenic characters. Most characters are polygenic.
- B. Genes that have three or more possible alleles are said to have _____. Multiple alleles control the ABO blood groups (blood types) in humans.
- C. _____ is a condition in which both alleles for the same gene are fully expressed. The genetics of human blood groups(above) is an example of codominance with multiple alleles

XII. GENES AFFECTED BY THE ENVIRONMENT- Phenotype (how it looks) can be affected by conditions in the environment, such as nutrients and temperature.

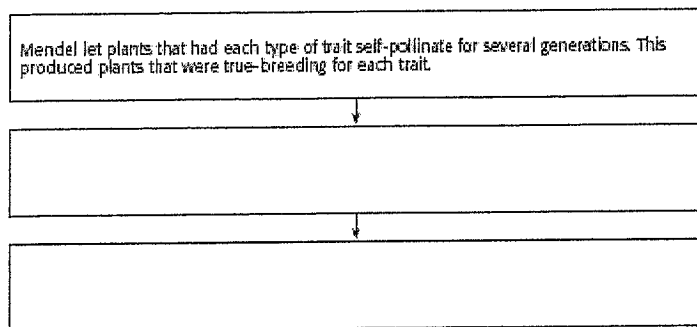
- A. In humans, many characters that are partly determined by heredity, such as height, are also affected by the environment.
- B. Many aspects of human personality and behavior are strongly affected by the environment, but genes also play an important role (nature vs. nurture)

XIII. GENES LINKED WITHIN CHROMOSOMES- During meiosis, genes that are close together on the same chromosome are less likely to be separated than genes that are far apart.

- A. Many traits do not follow Mendel's laws because he studied the simplest kinds of heredity where characters are determined by _____ genes.
- B. Genes that are close together, as well as the traits they determine, are said to be _____. Linked genes tend to be inherited together.

1. What was Mendel's main contribution to hereditary science?

2. Complete the process chart below to describe the major steps of Mendel's first experiment.



3. Identify three reasons Mendel chose to use garden peas in his experiments.

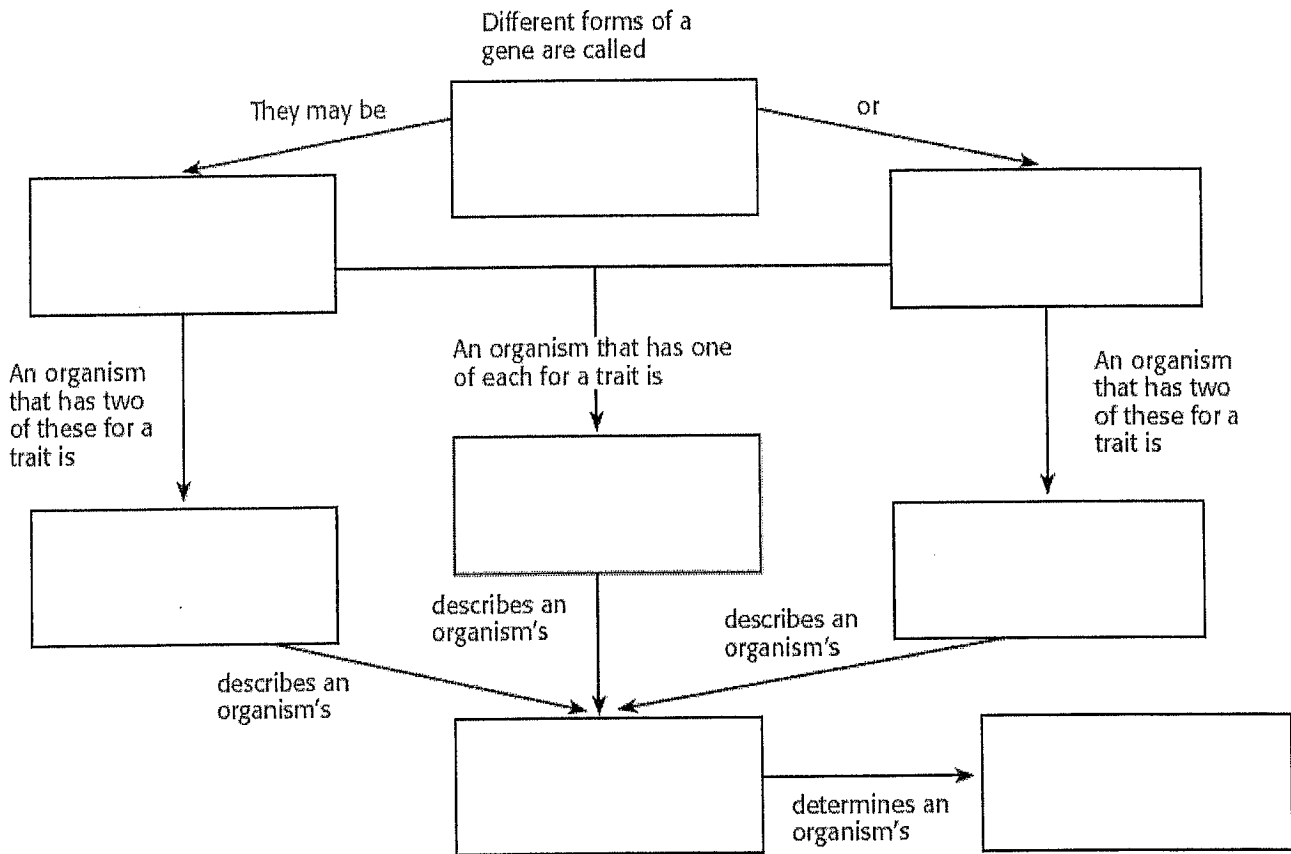
4. What was the typical ratio of traits in the F2 generation in Mendel's first experiments?

:

5. Mendel examined thousands of pea plants in his experiments. Why do you think he used so many?

Bellringer: Day M T W Th F Date _____ Question _____
Answer _____

1. Complete the following concept map.



2. Is it possible for two individuals to have the same phenotype and different genotypes? Explain your answer.

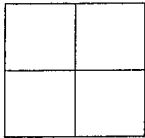
3. According to the law of independent assortment, what gametes can an individual with the genotype *AaBb* produce?

Bellringer: Day M T W Th F Date _____ Question _____

Answer _____

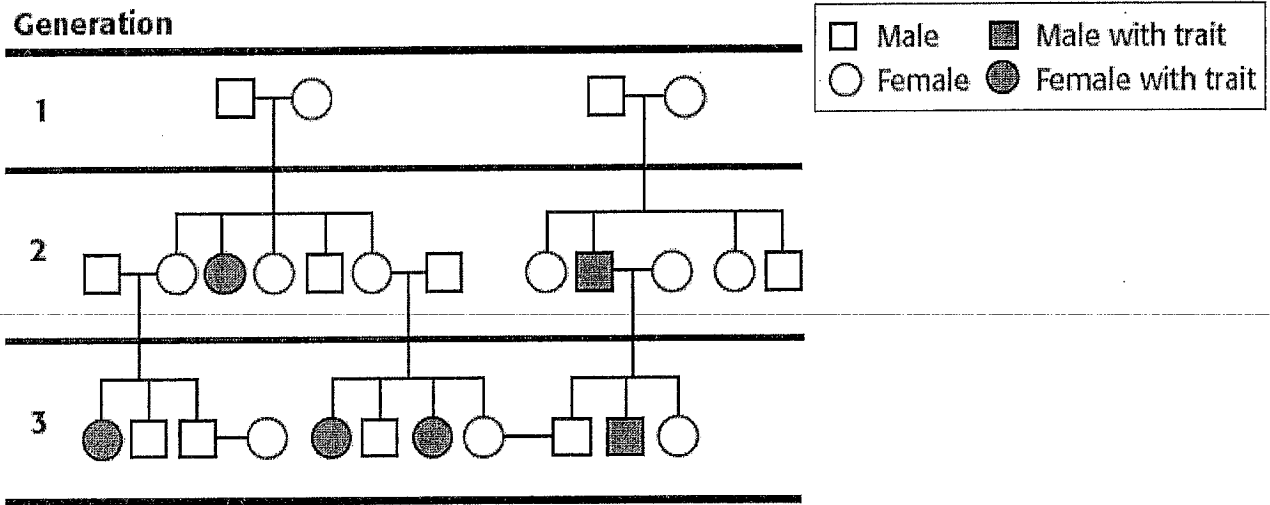
1. What are two ways a Punnett square can be used in genetics?

2. What is the probability that a cross between two heterozygous individuals will produce homozygous offspring? _____



3. When you analyze a pedigree, how can you determine whether an individual is a carrier for the trait?

Use the pedigree to answer the questions that follow. The pedigree shows the presence of albinism in a family. The gene for albinism is found on an autosome.



4. Is the allele for albinism recessive or dominant? How can you tell?

5. On the pedigree above, circle all the individuals who are definitely carriers for albinism.

1. What are three exceptions to the Mendelian pattern of one character controlled by two alleles?

2. How does codominance differ from incomplete dominance?

3. What are the possible genotypes and phenotypes for blood type of an individual whose father is $I^A I^B$ and whose mother is $i i$? Use a Punnett square to show these possibilities.

4. In humans, height may be affected by both heredity and the environment. If an individual has tall parents, what kind of environmental, or outside, factors may cause the individual to be short?

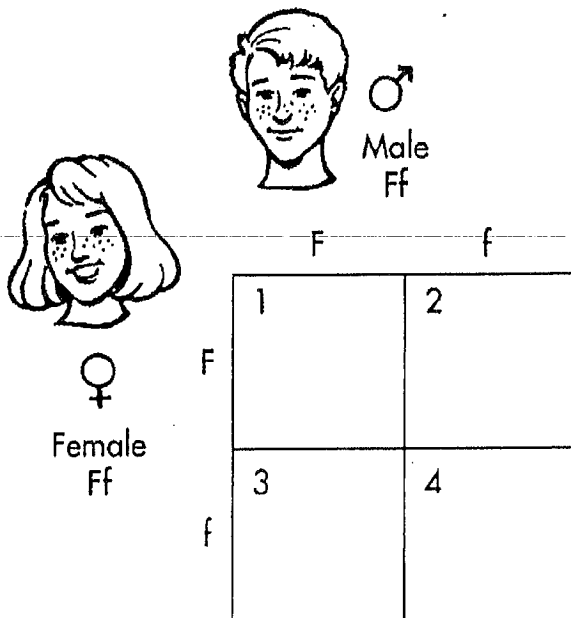
5. If two genes are known to be linked, what would you expect to happen to these genes during meiosis?

Bellringer: Day M T W Th F Date _____ Question _____

Answer _____

CHAPTER 12 REVIEW

1. What is the phenotype? Genotype?
2. What is the phenotype? Genotype? Whats the difference? Is genotype always expressed?
3. If an individual possesses two recessive alleles for the same trait, the individual is said to be _____
4. If an individual possesses two recessive alleles for the same trait, the individual is said to be _____. What will be the phenotype?
5. When an individual heterozygous for a trait is crossed with an individual homozygous recessive for the trait, the offspring produced will
6. When an individual heterozygous for a trait is crossed with an individual homozygous recessive for the trait, the offspring produced will have what genotype? Phenotype?
7. Tallness (T) is dominant to shortness (t) in pea plants. Which of the following represents a genotype of a pea plant that is heterozygous for tallness?
8. What is the law of independent assortment?
9. In humans, having freckles (F) is dominant to not having freckles (f). The inheritance of these traits can be studied using a Punnett square similar to the one shown below.



10. In rabbits, black fur (B) is dominant to brown fur (b). ANswer the questions for a cross between 2 heterozygous rabbits for fur color.

11. The unknown genotype of an individual with a dominant phenotype can be determined using a _____?
12. What is the probability that the offspring of a homozygous dominant individual and a homozygous recessive individual will exhibit the dominant phenotype? (in decimal- remember that a decimal can be changed into %)
13. Probability is calculated by dividing the number of one kind of possible outcome by the _____?
14. If a characteristic is sex-linked, the gene for it is found on
15. Since the allele for colorblindness is located on the X chromosome, colorblindness
16. A diagram in which several generations of a family and the occurrence of certain genetic characteristics are shown is called a
17. In humans, eye color and height are controlled by
18. name a human trait that is controlled by multiple alleles
19. What would be the blood type of a person who inherited an A allele from one parent and an O allele from the other?
20. How can the environment influence expression of a gene? How can you tell if it is being influenced?
21. Genes that are close together on a single chromosome are considered to be
22. The passing of traits from parents to offspring is called
23. The scientific study of heredity is called
24. who is the father of genetics?
25. Step 1 of Mendel's garden pea experiment, allowing each variety of garden pea to self-pollinate for several generations, produced the
26. Define the generations- P, F1, F2
27. An allele that is always expressed whenever it is present is called
28. What is the law of segregation? What does it say?



PROBLEM SOLVING IN BIOLOGY

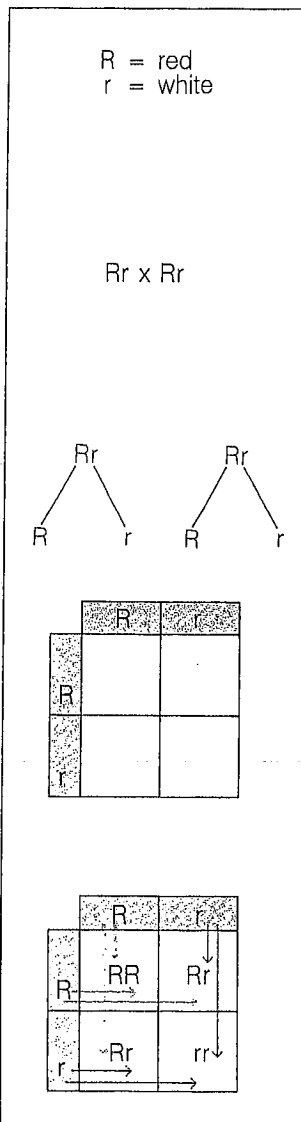
SOLVING GENETICS PROBLEMS

One-Factor Crosses: Sample Problem

In pea plants, red flowers are dominant over white flowers. A heterozygous red flower

is allowed to self-pollinate. What are the probable genotypic and phenotypic ratios in the offspring of this plant?

SOLUTION



Step 1 Choose a letter to represent the genes in the cross.

Use a letter whose capital form does not look too similar to its lowercase form. This will make it easier for you to read your finished Punnett square. Except for that requirement, it is not important which letter you select. In this case, let's use *R* for the dominant red allele and *r* for the recessive white allele.

Step 2 Write the genotypes of the parents.

This step is often written as an abbreviation of the cross being studied. The X between the parents' genotypes is read "is crossed with." In this case, *Rr* X *Rr* is read "*Rr* is crossed with *Rr*." Although only one parent is involved in this problem, you must still write it as a cross in which you account for a male parent and a female parent.

Step 3 Determine the possible gametes (reproductive cells) that the parents can produce.

Remember that alleles are segregated during the formation of gametes. Each gamete has 1/2 the number of alleles in the parent.

Step 4 Enter the possible gametes at the top and side of the Punnett square.

Step 5 Complete the Punnett square by writing the alleles from the gametes in the appropriate boxes.

This step represents the process of fertilization. The allele from the gamete above the box and the allele from the gamete to the side of the box are combined inside each of the four boxes. If there is a combination of capital letter and lowercase letter in a box, write the capital letter first. The letters inside the boxes represent the probable genotypes of the offspring resulting from the cross. In this example, 1/4 of the offspring are genotype *RR*, 1/2 are *Rr*, and 1/4 are *rr*.

PROBLEM SOLVING CONTINUED

	R	r
R	RR	Rr
r	Rr	rr

Genotypic ratio = 1:2:1
Phenotypic ratio = 3:1

Step 6 Determine the phenotypes of the offspring.
Remember that phenotype refers to the physical appearance of an organism. The principle of dominance makes it possible to determine the phenotype that corresponds to each genotype inside the Punnett square. In this example, 3/4 of the offspring have red flowers and 1/4 of the offspring have white flowers.

Step 7 Using the results of Steps 5 and 6, answer the problem.
Usually you will be asked to summarize the results of the cross by providing genotypic and phenotypic ratios. When writing such ratios, the numbers for the dominant genotype(s) or phenotype(s) come first. In this example, 1/4 of the offspring are genotype *RR*, 1/2 (or 2/4) are *Rr*, and 1/4 are *rr*. The genotypic ratio is therefore 1/4:2/4:1/4, or 1:2:1. Three fourths of the offspring have red flowers and 1/4 have white flowers. The phenotypic ratio is therefore 3/4:1/4, or 3:1.

Two-Factor Crosses: Sample Problem

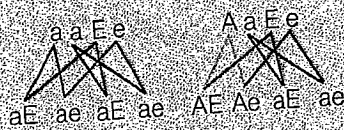
In the fruit fly *Drosophila melanogaster*, wings (*A*) are dominant over a lack of wings (*a*) and red eyes (*E*) are dominant over sepia (brownish) eyes (*e*). A wingless fly that is heterozygous for eye color is crossed with a fly

that is heterozygous for both eye color and presence of wings. What are the genotypic and phenotypic ratios for this cross? What fraction of the offspring from this cross will be wingless and have sepia eyes? What fraction will have the genotype *AaEe*?

SOLUTION

A = wings
a = wingless
E = red
e = sepia

aaEe × *AaEe*



	aE	ae	aE	ae
AE				
Ae				
aE				
ae				

- Step 1 Choose letters to represent the genes in the cross.**
In this particular problem, the letters to use are given to you. In the event that they are not, follow the same suggestions for choosing letters stated in Step 1 of the One-Factor Cross.
- Step 2 Write the genotypes of the parents.**
- Step 3 Determine the possible gametes that the parents can produce.**
- Step 4 Enter the possible gametes at the top and side of the Punnett square.**

SIMULATING A ONE-FACTOR CROSS

PROBLEM

How is probability applied to genetics?

MATERIALS (per student)

2 labeled game markers
paper cup

PROCEDURE

1. On a separate sheet of paper, prepare a completed data table similar to the one below.
2. In pea plants, yellow seeds (*A*) are dominant over green seeds (*a*). Using a Punnett square, determine the probable color of the seeds produced by pea plants whose parents are heterozygous (*Aa*) for the seed-color trait. Record the expected genotypic and phenotypic ratios in the appropriate places in your data table.
3. Each labeled marker represents the alleles in the heterozygous plant. Tossing the labeled markers together represents the crossing of heterozygous plants.
4. Put the 2 labeled markers into the cup. Holding one hand over the mouth of the cup, shake the cup to toss the markers. Empty the cup onto your desk or laboratory table. Record the results of each of 10 tosses by making a tally mark in the appropriate box in your data table.
5. Toss the markers 100 times and record the results in your data table.
6. One student in the class will compile the data for 100 tosses by 10 students and report the results. Record this information.

7. Count the tally marks for each genotype in each series of tosses (10, 100, 1000). Record these totals in the appropriate box.
8. Determine the total number of seeds with the yellow phenotype for each series of tosses.
9. Using the data, calculate the genotypic and phenotypic ratios for each series of tosses. This is done by dividing each number in the ratio by the ratio's smallest number and rounding off to the nearest tenth's place. For example, suppose you obtained 23 *AA*, 51 *Aa*, and 26 *aa* for a series of 100 tosses. This gives you the ratio 1:2.2:1.1 ($23/23 = 1$, $51/23 = 2.2$, $26/23 = 1.1$)

OBSERVATIONS

1. Which genotype was obtained most often?
2. What were your expected genotypic and phenotypic ratios?
3. What were your genotypic and phenotypic ratios for a series of 10 tosses? 100 tosses? 1000 tosses?

ANALYSIS AND CONCLUSIONS

1. How do the experimental ratios compare with the expected ratios?
2. Which series of tosses produced the experimental ratios that were closest to the expected ratios? Explain your results.
3. How does probability apply to the results of your experiment? How does probability apply to the study of genetics?

Offspring Phenotype	Yellow				Green		Total Number of Yellow Seeds (<i>AA</i> + <i>Aa</i>)	Expected Genotypic Ratio	Expected Phenotypic Ratio	Experimental Genotypic Ratio	Experimental Phenotypic Ratio
	<i>AA</i>		<i>Aa</i>		<i>aa</i>						
	Tally	Total	Tally	Total	Tally	Total					
10 Tosses											
100 Tosses											
1000 Tosses	X		X		X						

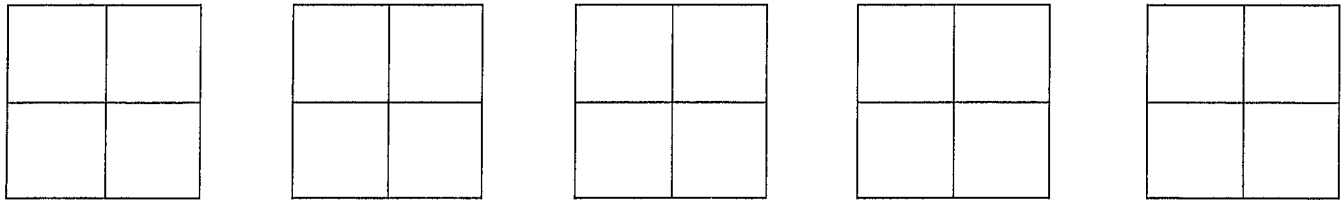
Punnett Squares Practice

Monohybrid Crosses

DIRECTIONS: All these genetic problems deal with pea plants and their traits. Use the following key for all problems. Put the gametes for the 1st parent of each cross along the top, and the gametes for the 2nd parent along the left side.

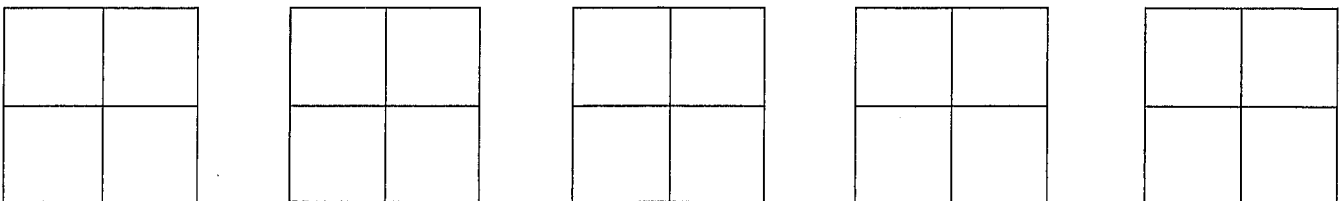
T = Tall **G = Green Pod** **Y = Yellow Seed** **S = Smooth Seed** **P = Purple Flower**
t = Short **g = Yellow Pod** **y = Green Seed** **s = Wrinkled Seed** **p = White Flower**

1. $PP \times Pp$ 2. $TT \times Tt$ 3. $Ss \times Ss$ 4. $yy \times yy$ 5. $Gg \times Gg$



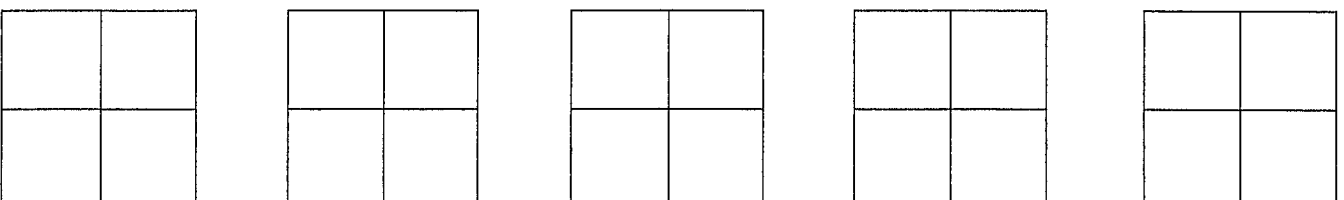
$\begin{array}{c} \text{---} \\ | \\ PP \quad Pp \quad pp \\ | \\ \text{---} \end{array}$
 $\begin{array}{c} \text{---} \\ | \\ TT \quad Tt \quad tt \\ | \\ \text{---} \end{array}$
 $\begin{array}{c} \text{---} \\ | \\ Ss \quad Ss \quad ss \\ | \\ \text{---} \end{array}$
 $\begin{array}{c} \text{---} \\ | \\ yy \quad yy \quad yy \\ | \\ \text{---} \end{array}$
 $\begin{array}{c} \text{---} \\ | \\ Gg \quad Gg \\ | \\ \text{---} \end{array}$

6. hybrid tall x short $Tt \times tt$ 7. purebrid tall x short $TT \times tt$ 8. heterozygous yellow seed x green seed
 9. hybrid green pod x hybrid green pod 10. hybrid tall x purebred tall



$\begin{array}{c} \text{---} \\ | \\ TT \quad Tt \quad tt \\ | \\ \text{---} \end{array}$
 $\begin{array}{c} \text{---} \\ | \\ TT \quad Tt \quad tt \\ | \\ \text{---} \end{array}$
 $\begin{array}{c} \text{---} \\ | \\ YY \quad Yy \quad yy \\ | \\ \text{---} \end{array}$
 $\begin{array}{c} \text{---} \\ | \\ GG \quad Gg \quad gg \\ | \\ \text{---} \end{array}$
 $\begin{array}{c} \text{---} \\ | \\ TT \quad Tt \quad tt \\ | \\ \text{---} \end{array}$

11. purebred purple flowers x white flowers 12. hybrid purple flowers x white flowers
 13. heterozygous purple flowers x white flowers 14. hybrid smooth seeds x hybrid smooth seeds
 15. short plant x short plant



$\begin{array}{c} \text{---} \\ | \\ PP \quad Pp \quad pp \\ | \\ \text{---} \end{array}$
 $\begin{array}{c} \text{---} \\ | \\ PP \quad Pp \quad pp \\ | \\ \text{---} \end{array}$
 $\begin{array}{c} \text{---} \\ | \\ PP \quad Pp \quad pp \\ | \\ \text{---} \end{array}$
 $\begin{array}{c} \text{---} \\ | \\ SS \quad Ss \quad ss \\ | \\ \text{---} \end{array}$
 $\begin{array}{c} \text{---} \\ | \\ TT \quad Tt \quad tt \\ | \\ \text{---} \end{array}$

phenotype ratios:
 Purple White

Punnett Squares Practice Practice

Dihybrid Crosses

DIRECTIONS: All these genetic problems deal with pea plants and their traits. Use the following key for all problems. Put the gametes for the 1st parent of each cross along the top, and the gametes for the 2nd parent along the left side. Then, write the phenotypic ratio.

T = Tall **G = Green Pod** **Y = Yellow Seed** **S = Smooth Seed** **P = Purple Flower**
t = Short **g = Yellow Pod** **y = Green Seed** **s = Wrinkled Seed** **p = White Flower**

1. $TTGG \times ttgg$

phenotype ratio

tall plant
green pod _____
tall plant
yellow pod _____
short plant
green pod _____
short plant
yellow pod _____

2. $TtGg \times TtGg$

phenotype ratio

tall plant
green pod _____
tall plant
yellow pod _____
short plant
green pod _____
short plant
yellow pod _____

3. $GgYy \times ggYy$

phenotype ratio

green pod
yellow seed _____
green pod
green seed _____
yellow pod
green seed _____
yellow pod
yellow seed _____

4. $SsGg \times ssGg$

phenotype ratio

smooth seed
green pod _____
smooth seed
yellow pod _____
wrinkled seed
green pod _____
wrinkled seed
yellow pod _____

5. $PpGg \times PpGg$

phenotype ratio

6. $ppGG \times PPgg$

phenotype ratio

7. $TtSs \times Ttss$

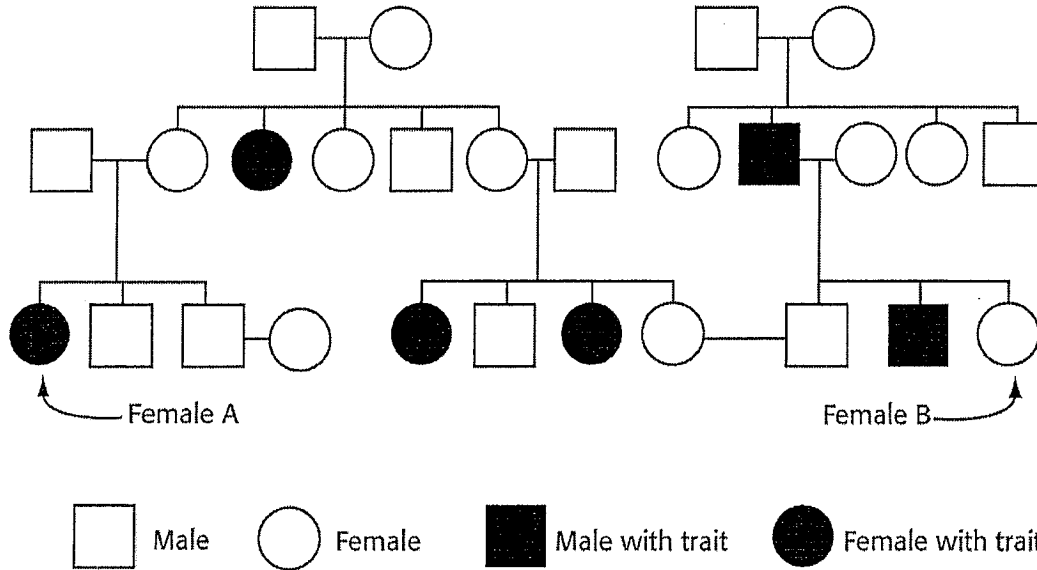
phenotype ratio

8. $ttss \times TtSs$

phenotype ratio

Pedigree Analysis

You will practice interpreting a pedigree. The pedigree to the right shows the presence or absence of the albinism trait in several generations of a family.



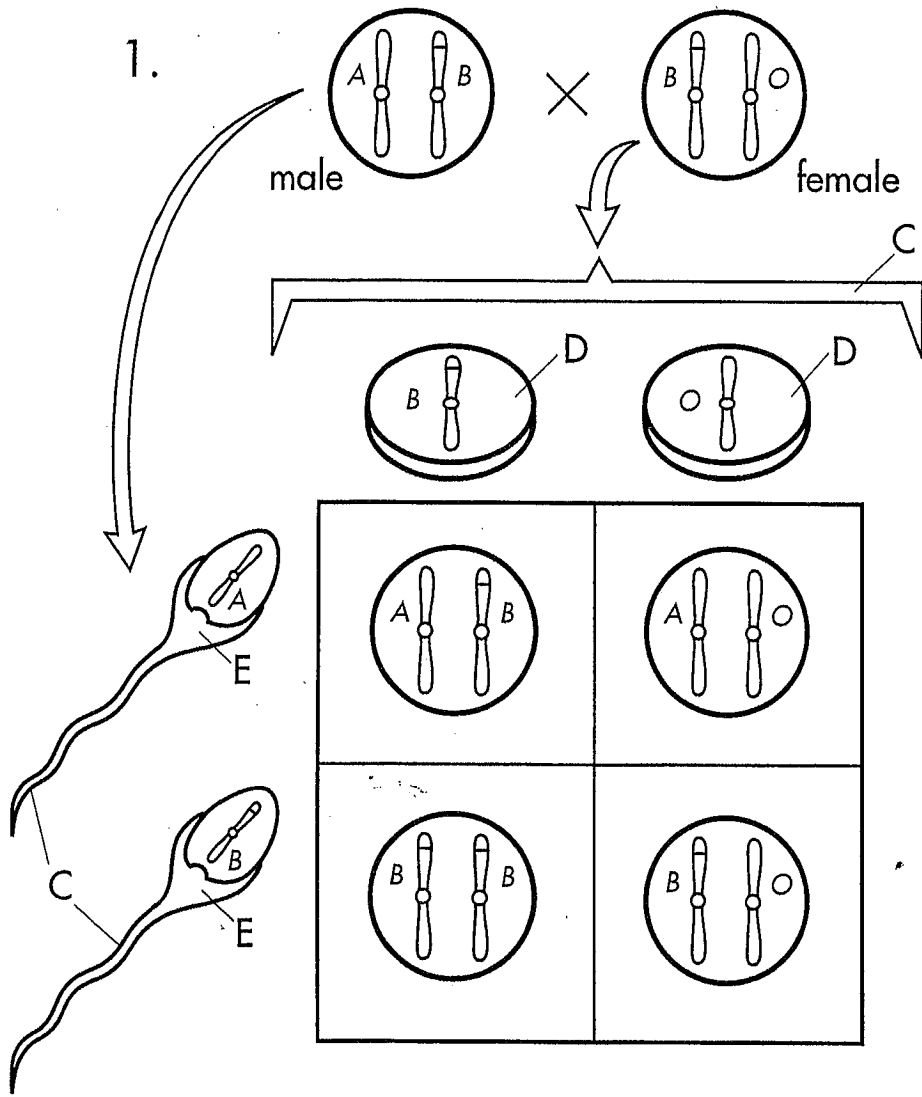
Analysis

- Determine** whether the albinism trait is dominant or recessive. Explain your reasoning.

- Determine** if Female A could be heterozygous for albinism. Do the same for Female B.

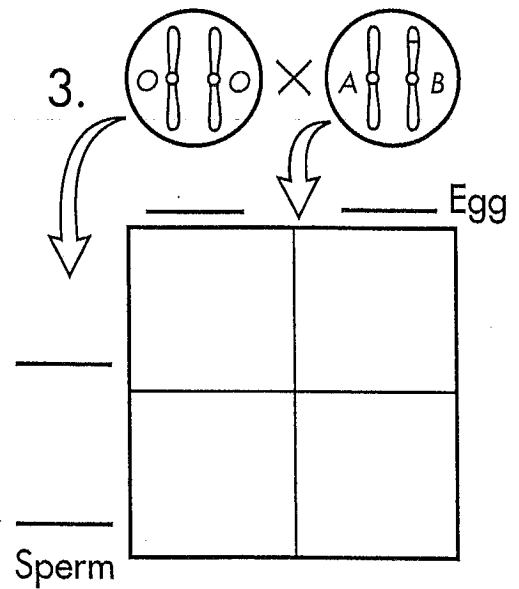
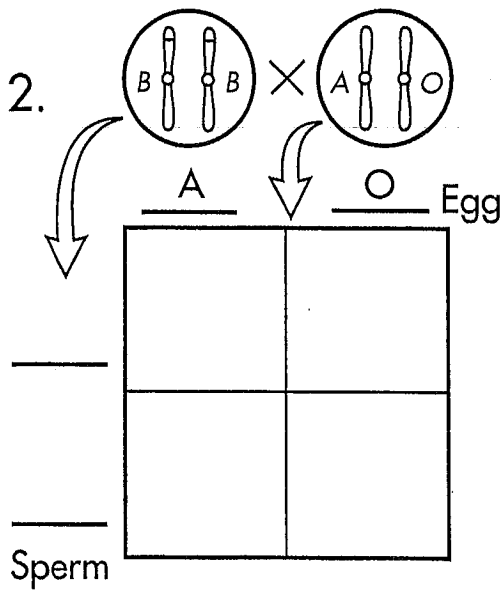
- Critical Thinking Applying Information** Suppose that Female B is homozygous and produces children with Male C. If Male C is heterozygous, what is the probability that the children will have the albinism trait?

Multiple Alleles



Multi

- Allele AA
- Allele BB
- Allele OO
- GametesC
- Egg CellsD
- Sperm CellsE



PEDIGREE PROJECT

You will complete a pedigree of your family. Each family member will have their own box with the traits you tested. You will try to determine the genotype based on phenotype and the offspring produced. You may only be able to determine one allele with certainty in the case of individuals with the dominant phenotype. Any individual with the recessive phenotype you will know the complete genotype.

Instructions:

- Each male will have a square chart, females will have round.
- Each chart will have the person's name. you will follow the rules you have learned for creating pedigrees. All lines must be created using a ruler, all circles must be made with a stencil or compass. You can hand write the names and alleles, or you may print out the keys (on J drive)
- If the person has the dominant phenotype, color the boxes for the alleles in the color you choose for that trait. It must be included in the key and stay the same for the entire pedigree.
- You may use photos for extra credit. If you choose to use photos, you will need a poster sized paper.
- You will be graded on neatness and completeness. Please consult your notes (ch 12) for correct symbols used in a pedigree.

	Dominant		Recessive
T	Tongue rolling	t	No tongue roll
M	Second toe shorter	m	second toe longer
E	Brown eyes	e	blue, green hazel eyes
P	PTC tasters	p	No taste
H	Straight thumb	h	Hitch-hikers thumb
W	Widows peak	w	Straight hairline
C	Cleft chin	c	No cleft in chin
D	Dimples	d	No dimples
L	Free earlobes	f	Attached earlobes

***If you can not do the project and have spoken to me, you may use the Fred and Ethel family to make a pedigree. Use the chart above for all traits. The same grading will be used, but ALL the people on the fictitious family will have a COMPLETE genotypes!!! (That means you will know both alleles for everyone)

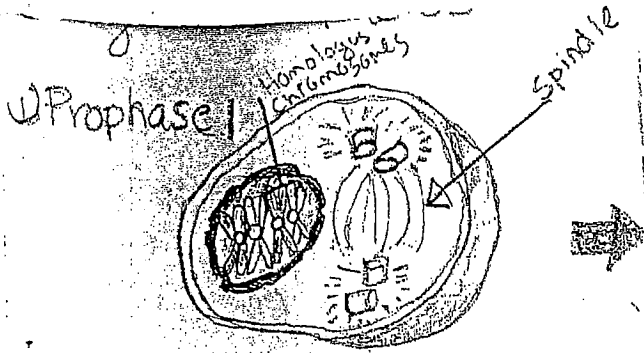
PLC TASTER		
2 ND TOE		
THUMB		
TONGUE		
EYES		

PLC TASTER		
2 ND TOE		
THUMB		
TONGUE		
EYES		

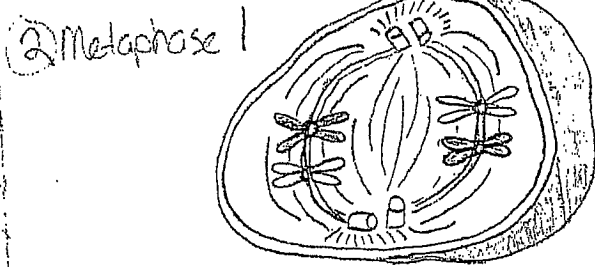
PLC TASTER		
2 ND TOE		
THUMB		
TONGUE		
EYES		

PLC TASTER		
2 ND TOE		
THUMB		
TONGUE		
EYES		

meiosis.

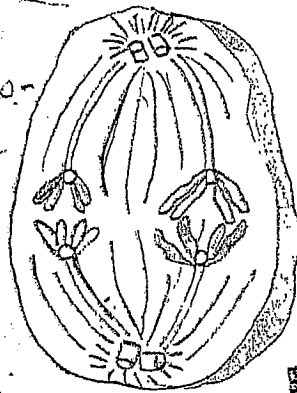


• Chromosomes condense, nuclear envelope breaks down

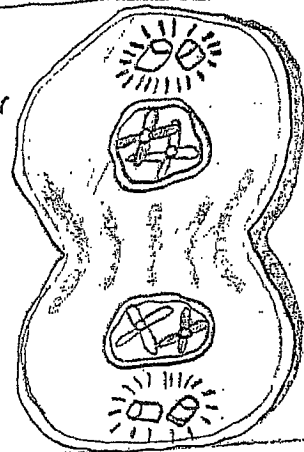


• Pairs of homologous chromosomes move to the cell's equator

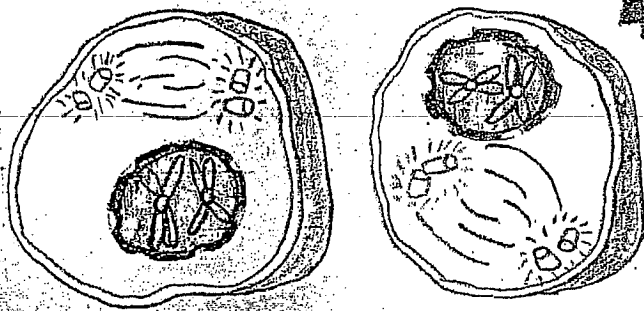
3 Anaphase I
• Homologous chromosomes move to the cell's opposite poles



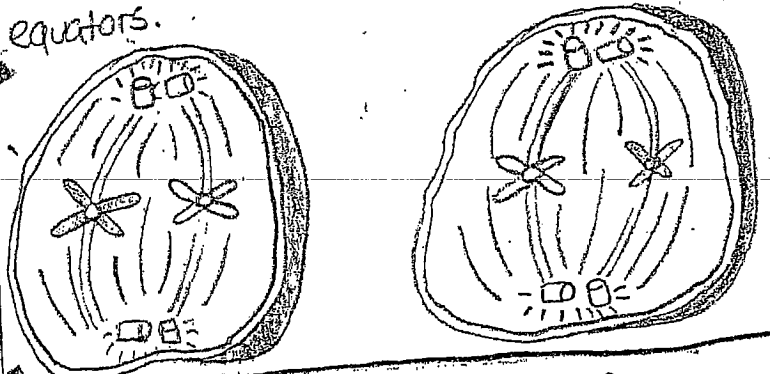
4 Telophase I
• Chromosomes gather at the poles. The cytoplasm divides



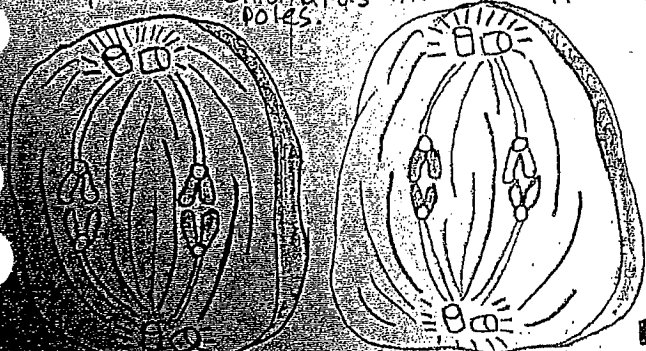
5 Prophase II - A new spindle forms around the chromosomes



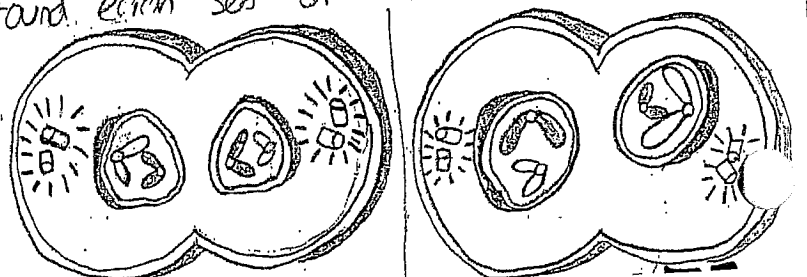
6 Metaphase II - Chromosomes line up at equators.



7 Anaphase II - Centromeres divide, and chromatids move to opposite poles.



8 Telophase II - A nuclear envelope forms around each set of chromosomes. The cells divide.



How Well Does a Punnet Square Predict the Actual Ratios?

In this lab you will make predictions using Punnet Squares, you will then use pennies (or chips) to simulate the crosses. Then compare the Actual Ratios with the Predicted Ratios.

The trait you are looking at is the gene that codes for a short second toe in humans. **T** represents the dominant allele (short second toe), **t** is the recessive allele, long second toe. The following genotypes are possible. Fill in the phenotypes for them

<u>Genotype</u>	<u>Phenotype</u>
T T	_____
T t	_____
t t	_____

Part I

Use a Punnet Square to predict the ratio of offspring in a cross where the parents are both Tt (The Square is set up for you below)

T		
t		

What proportion of the offspring (out of 4) will be:

Short Toe _____

Long Toe _____

***These are your predicted ratios.**

Now you will determine the actual ratios by using pennies (chips) to represent the crosses. You have two pennies. One side of the penny is the letter T, on the other side is the letter t. **This penny represents a parent that has the genotype T t.** A second penny represents the other parent. One partner is going to play the role of female, the other will play the role of male. When the coin is flipped, you are determining what sperm or what egg is being donated to the match.

Practice flips. Flip the two pennies. The results show you what your offspring will be.

Did you get a TT, a Tt or a tt _____ what is the Phenotype of your offspring (tall or short?) _____

Procedure: To determine Actual Ratios, you will flip your coins 100 times, recording in the table below how often each combination came up. (Use tally marks to record your data then summarize as a number)

Gene Combination (Genotype)	Tally	Total
TT		
Tt		
tt		

Phenotypes	Total
Short toe (add TT + Tt)	
Long Toe (tt)	

Since you flipped one hundred times, your totals above represent a Percentage. Your proportions from the Punnet Square in your prediction can also represent a Percentage.

$1/4 = 25\%$ $2/4 = 50\%$ $3/4 = 75\%$ $4/4 = 100\%$

Now compare your **predicted ratios** to your **actual Ratios** in the chart below.

	Predicted (from the Square you did)	Actual (from the flips)
TT		
Tt		
tt		
Short Toe		
Long Toe		

Would you consider the predicted values to be the same, close to the same, or not at all the same? _____

Part II

You will repeat the procedure for parents that are Tt and t t

1. First make your predictions by setting up a Punnet square for the parents. (This one is not set up for you)

How many are predicted to be:

Short Toe _____

Long Toe _____

**Replace one of your pennies (chips) with a t t penny

Perform the flips with your new set of parents (100). Record your data in the table below

	Tally	Total
Tt		
tt		

What percentage of your offspring are Tt _____ What percentage are short toes _____

What percentage of your offspring are tt _____ What percentage are long toes _____

Compare the **Predicted Ratios** of the cross to the **Actual Ratios**.

	Predicted (from Square)	Actual (from flips)
Short Toe		
Long Toe		

Analysis

1. Why are the Predicted Ratios rarely the same as the Actual Ratios?

2. Why are Punnet squares useful for determining the probabilities of phenotypes in the offspring?

3. Use a Punnet Square to predict the phenotypic ratios in this cross: $T T \times T t$

Short toe _____ Long toe _____

4. If you used the coin toss method to determine the actual ratios, would it come out the same? Why?

5. What do the pennies or chips represent in the simulation?

6. When you toss the coin to see which side lands up, you are actually simulating what part of the process of sexual reproduction?

7. When you put the two coins that are flipped together, you are simulating what part of the process of sexual reproduction?

Testcross

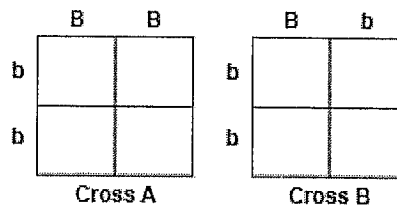
When genotypes are known, Punnett squares can be used to predict phenotypes. But can genotypes be determined if only phenotypes are known?

Suppose a breeder has a rabbit that has a dominant phenotype, such as black fur (as opposed to recessive brown fur). How could the breeder know whether the rabbit is homozygous (BB) or heterozygous (Bb) for fur color? The breeder could perform a testcross.

A *testcross* is used to test an individual whose phenotype for a characteristic is dominant but whose genotype is not known. This individual is crossed with an individual whose genotype is known to be homozygous recessive. In our example, the breeder would cross the black rabbit (BB or Bb) with a brown rabbit (bb).

Procedure

On a separate sheet of paper, copy the two Punnett squares shown here. Write the appropriate letters in the boxes of each square.



Analysis

1. **Label** what each pair of letters represents in each of the Punnett squares.

2. **Identify** which figure represents a testcross involving a heterozygous parent.

3. **Identify** which figure shows a cross in which all offspring will have black fur.

4. **Critical Thinking Applying Models** If half of the offspring in a testcross have brown fur, what is the genotype of the parent that has black fur?

What Blood Types Can Be Mixed?

Sometimes patients may lose a lot of blood. In these cases, blood from another person can be given to the patient. Giving someone else's blood to a person is called a transfusion.

Only certain blood types can be mixed when a transfusion is done. There are four main blood types—A, B, AB, and O. Each of these blood types only can be mixed safely with certain other ones. Let's find out which blood types can be mixed safely.

GOALS

In this exercise, you will:

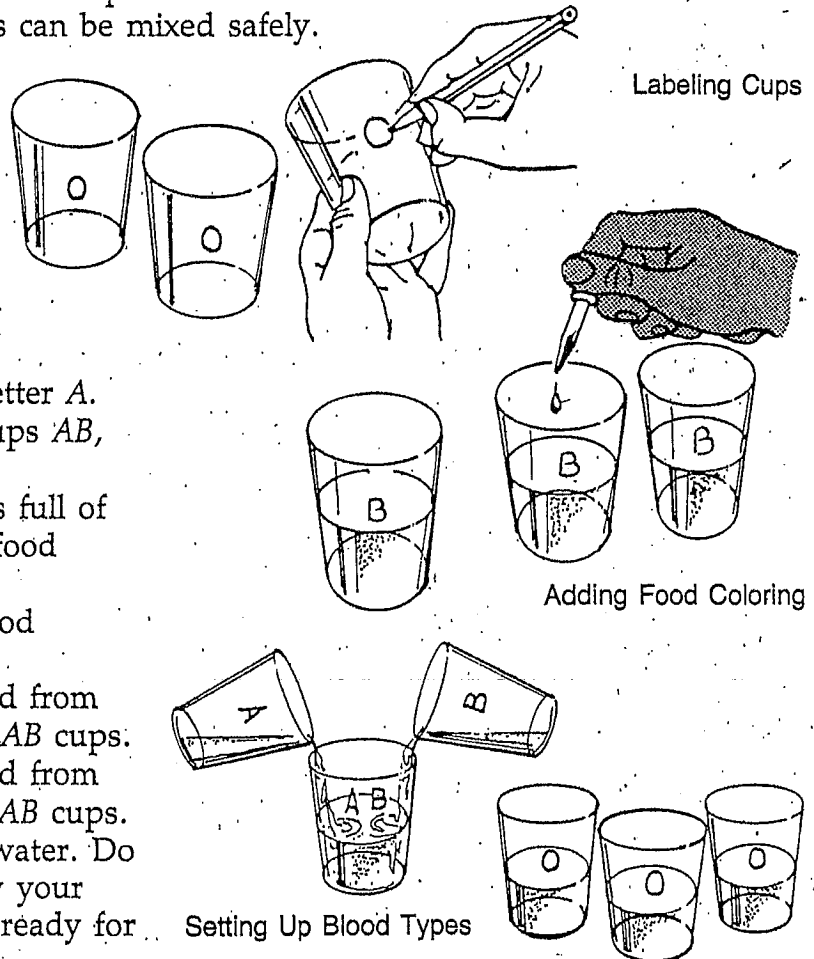
- a. set up colored water "blood" samples.
- b. find out which blood types can be mixed safely.

MATERIALS

clear plastic cups—12
wax pencil
red food coloring
blue food coloring
stirring rod

PROCEDURE

1. Label three cups with the letter A. Label three cups B, three cups AB, and three cups O.
2. Fill the A cups three-fourths full of water. Add 4 drops of red food coloring to each cup. Stir.
3. Repeat Step 2 using blue food coloring in the B cups.
4. Pour one-fourth of the liquid from each A cup into one of the AB cups.
5. Pour one-fourth of the liquid from each B cup into one of the AB cups.
6. Fill the O cups half full of water. Do not add food coloring. Now your blood types are set up and ready for "transfusions."
7. Pour about one-fourth of the liquid from one cup of each blood type into one cup of each of the other blood types. This pouring represents a transfusion. If the liquid changes color, the transfusion is not safe. If real blood of those types were mixed, the transfusion would not be safe because clumping would occur.



- Record color changes with a "yes" or "no" in the color change table. Part of the table has been done for you. Note that there is no color change when blood of the same type is mixed. It is safe to mix blood of the same type.
- Complete the table showing which blood types can be donated to which kind of patient. Use the information you got from mixing the colored water samples.

"Blood" type	Color change when mixed with "blood" type			
	A	B	AB	O
A	no			
B		no		
AB			no	
O				no

Blood type	Can donate blood to type(s)	Can receive blood from type(s)
A		
B		
AB		
O		

QUESTIONS

- What blood types can be given safely to persons with all other blood types? _____

- What blood types can be given safely to persons with AB blood? _____

- What blood type(s) can be given safely to persons with B type blood? _____
- What blood type(s) can be given safely to persons with O type blood? _____

APPLICATIONS

- A person with type O blood is often called a "universal donor." From this exercise, explain why. _____

- A person with type AB blood is called a "universal receiver." Explain why. _____

VOCABULARY

Complete the following sentences using the correct word.

- Receiving another person's blood is called a(n) _____.
- There are four main blood types which are _____, _____, _____, and _____.
- If real blood samples were mixed that should not be, blood _____ results.

Blood typing game

http://nobelprize.org/educational_games/medicine/landsteiner/landsteiner.html

flash card game

<http://www.quia.com/jfc/66181.html>

hereditary diseases

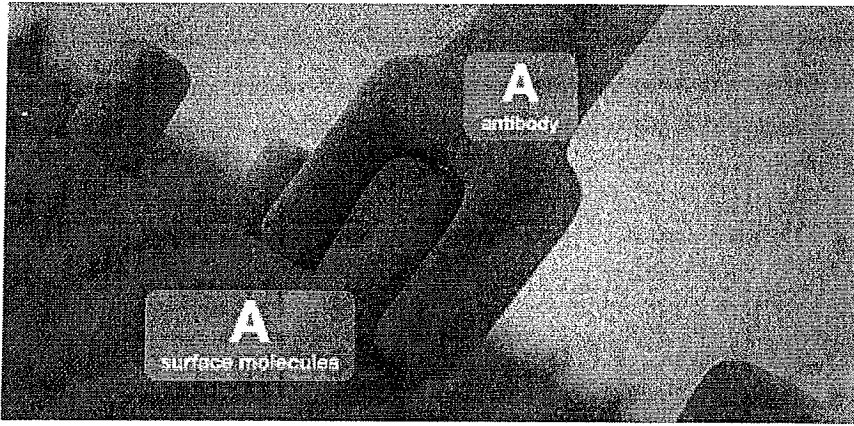
<http://www.yourgenesyourhealth.org/>

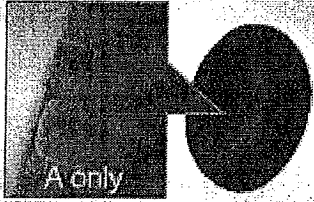

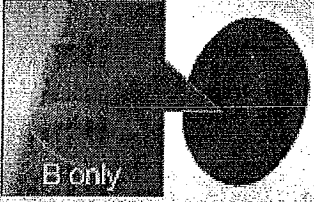
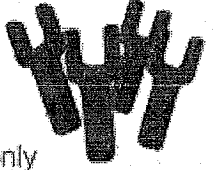
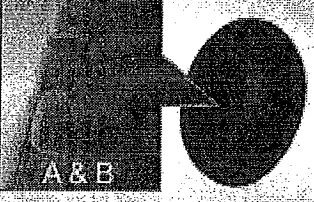
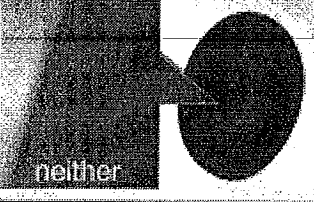
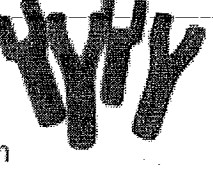
practice quiz

<http://anthro.palomar.edu/mendel/quizzes/mendqui2.htm>

pet chicken punnett square

<http://www2.edc.org/weblabs/Punnett/punnettsquares.html>



blood type	red blood cell surface molecules	plasma antibodies
type A	 A only	 B only
type B	 B only	 A only
type AB	 A & B	neither
type O	 neither	 both

LABORATORY INVESTIGATION

SIMULATING A ONE-FACTOR CROSS

PROBLEM

How is probability applied to genetics?

MATERIALS (per student)

2 labeled game markers
paper cup

PROCEDURE

1. On a separate sheet of paper, prepare a completed data table similar to the one below.
2. In pea plants, yellow seeds (*A*) are dominant over green seeds (*a*). Using a Punnett square, determine the probable color of the seeds produced by pea plants whose parents are heterozygous (*Aa*) for the seed-color trait. Record the expected genotypic and phenotypic ratios in the appropriate places in your data table.
3. Each labeled marker represents the alleles in the heterozygous plant. Tossing the labeled markers together represents the crossing of heterozygous plants.
4. Put the 2 labeled markers into the cup. Holding one hand over the mouth of the cup, shake the cup to toss the markers. Empty the cup onto your desk or laboratory table. Record the results of each of 10 tosses by making a tally mark in the appropriate box in your data table.
5. Toss the markers 100 times and record the results in your data table.
6. One student in the class will compile the data for 100 tosses by 10 students and report the results. Record this information.

7. Count the tally marks for each genotype in each series of tosses (10, 100, 1000). Record these totals in the appropriate box.
8. Determine the total number of seeds with the yellow phenotype for each series of tosses.
9. Using the data, calculate the genotypic and phenotypic ratios for each series of tosses. This is done by dividing each number in the ratio by the ratio's smallest number and rounding off to the nearest tenth's place. For example, suppose you obtained 23 *AA*, 51 *Aa*, and 26 *aa* for a series of 100 tosses. This gives you the ratio 1:2.2:1.1 ($23/23 = 1$, $51/23 = 2.2$, $26/23 = 1.1$)

OBSERVATIONS

1. Which genotype was obtained most often?
2. What were your expected genotypic and phenotypic ratios?
3. What were your genotypic and phenotypic ratios for a series of 10 tosses? 100 tosses? 1000 tosses?

ANALYSIS AND CONCLUSIONS

1. How do the experimental ratios compare with the expected ratios?
2. Which series of tosses produced the experimental ratios that were closest to the expected ratios? Explain your results.
3. How does probability apply to the results of your experiment? How does probability apply to the study of genetics?

Offspring Phenotype	Yellow				Green		Total Number of Yellow Seeds (<i>AA</i> + <i>Aa</i>)	Expected Genotypic Ratio	Expected Phenotypic Ratio	Experimental Genotypic Ratio	Experimental Phenotypic Ratio
	<i>AA</i>		<i>Aa</i>		<i>aa</i>						
	Tally	Total	Tally	Total	Tally	Total					
10 Tosses											
100 Tosses											
1000 Tosses	X		X		X						

THE RESULTS OF MENDEL'S PARENTAL CROSSES













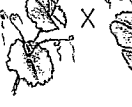








	Seed Shape	Seed Color	Seed Coat Color	Pod Shape	Pod Color	Flower Position	Plant Height
P	Round 	Yellow 	Gray 	Smooth 	Green 	Axial 	Tall 
	Wrinkled 	Green 	White 	Constricted 	Yellow 	Terminal 	Short 
F ₁	Round 	Yellow 	Gray 	Smooth 	Green 	Axial 	Tall 

Figure 9-4 When Mendel crossed plants with contrasting characters for the same trait, the resulting offspring had only one of the characters. From the results of these experiments, Mendel concluded that factors that do not blend control the inheritance of traits and that some of these factors are dominant, whereas others are recessive.

plants with the short ones; the plants with yellow seeds with those with green seeds; and so on. From the crosses in his pea plants, Mendel obtained seeds that he then grew into plants. These plants were **hybrids**, or organisms produced by crossing parents with differing characters.

What were those hybrid plants like? Did the characters of the parent plants blend in the offspring? To Mendel's surprise, the plants were not half tall, nor were the seeds they produced half yellow. Instead, all of the offspring had the character of only one of the parents. The plants resulting from his crosses were all tall or produced only yellow seeds. The other character had apparently disappeared.

From this set of experiments, Mendel was able to draw two conclusions. The first is that individual factors, which do not blend with one another, control each trait of a living thing. Mendel used the word *Merkmal* to refer to these factors. *Merkmal* means character in German. Today the factors that control traits are called **genes**. Each of the traits Mendel studied was controlled by one gene that occurred in two contrasting forms. These contrasting forms produced the different characters of each trait. For example, the gene for plant height occurs in a tall form and a short form. The different forms of a gene are now called **alleles** (uh-LEELZ).

The second of Mendel's conclusions is often called the principle of **dominance**: Some factors (alleles) are **dominant**, whereas others are **recessive**. The effects of a dominant allele are seen even if it is present with a contrasting recessive allele. The effects of a recessive allele are not observed when the dominant allele is present. In Mendel's experiments, the tall

Interpreting Information in a Pedigree

Organizing information is often the key to solving a problem. Tracing the hereditary characteristics over many generations can be confusing unless the information is well organized. In this lab, you will learn how to organize hereditary information, making it much easier to analyze.

OBJECTIVES

- Analyze a pedigree.
- Construct a pedigree.

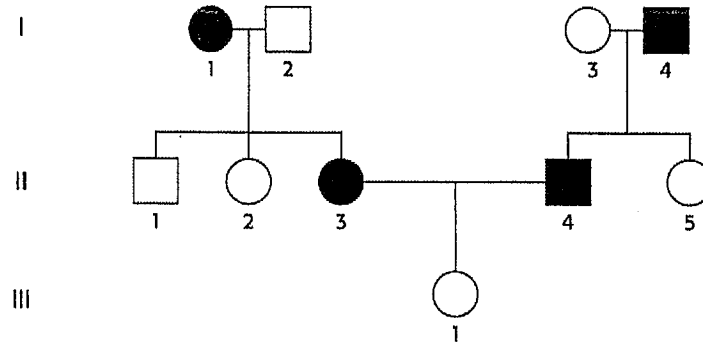
MATERIALS

- paper
- pencil

Procedure

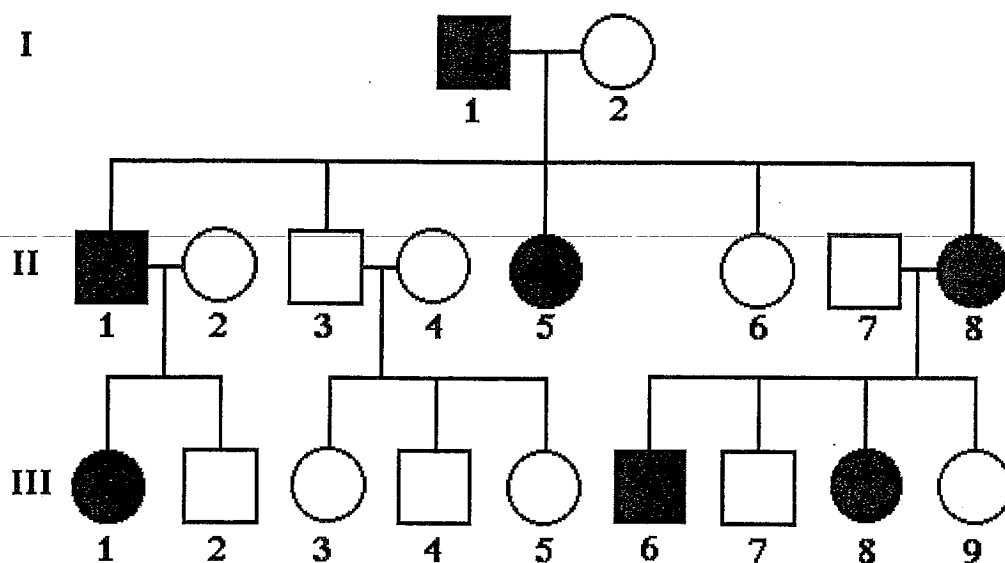
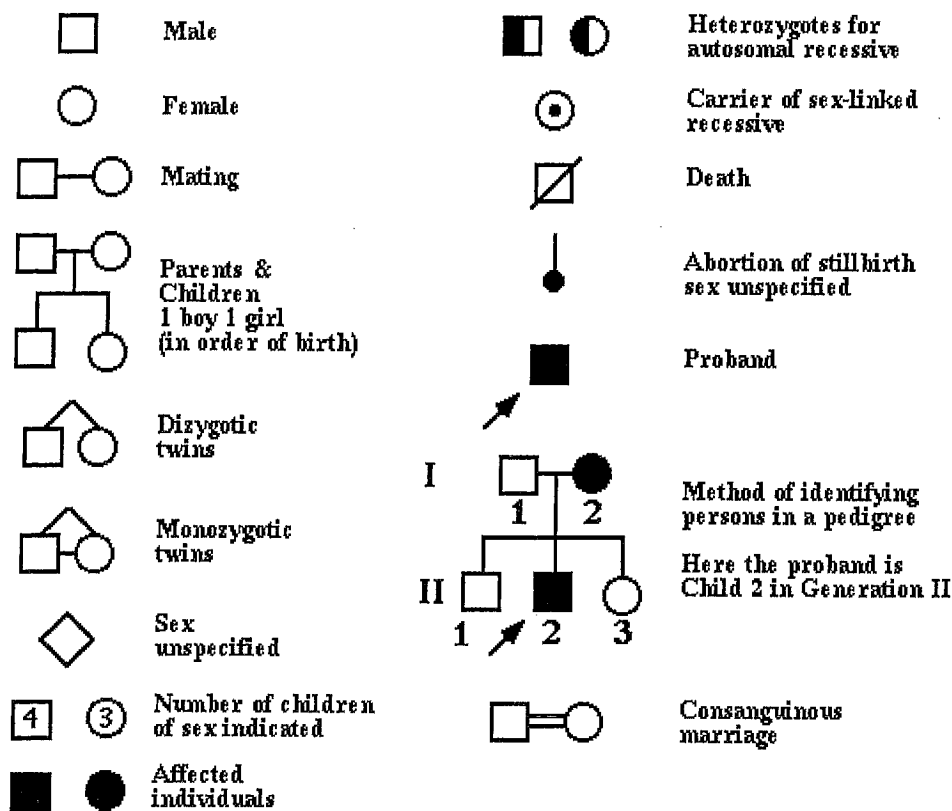
1. Examine Pedigree I, which traces the dimples trait through three generations of a family. Blackened symbols represent people with dimples. Circles represent females, and squares represent males.

FIGURE 1



Pedigree I

2. Read the following passage, which describes the family shown in Pedigree I. Write the name of each person below the correct symbol in Pedigree I.
Although Jane and Joe Smith have dimples, their daughter, Clarissa, does not. Joe's father has dimples, but his mother and his sister, Grace, do not. Jane's father, Mr. Renaldo, her brother, Jorge, and her sister, Emily, do not have dimples, but her mother does.
3. Look at Pedigree I again.



Pedigree 1. An idealized pedigree of a family with hypercholesterolemia, an autosomal dominant disease where the heterozygote has a reduced number of functional low density lipoprotein receptors.

Simulating Blood Typing

Pre-Lab Discussion

Human blood may be classified according to the presence or absence of certain *antigens*, or factors, that are attached to the surface of the red blood cells, or erythrocytes. Two of the antigens used in blood typing are known as A and B. A person whose red blood cells have only antigen A has type A blood, whereas a person whose red blood cells have only antigen B has type B blood. People who have both A and B antigens on their red blood cells have type AB blood. Those whose blood cells have neither A nor B antigens have type O blood.

The plasma of each blood group contains a certain type or combination of *antibodies*. Antibodies are substances that attack antigens. Blood type A plasma contains anti-B antibodies, whereas blood type B plasma has anti-A antibodies. Anti-A antibodies attack red blood cells that have A antigens; anti-B antibodies attack those that have B antigens. The attacking antibodies bind to the red blood cells, causing them to *agglutinate*, or clump together. Type AB plasma has both A and B antigens and has neither type of antibody. Type O blood has neither A nor B antigens and contains both anti-A and anti-B antibodies. In transfusions, the blood types of the donor and recipient must be carefully matched because transfusion of the wrong type of blood can be fatal to the recipient.

In this investigation, you will simulate human blood typing.

Problem

How is a person's blood type determined?

Materials (per group)

Glass slide with two depressions
Simulated anti-A serum
Simulated anti-B serum
Simulated blood—types A, B, AB, O

Safety



Put on a laboratory apron if one is available. Put on safety goggles. Handle all glassware carefully. Always use special caution when working with laboratory chemicals, as they may irritate the skin or cause staining of the skin or clothing. Never touch or taste any chemical unless instructed to do so. Note all safety alert symbols next to the steps in the Procedure and review the meanings of each symbol by referring to the symbol guide on page 10.

Procedure

- Put on safety goggles. Place 2 drops of the solution in the dropper bottle labeled Bottle 1 in each of the two depressions in the glass slide. To the left depression, add 2 drops of the solution in the bottle labeled anti-A serum. To the right depression, add 2 drops of the solution in the bottle labeled anti-B serum. **CAUTION:** Use caution when working with laboratory chemicals. If a laboratory chemical comes into contact with your skin, wash the area with water immediately.
- Examine the substances in the two depressions for signs of clumping. If clumping occurs only on the left side of the depression slide, this simulates the presence of type A blood. If clumping occurs only on the right side of the depression slide, this simulates the presence of type B blood. If clumping occurs on both sides of the depression slide, this simulates the presence of type AB blood. If no clumping occurs on either side of the depression slide, this simulates the presence of type O blood. See Figure 1. Record your observations in the appropriate places in the Data Table.

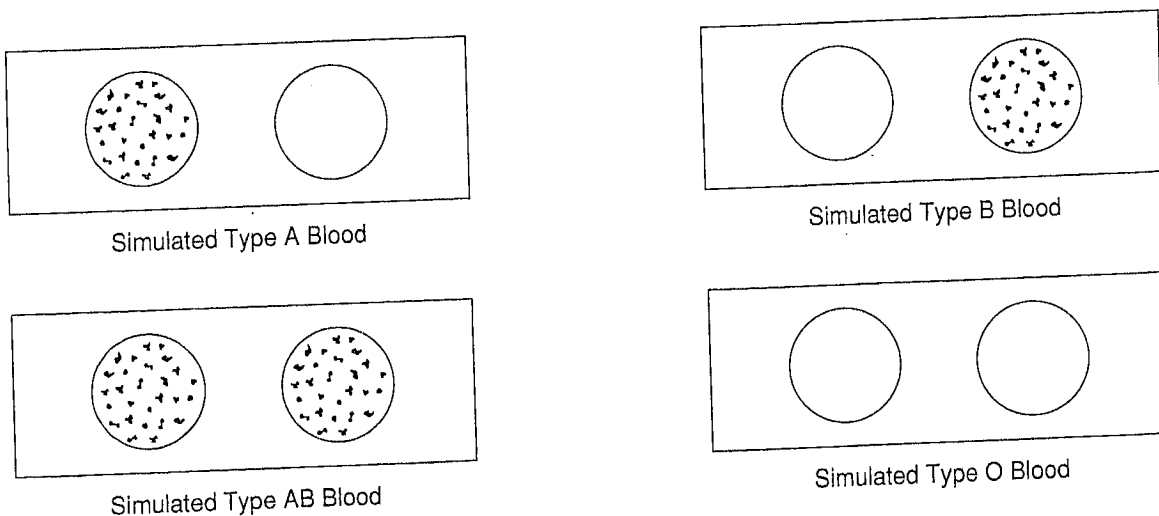


Figure 1

- Based on your results, determine the type of simulated blood that is contained in Bottle 1. Record this information in the appropriate place in the Data Table.
- Carefully wash and dry the glass slide thoroughly.
- Repeat steps 1 through 4 using the solutions in Bottles 2, 3, and 4.

Observations

Data Table

Bottle	Clumping in the Left Side of the Depression Slide?	Clumping in the Right Side of the Depression Slide?	Simulated Blood Type
1			
2			
3			
4			

Analysis and Conclusions

1. a. Which simulated blood type(s) showed clumping when simulated anti-A serum was added?

- b. Which simulated blood type(s) showed clumping when simulated anti-B serum was added?

2. a. If clumping occurs when both anti-A serum and anti-B serum are added, what is the blood type? _____
- b. If clumping does not occur when either anti-A serum or anti-B serum is added, what is the blood type? _____
3. Which blood type(s) must people have in order to safely receive a transfusion of type A blood? _____
4. Which blood type(s) must people have in order to safely receive a transfusion of type B blood?

5. Which blood type(s) must people have in order to safely receive a transfusion of type AB blood? _____
6. How is this simulation similar to actual human blood typing? _____

Critical Thinking and Application

1. Why is it advisable for you to know your own blood type? _____

2. How could you tell whether two blood samples are compatible for a transfusion if no typing serum were available? _____

3. Why is a person with type AB blood sometimes called a “universal recipient”?

4. Why is a person with type O blood sometimes called a “universal donor”?

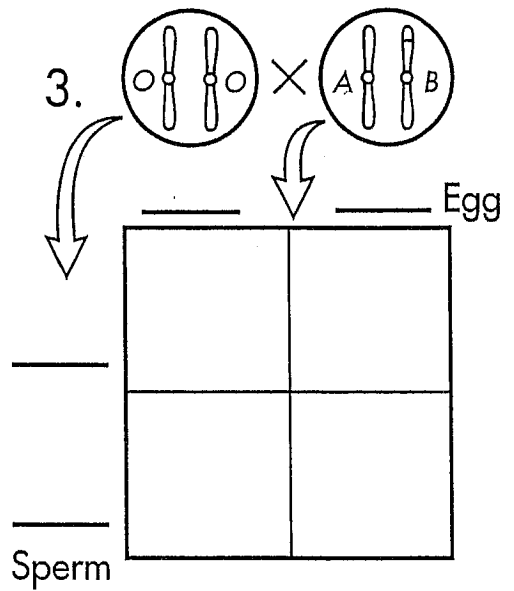
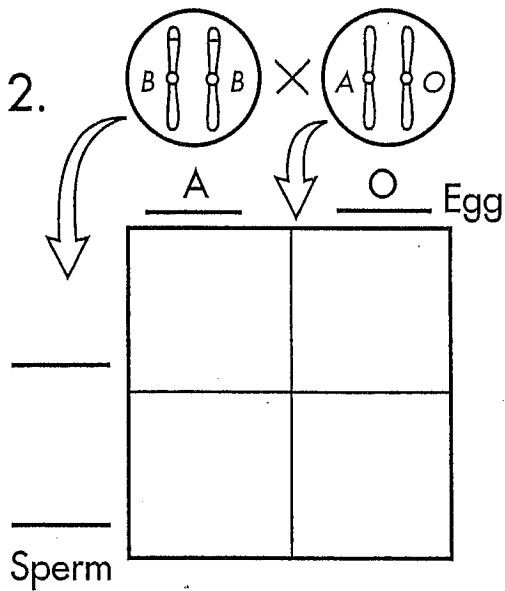
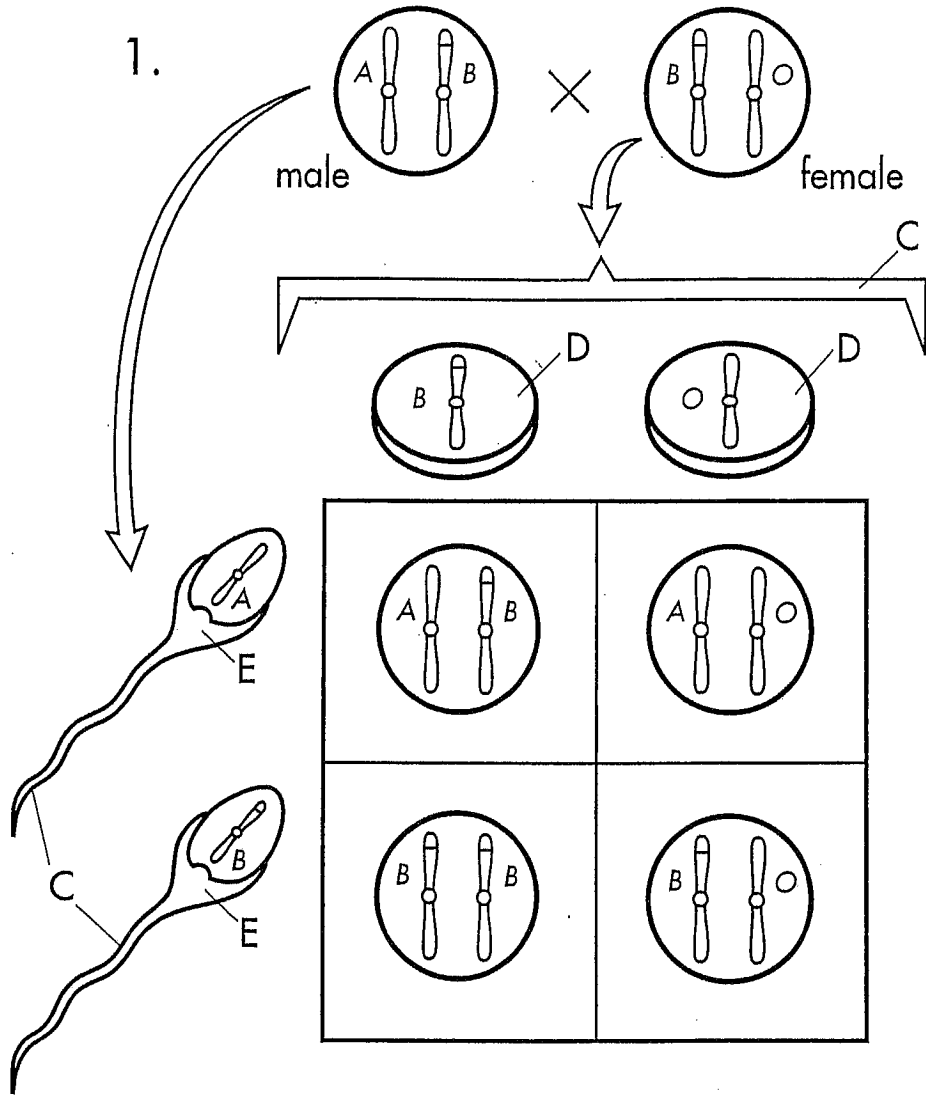
5. Why is a person with type O blood unable to receive blood from any type other than O?

Going Further

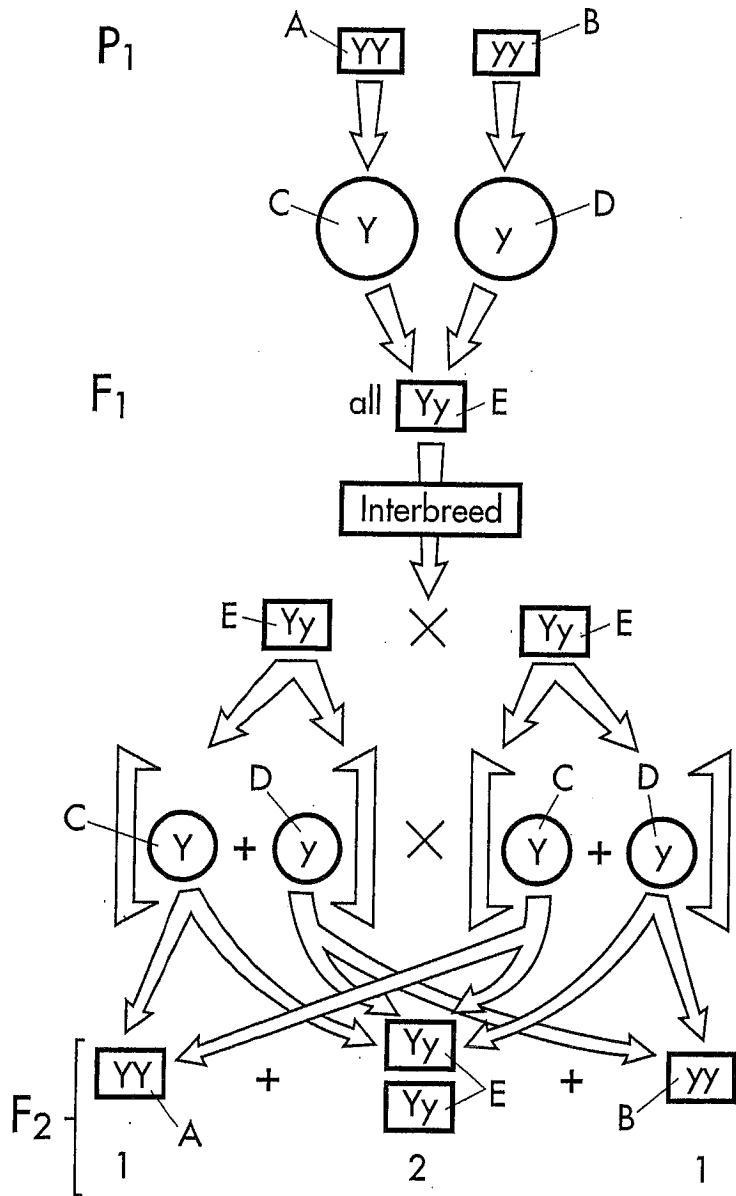
1. Successful organ transplant surgery depends on advances made in the area of tissue typing and compatibility. Using reference materials, write a report comparing blood typing with the relatively new science of tissue typing.
2. Use reference materials to research the topic of Rh factors. How were they discovered? How is a person's blood tested for Rh factor? Why is this knowledge important?

Multiple Alleles

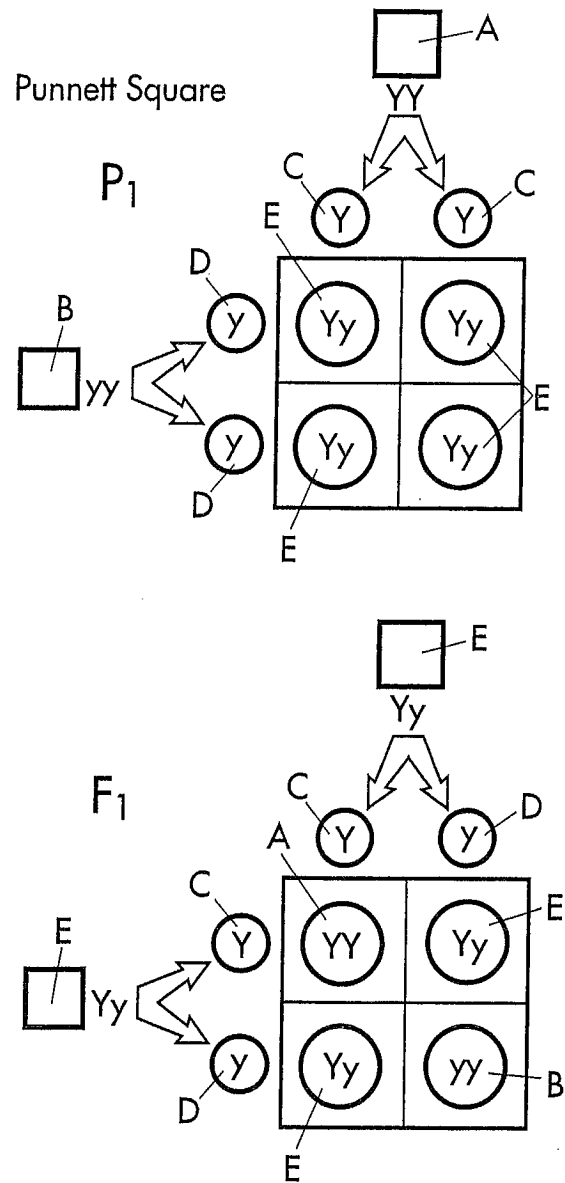
Multiple Alleles



Actual Crosses



Punnett Square



- The Monohybrid Cross
- Homozygous Dominant...A
 - Homozygous Recessive ..B
 - Gamete with Dominant AlleleC
 - Gamete with Recessive AlleleD
 - Heterozygous (Hybrid) IndividualE

WORKSHEET

40

MATH IN SCIENCE: LIFE SCIENCE

MATH SKILLS USED

Multiplication
Decimals
Percentages

Punnett Square Popcorn

Use the Punnett Square to learn about dominance and codominance in inherited traits.

You are a cofounder of Flav-R-Gro, Inc., a company that specializes in creating genetically engineered foods. You and your partner, Maisie Mantequilla, have recently been concentrating on developing new types of corn. Together, you have developed a type of corn that, fresh from the stalk, tastes like it has been roasted with just the perfect amount of butter and salt! Your new creation, which you and Maisie call WonderCorn, is bringing you the admiration of your peers and the loyalty of customers. Hungry corn consumers are eager to try your tasty creation because they can eat it without worrying about the health risks caused by adding butter and salt to food. You and Maisie succeeded through determination, hard work, and an understanding of *codominance*.

Background

In some cases of genetic inheritance, two dominant traits are expressed together instead of one trait being dominant and one trait being recessive. This phenomenon is known as **codominance**. When codominance occurs, both traits are evident in the phenotype. For example, a cross between a homozygous red horse and a homozygous white horse results in offspring with a roan coat, which consists of both red hairs and white hairs. Human blood types are also determined by codominant traits.

You and Maisie suspected that the taste trait in corn was codominant. To find out, you crossed two other types of corn that you created: a homozygous salty corn (*SS*) and a homozygous buttery corn (*BB*). The offspring were all WonderCorn. See the Punnett square below for this cross.

	<i>B</i>	<i>B</i>
<i>S</i>	<i>SB</i>	<i>SB</i>
<i>S</i>	<i>SB</i>	<i>SB</i>

Solve the Punnet Problems!

1. What is the genotype of WonderCorn?

2. What percentage of the offspring have this genotype?

Name _____ Date _____ Class _____

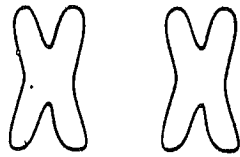
Use with Section 27:1.

CHROMOSOME NUMBERS

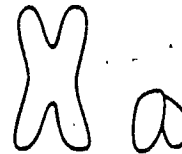
Several different numbers are important in understanding chromosomes in human genetics. Fill in the blanks in the sentences that follow with the correct numbers.

1. Each human sperm or egg has _____ chromosome(s).
2. Each human body cell has _____ chromosome(s).
3. There are _____ pairs of chromosome(s) in a human body cell.
4. Each body cell of a human female has _____ X chromosome(s).
5. The body cells of a human male have _____ X and _____ Y chromosome(s).
6. Females produce _____ kind(s) of egg.
7. Males make _____ kind(s) of sperm.

Look at the diagrams of the human sex chromosomes below. Use the diagram to help you answer the questions that follow.



Sex chromosomes of a female



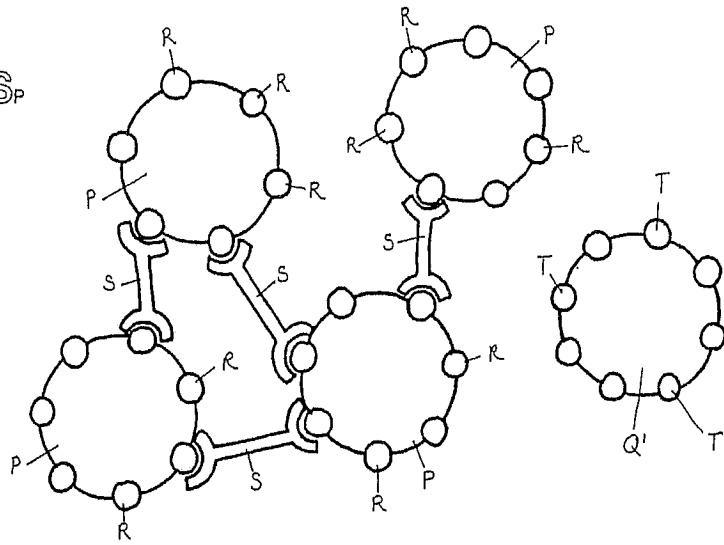
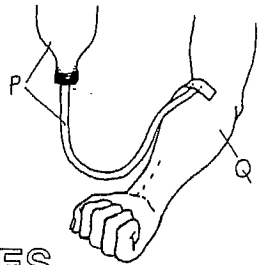
Sex chromosomes of a male

1. Does the sex chromosome of the mother or of the father determine the sex of a child? Explain.

2. X chromosomes are found in _____
3. Y chromosomes are found in _____
4. Design a Punnett square to show that the chance of having a male or female child is 1:1, or 50:50.

CODOMINANCE AND BLOOD TYPES.

AGGLUTINATION*
 TYPE A RED BLOOD CELLS,
 TYPE P,
 TYPE B PATIENT./CELL,
 TYPE Q,
 ANTIGEN A,
 ANTI-A ANTIBODIES,
 ANTIGEN B,



BLOOD TYPES*
 TYPE A GENE,
 TYPE O GENE,
 TYPE B GENE,

ANTI-B ANTIBODIES,
 TYPE AB RED BLOOD CELL,
 TYPE O RED BLOOD CELL,

GENOTYPE	BLOOD	PHENOTYPE (BLOOD "TYPE")	IN ANTI-A SERUM	IN ANTI-B SERUM
$I^A I^A$ U		A^{P^1} A		
$I^A I^O$ U				NONAGGLUTINATED RED BLOOD CELLS
$I^B I^B$ W		B^{Q^2} B		
$I^B I^O$ W				AGGLUTINATED RED BLOOD CELLS
$I^A I^B$ U		AB^{Y^1} AB		
$I^O I^O$ V		O^{Z^1} O		

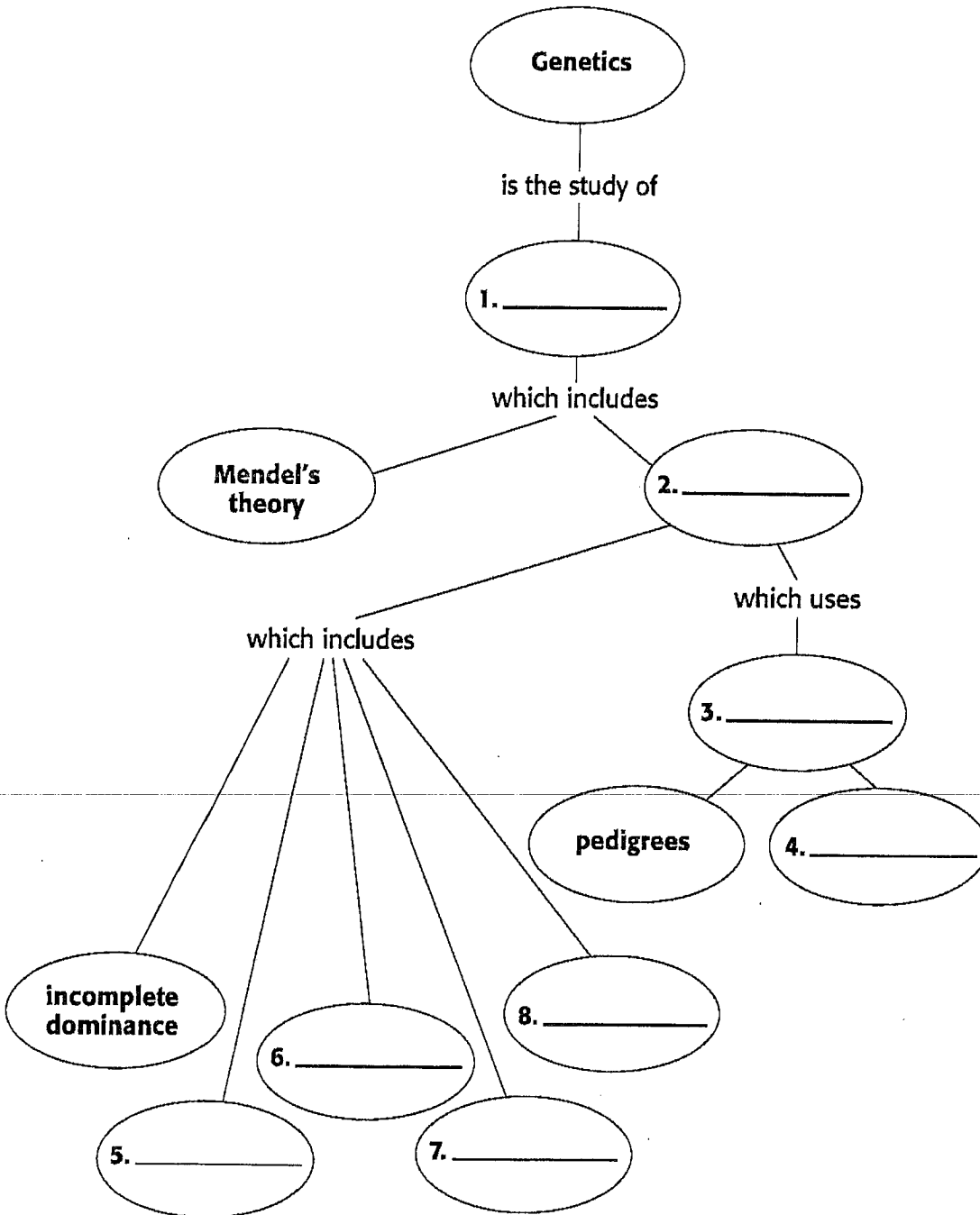
Concept Mapping

Using the terms and phrases provided below, complete the concept map showing the principles of genetics.

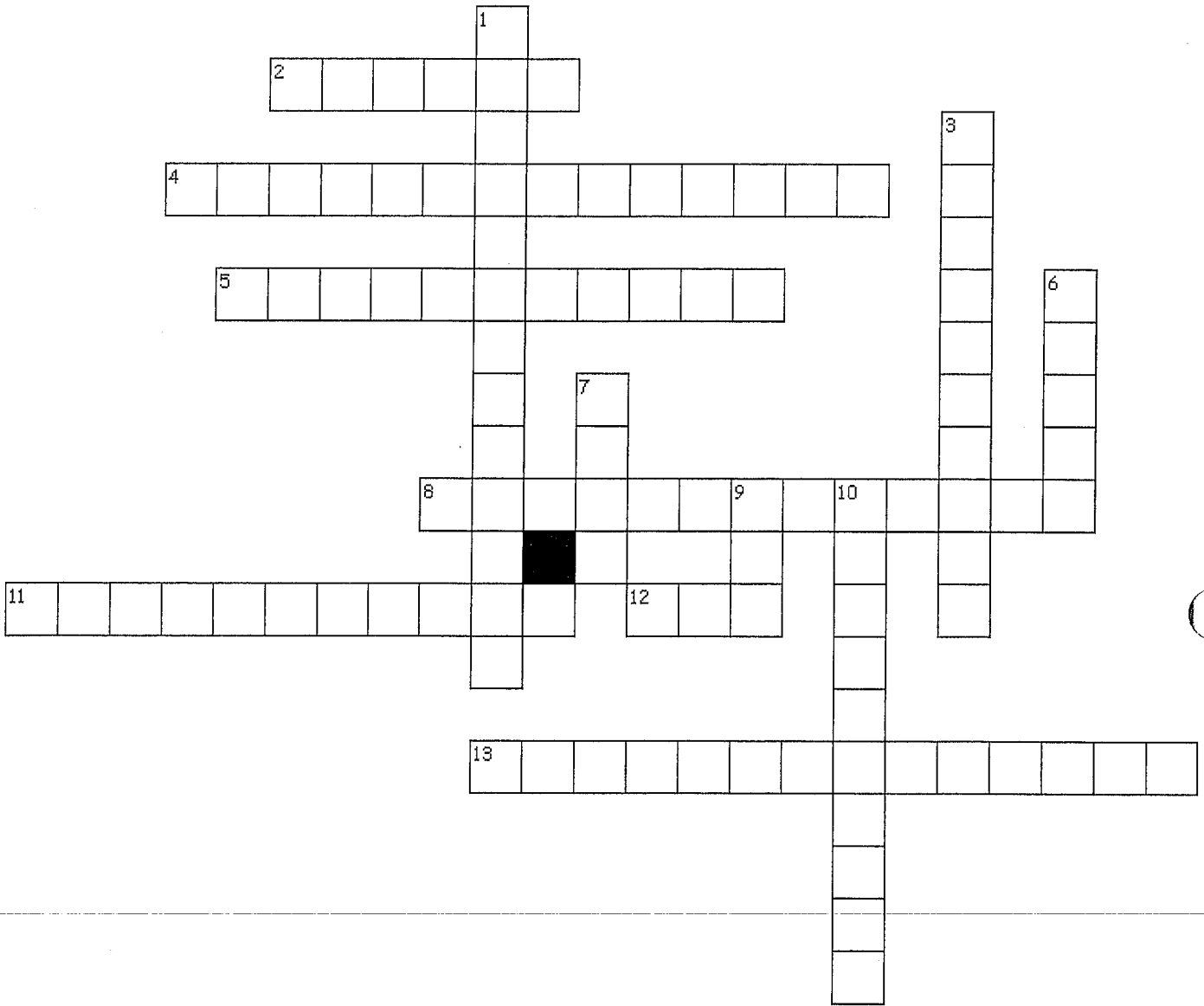
codominance
heredity
linked genes

modern genetics
multiple alleles
polygenic characters

probabilities
Punnett squares



Ch 13 Crossword/ Vocab



Across

2. a nitrogenous base that has a double-ring structure; adenine or guanine
4. the manifestation of the genetic material of an organism in the form of specific traits
5. the portion of protein synthesis that takes place at ribosomes and that uses the codons in mRNA molecules to specify the sequence of amino acids in polypeptide chains
8. the process of forming a nucleic acid by using another molecule as a template
11. an enzyme that unwinds the DNA double helix during DNA replication
12. deoxyribonucleic acid, the material that contains the information that determines inherited characteristics
13. the process of making a copy of DNA

Down

1. an enzyme that catalyzes the formation of the DNA molecule
3. in a nucleic acid chain, a subunit that consists of a sugar, a phosphate, and a nitrogenous base
6. in DNA and mRNA, a three-nucleotide sequence that encodes an amino acid or signifies a start signal or a stop signal
7. a segment of DNA that is located in a chromosome and that codes for a specific hereditary unit
9. ribonucleic acid, a natural polymer that is present in all living cells and that plays a role in protein synthesis
10. a nitrogenous base that has a single-ring structure; in DNA, either thymine or cytosine

gene a segment of DNA that is located in a chromosome and that codes for a specific hereditary unit

DNA deoxyribonucleic acid, the material that contains the information that determines inherited characteristics

CHAPTER 13 VOCAB

Gene

DNA

nucleotide

purine

pyrimidine

DNA replication

DNA helicase

DNA polymerase

RNA

Gene expression

Transcription

Translation

Codon

Purine

Pyrimidines

RNA polymerase

mRNA

tRNA

rRNA

anticodon

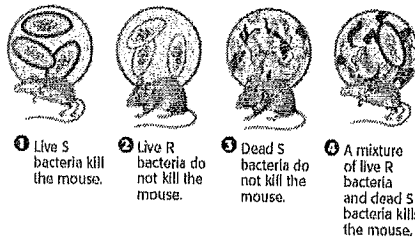
Chapter 13 DNA, RNA, and Proteins

I. **DNA: THE GENETIC MATERIAL**- DNA is the _____ for all inherited traits. The instructions for each trait are called a gene and are a series of bases that are like a written language.

II. **SEARCHING FOR THE GENETIC MATERIAL**- The discovery and understanding of DNA was built on several people's research.

A. In 1928, Frederick Griffith worked with two related strains of bacteria.

1. Griffith discovered that when harmless live bacteria were mixed with heat-killed disease-causing bacteria and then injected into mice, the mice died.
2. These results led Griffith to discover transformation. Transformation is a change in genotype that is caused when cells take up foreign genetic material.
3. Griffith's experiments led to the conclusion that genetic material could be transferred between cells.



B. In the 1940s, Oswald Avery wanted to determine whether the transforming agent in Griffith's experiments was protein, RNA, or DNA.

1. Avery used enzymes to destroy each of these molecules in heat-killed bacteria.
2. Avery's experiments led to the conclusion that DNA is responsible for transformation in bacteria. Alfred Hershey and Martha Chase studied bacteriophages. Bacteriophages are viruses that infect bacterial cells and cause the cells to produce viruses.
3. By using radioactive isotopes, Hershey and Chase showed that DNA, not protein, is the genetic material in viruses.

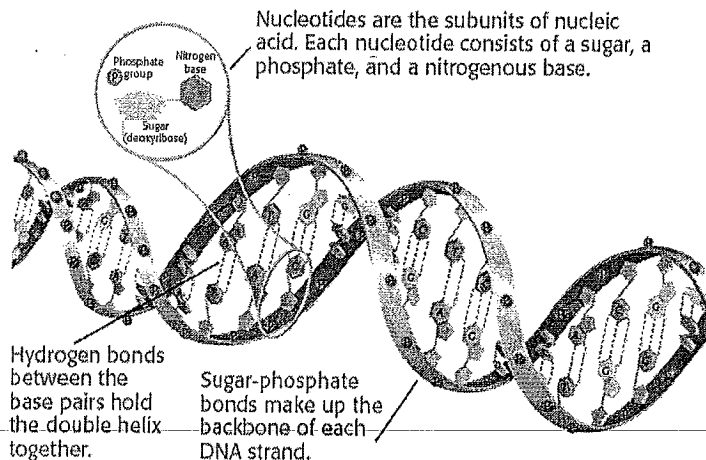
C. James Watson and Francis Crick used information from experiments by Erwin Chargaff, Maurice Wilkins, and Rosalind Franklin to determine the three-dimensional structure of DNA.

1. Chargaff showed that the amount of adenine always equaled the amount of thymine, and the amount of guanine always equaled the amount of cytosine.
2. Franklin and Wilkins developed X-ray diffraction images of strands of DNA that suggested the DNA molecule resembled a tightly coiled helix.
3. Watson and Crick used both Chargaff's data and the X-ray diffraction studies to create a complete three-dimensional model of DNA.

4. Their model showed a “spiral staircase” in which two strands of nucleotides twisted around a central axis.

III. **THE SHAPE OF DNA-** A DNA molecule is shaped like a spiral staircase and is composed of two parallel strands of linked subunits.

- A. The spiral shape of DNA is known as a _____.
- B. Each strand of DNA is made up of linked subunits called _____.
- C. A nucleotide is made up of three parts: a _____ group, a five-carbon _____ molecule, and a nitrogen-containing _____.
- D. The _____ groups and the sugar molecules of nucleotides link together to form a “backbone” for the DNA strand.
- E. The five-carbon sugar in DNA is called _____, from which DNA gets its full name, deoxyribonucleic acid.



IV. **THE INFORMATION IN DNA-**The information in DNA is contained in the order of the bases, while the base-pairing structure allows the information to be copied. In DNA, each nucleotide has the same sugar molecule and phosphate group, but each nucleotide can have one of four nitrogenous bases.

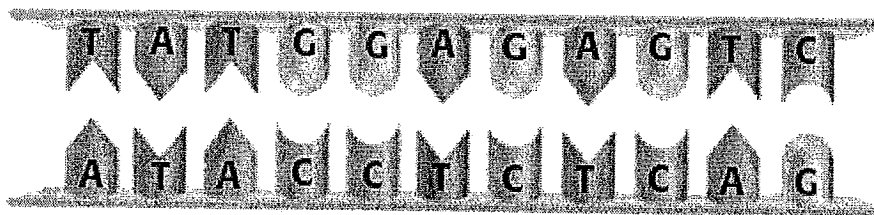
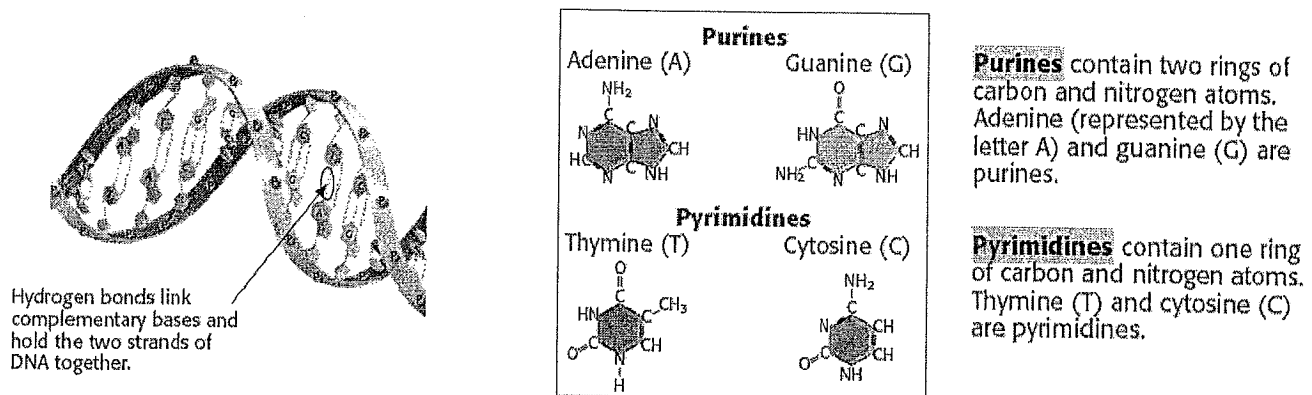
- A. The four bases are adenine (A), guanine (G), thymine (T), and cytosine (C).
- B. Bases A and G have a double-ring structure and are classified as _____.

C. Bases T and C have a single-ring structure and are classified as _____

D. A purine on one strand of a DNA molecule is always paired with a pyrimidine on the other strand. Specifically, adenine always pairs with thymine, and guanine always pairs with cytosine.

E. The _____ bonds between bases keep the two strands of DNA together.

F. Because of base-pairing rules, if the sequence of bases is known for one strand of DNA, then the sequence of bases for the complementary strand can be quickly identified.



This diagram shows how complementary base pairs join together. Note that adenine (A) always pairs with thymine (T), and cytosine (C) always pairs with guanine (G). In other words, the bases are *complementary*.

V. **DNA REPLICATION**- In DNA replication, the DNA molecule unwinds, and the two sides split. Then, new bases are added to each side until two identical sequences result.

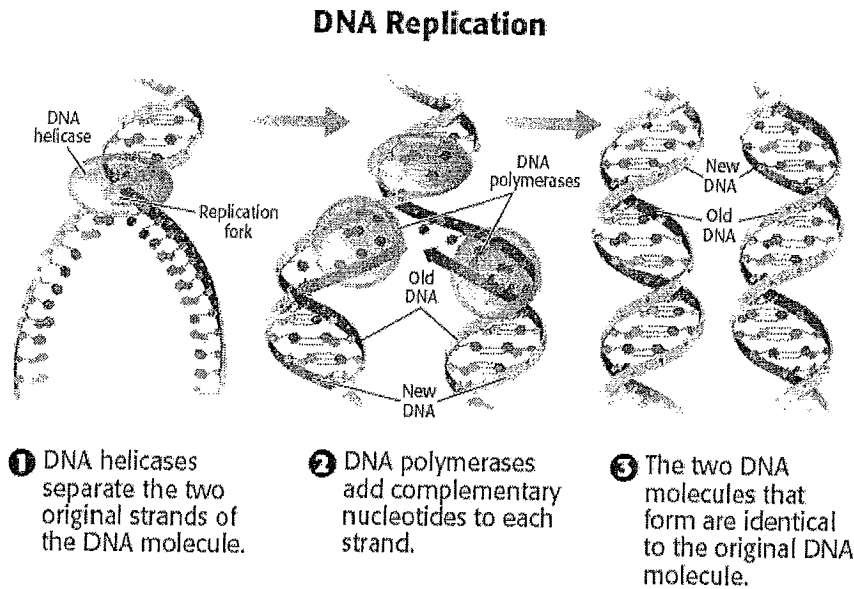
A. Because DNA is made of two strands of complementary base pairs, if the strands are separated, each strand can serve as a pattern to make a new complementary strand.

B. The process of making a copy of DNA is called _____.

C. As the double helix unwinds, the two complementary strands of DNA separate from each other and form Y shapes. These Y-shaped areas are called _____.

D. At the replication fork, new nucleotides are added to each side and new base pairs are formed according to the base-pairing rules.

E. Each double-stranded DNA helix is made of one new strand of DNA and one original strand of DNA.



VI. **REPLICATION PROTEINS-** During the replication of DNA, many proteins form a machinelike complex of moving parts.

A. Proteins called DNA _____ unwind the DNA double helix during DNA replication. These proteins wedge themselves between the two strands of the double helix and break the hydrogen bonds between the base pairs.

B. Proteins called _____ drive the formation of the DNA molecule by moving along each strand and adding nucleotides that pair with each base.

1. DNA polymerases also have a “_____” function.
2. During DNA replication, errors sometime occur and the wrong nucleotide is added to the new strand.
3. If a mismatch occurs, the DNA polymerase can backtrack, remove the incorrect nucleotide, and replace it with the correct one.

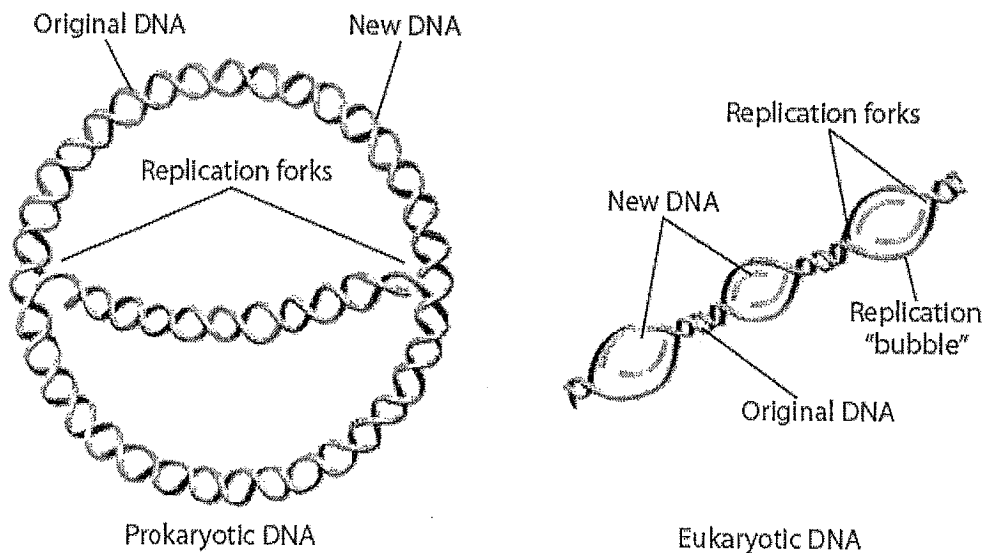
VII. EUKARYOTES AND PROKARYOTES REPLICATE DIFFERENTLY

A. Prokaryotic cells usually have a single chromosome, which is a closed _____ attached to the inner cell membrane.

1. Replication in prokaryotes begins at one place along the loop. This site is called the _____ of replication.
2. Two replication forks begin at the origin of replication in prokaryotes.
3. Replication occurs in opposite directions until the forks meet on the opposite side of the loop.

B. Eukaryotic cells often have several chromosomes, which are linear and contain both DNA and protein.

1. Replication starts at many sites along the chromosome. This process allows eukaryotic cells to replicate their DNA faster than prokaryotes.
2. Two distinct replication forks form at each start site, and replication occurs in opposite directions.
3. This process forms replication “bubbles” along the DNA molecule.
4. Replication bubbles continue to get larger as more of the DNA is copied.
5. The smallest eukaryotic chromosomes are often 10 times the size of a prokaryotic chromosome. Eukaryotic chromosomes are so long that it would take 33 days to replicate a typical human chromosome if there were only one origin of replication.
6. Because eukaryotic cells have multiple replication forks working at the same time, an entire human chromosome can be replicated in about 8 hours.



In prokaryotic cells, each circular chromosome has two replication forks. In eukaryotic cells, each linear chromosome may have many replication forks.

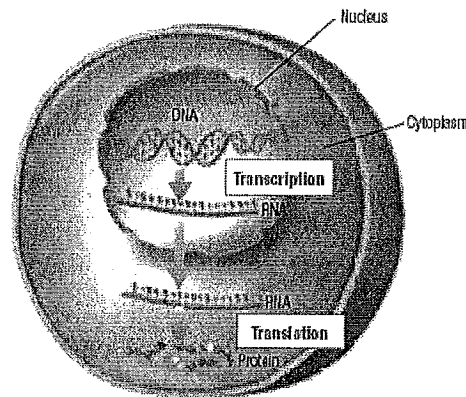
VIII. GENE EXPRESSION- Gene expression produces proteins by transcription and translation. This process takes place in two stages, both of which involve RNA.

A. DNA provides the original information from which proteins are made in a cell, but DNA does not directly make proteins because DNA does not leave the nucleus

B. Ribonucleic acid, or _____, is a second type of nucleic acid, which takes the information from DNA and makes proteins.

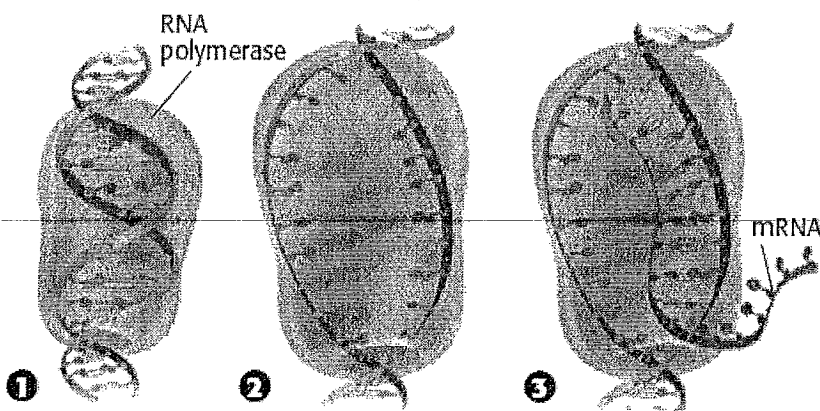
C. The first stage of gene expression is called _____. Transcription is the process of making RNA from the information in DNA. Transcription is similar to copying (transcribing) notes from the board (DNA) to a notebook (RNA).

D. The second stage of gene expression is called _____. Translation uses the information in RNA to make a specific protein. Translation is similar to translating a sentence in one language (RNA, the nucleic acid “language”) to another language (protein, the amino acid “language”).



Gene expression consists of two main steps: transcription and translation. In eukaryotic cells, like the one shown here, transcription occurs in the nucleus, and translation occurs in the cytoplasm.

Transcription



- 1 RNA polymerase binds to a specific part of the gene called the promoter region.
- 2 The two DNA strands unwind and separate.
- 3 The RNA polymerase moves along the DNA strand. It adds complementary mRNA nucleotides to a growing mRNA strand as it moves. At the end of transcription, the RNA polymerase has produced an mRNA strand that is complementary to the DNA in the gene.

IX. RNA: A MAJOR PLAYER- In cells, three types of RNA complement DNA and translate the genetic code into proteins. RNA differs from DNA in three ways.

- A. First, RNA usually is composed of _____ strand of nucleotides rather than two strands. –
- B. Second, RNA nucleotides contain the five-carbon sugar _____ rather than the sugar deoxyribose.
- C. Third, RNA nucleotides have a nitrogenous base called _____ (U) instead of the base thymine (T). Uracil (U) is complementary to adenine (A) whenever RNA pairs with another nucleic acid.

X. TYPES OF RNA- The three main types of RNA that play a role in gene expression are messenger RNA, transfer RNA, and ribosomal RNA.

- A. _____ RNA (mRNA) is produced when DNA is transcribed into RNA. The mRNA carries instructions for making a protein from a gene and delivers the instructions to the site of translation.
- B. At the site of translation _____ RNA (tRNA) “reads” the instructions carried by the mRNA, and then translates the mRNA sequence into protein subunits called amino acids.
- C. _____ RNA (rRNA) is an RNA molecule that is part of the structure of ribosomes. Ribosomes are the cellular structure where protein production occurs.

Type of RNA	Description
Messenger RNA (mRNA)	produced during transcription; is complementary to a DNA strand
Transfer RNA (tRNA)	used during translation; attaches to an amino acid; contains a sequence of bases that are complementary to part of an mRNA strand
Ribosomal RNA (rRNA)	found in ribosomes; helps to bind amino acids together during translation

XI. TRANSCRIPTION: READING THE GENE- During transcription, the information in specific region of DNA (a gene) is transcribed, or copied, into mRNA.

- A. _____ is carried out by a protein called RNA _____.
- B. Transcription begins when RNA polymerase binds to the specific DNA sequence in the gene that is called the promoter.

1. RNA polymerase then unwinds and separates the two strands of the double helix to expose the DNA bases on each strand.
2. RNA polymerase moves along the bases on the DNA strand and adds complementary RNA bases as it "reads" the DNA of the gene.
3. As RNA polymerase moves down the DNA strand, a single strand of mRNA grows.
4. Behind the moving RNA polymerase, the two strands of DNA close up and re-form the double helix.

C. _____ . In transcription, a new molecule of RNA is made from the DNA. In DNA replication, a new molecule of DNA is made from the DNA.

XII. THE GENETIC CODE: CODONS=THREE-LETTER "WORDS"- The genetic code is based on _____, each of which represents a specific amino acid. A three-nucleotide sequence is called a codon. Each codon corresponds to 1 of _____ amino acids. Codons also act as a start or stop signal for translation. There are 64 mRNA codons. Each codon specifies only one amino acid, but several amino acids have more than one codon.

Find the first base of the mRNA codon in this column. Follow that row to the column that matches the second base of the codon. Move up or down in that box until you match the third base of the codon with this column.

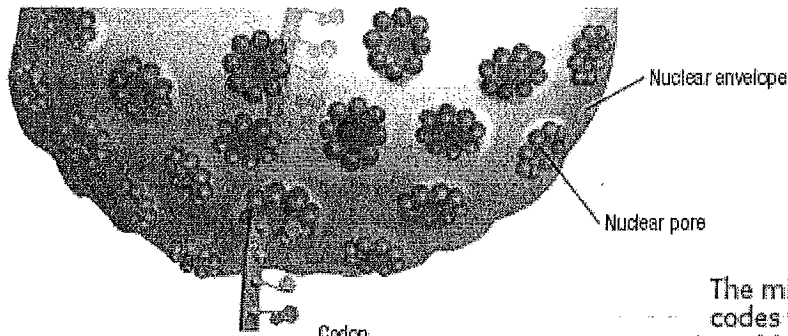
Codons in mRNA						
First base	Second base				Third base	
	U	C	A	G		
U	UUU Phenylalanine UUC UUA Leucine UUG	UCU Serine UCC UCA UCG	UAU Tyrosine UAC UAA Stop UAG	UGU Cysteine UGC UGA-Stop UGG-Tryptophan	U C A G	
C	CUU Leucine CUC CUA CUG	CCU Proline CCG CCA CCG	CAU Histidine CAC CAA Glutamine CAG	CGU Arginine CGC CGA CGG	U C A G	
A	AUU Isoleucine AUC AUA AUG-Start/Methionine	ACU Threonine ACC ACA ACG	AAU Asparagine AAC AAA Lysine AAG	AGU Serine AGC AGA Arginine AGG	U C A G	
G	GUU Valine GUC GUA GUG	GCU Alanine GCC GCA GCG	GAU Aspartic acid GAC GAA Glutamic acid GAG	GGU Glycine GGC GGA GGG	U C A G	

XIII. TRANSLATION: RNA TO PROTEINS- _____ occurs in a sequence of steps, involves three kinds of RNA, and results in a complete polypeptide (protein).

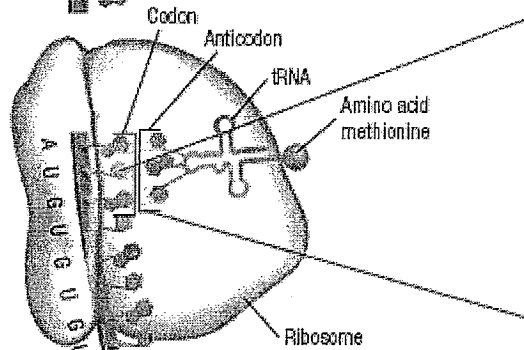
- A. Translation takes place in the _____, where tRNA, rRNA, and mRNA interact to assemble proteins.
- B. A specific amino acid is added to one end of each tRNA. The other end of the tRNA has an _____. An anticodon is a three-nucleotide sequence on tRNA that is complementary to an mRNA codon.
- C. The mRNA joins with a ribosome and tRNA.
- D. A tRNA molecule that has the correct anticodon and amino acid binds to the second codon on the mRNA.
- E. A peptide bond forms between the two amino acids, and the first tRNA is released from the ribosome.
- F. The ribosome then moves one codon down the mRNA.
- G. The amino acid chain continues to grow as each new amino acid binds to the chain and the previous tRNA is released.
- H. This process is repeated until one of three stop codons is reached. A _____ codon does not have an anticodon, so protein production stops.
- I. Many copies of the same protein can be made rapidly from a single mRNA molecule because several ribosomes can translate the same mRNA at the same time.

XIV. COMPLEXITIES OF GENE EXPRESSION- The relationship between genes and their effects is complex.

- A. Some genes are expressed only at certain times or under specific conditions.
- B. Variations and mistakes can occur at each of the steps in replication and expression.
- C. The final outcome of gene expression is affected by the _____ of the cells, the presence of other cells, and the timing of gene expression.



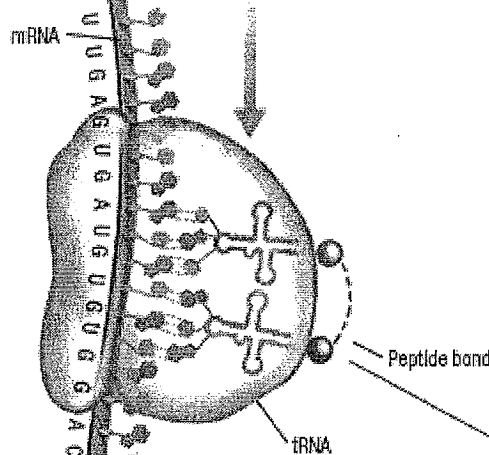
1 After the mRNA strand leaves the nucleus, it binds to a ribosome and to a tRNA carrying the amino acid methionine. The anticodon on the tRNA binds to the codon on the mRNA.



The mRNA codon AUG codes for the amino acid methionine. It is also the "start" codon, which tells the ribosome where to begin translation.

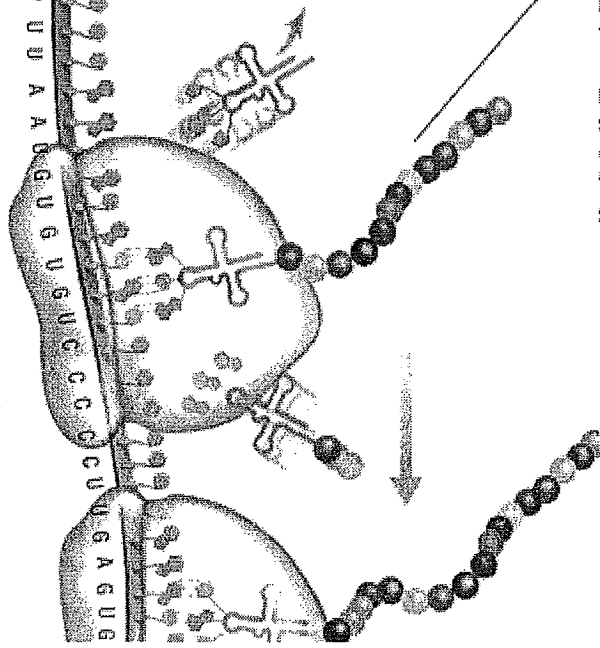
An *anticodon* is a group of three nucleotides on a tRNA molecule. The anticodon is complementary to an mRNA codon. A tRNA with a particular anticodon carries only the amino acid that corresponds to the complementary codon.

2 A new tRNA arrives and binds to the next codon on the mRNA. A type of bond called a *peptide bond* forms between the methionine and the second amino acid. The bond between the first tRNA and the methionine is broken, and the first tRNA moves away from the ribosome.



As one ribosome moves further down the mRNA strand, another ribosome can begin to translate the mRNA again. In this way, many molecules of the same protein can be produced from a single strand of mRNA.

3 The ribosome moves to the next codon on the mRNA. A tRNA with the complementary anticodon binds to the mRNA codon. The amino acid on this tRNA forms a peptide bond to the chain of amino acids attached to the previous tRNA. As the ribosome moves down the mRNA strand, more and more amino acids are added.



4 When the ribosome reaches a stop codon

1. Describe the results of three experiments that helped to show that DNA is the genetic material.

2. What is the shape of a DNA molecule?

3. Give the sequence of bases that is complementary to the sequence AATGCCGTATAG.

4. How does the complementary pairing of bases allow both strands of a DNA molecule to contain the same information?

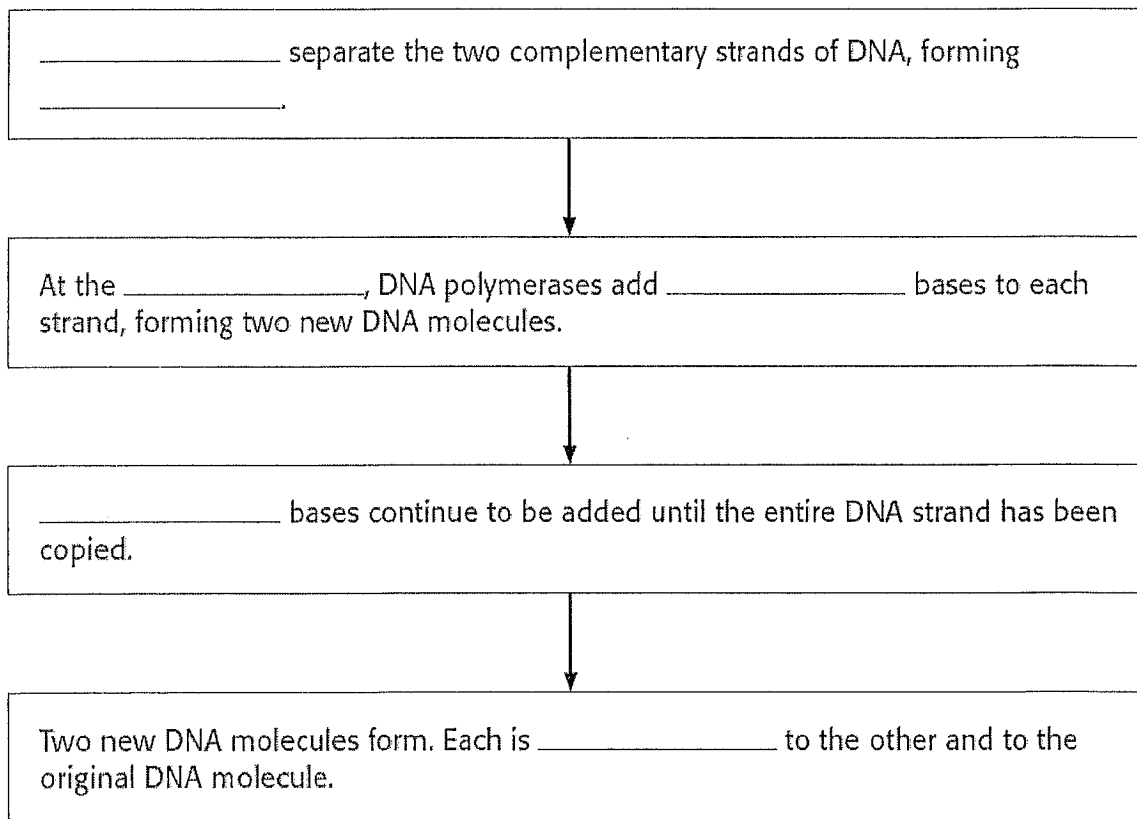
5. Explain how the results of Chargaff's experiment may have helped Watson and Crick determine the structure of DNA.

Bellringer: Day M T W Th F Date _____ Question _____

Answer _____

1. Give two functions of DNA polymerase in DNA replication.

2. Fill in the blanks in the flowchart below to show how DNA replication occurs.



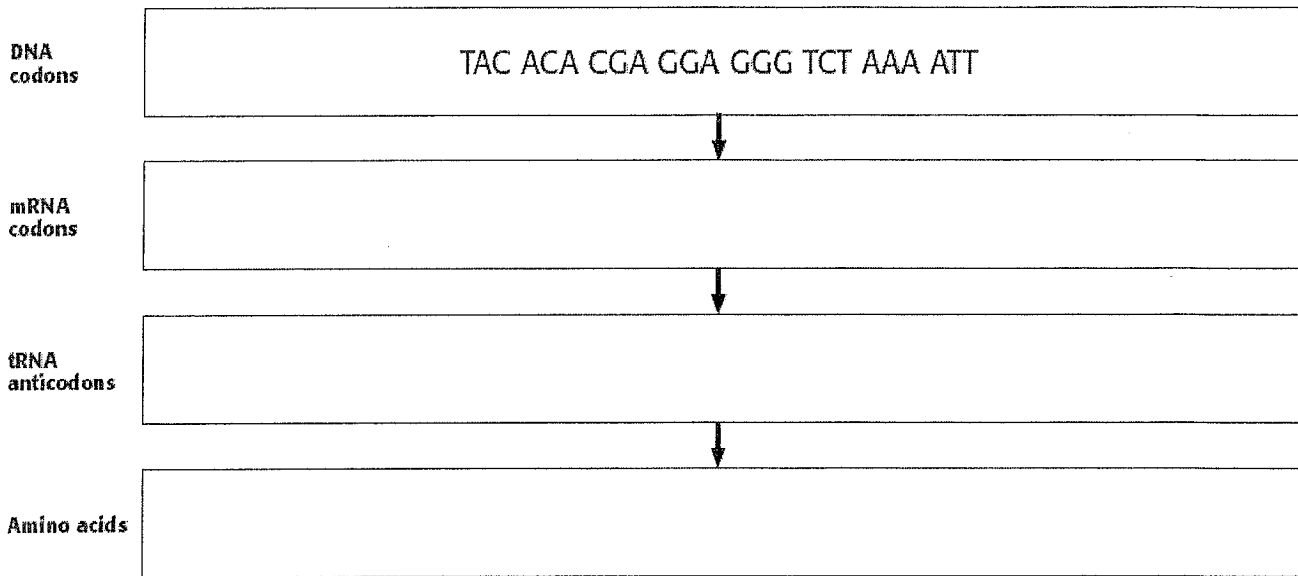
3. Give one difference and one similarity between DNA replication in eukaryotic cells and DNA replication in prokaryotic cells.

Bellringer:Day M T W Th F Date _____ Question _____
Answer _____

1. Write a definition of gene expression in your own words.

2. What role does tRNA play in gene expression?

3. Fill in the chart below to show how a DNA base sequence is converted into a sequence of amino acids.



4. What are two things that can affect the result of gene expression?

Bellringer: Day M T W Th F Date _____ Question _____

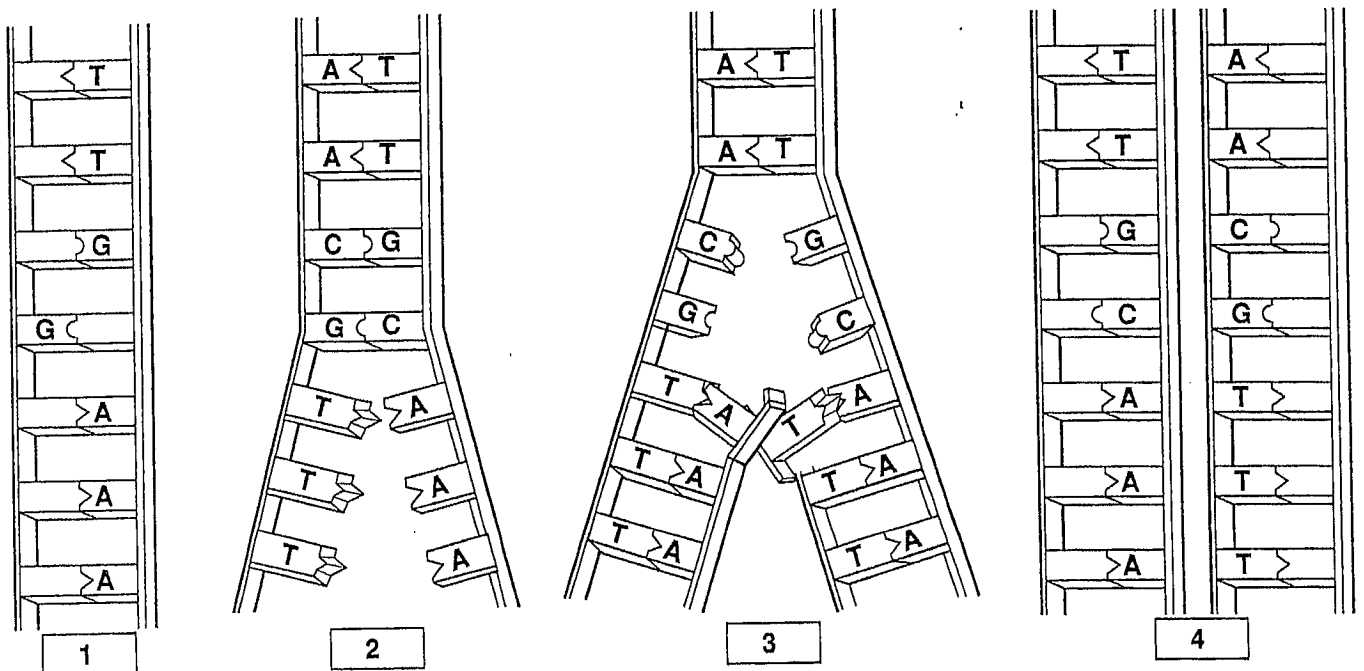
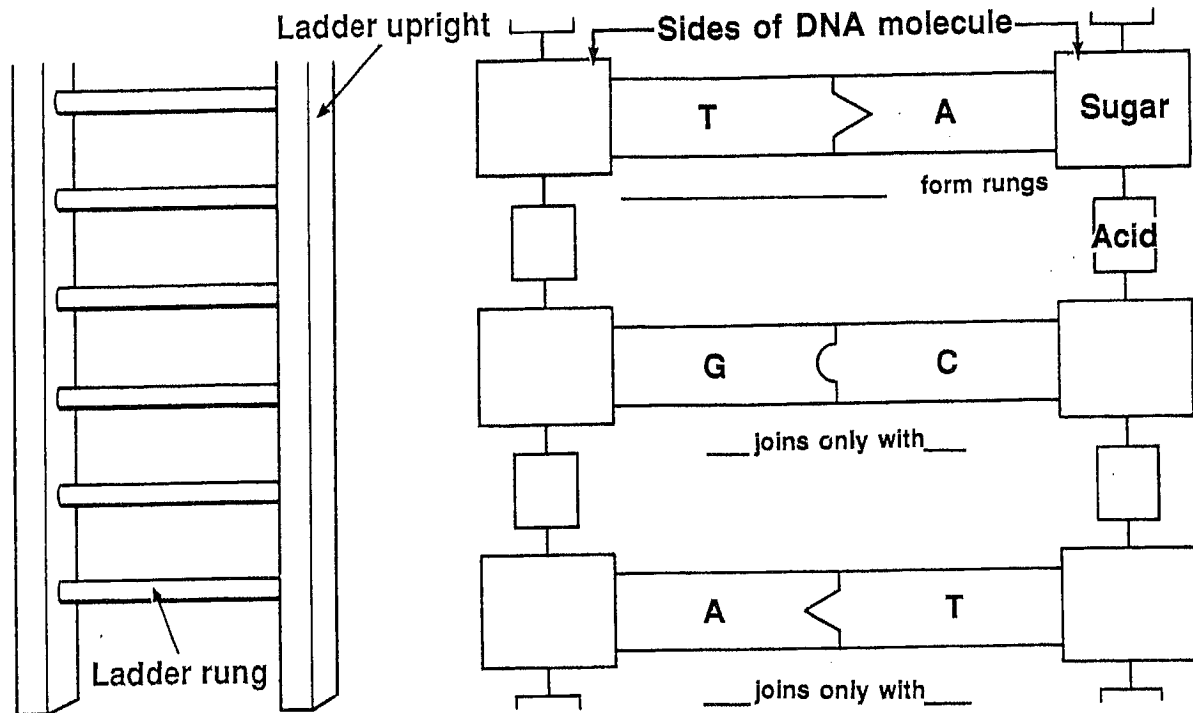
Answer _____

Name _____ Date _____ Class _____

Use with Section 28:1.

DNA STRUCTURE AND HOW DNA COPIES ITSELF

Complete the diagrams by filling in the correct terms and letters.



Chapter 13 Review

1. what did Griffith's experiments show?
2. What is DNA made of?
3. what does a nucleotide consist of?
4. The part of the molecule for which DNA is named is the
5. What is a purine? Which DNA bases are purines? What is a pyrimidine? What bases are pyrimidines?
6. The amount of guanine in an organism always equals the amount of
7. Who discovered the structure of DNA?
8. During DNA replication, a complementary strand of DNA is made from each original DNA strand. Thus, if a portion of the original strand is CCTAGCT, then the new strand will be
9. What enzymes attach nucleotides to complementary strands of DNA?
10. The enzymes responsible for adding nucleotides to the exposed DNA bases during replication
11. What are the enzymes responsible for adding nucleotides to the exposed DNA bases during replication
12. The enzymes that unwind DNA during replication are called
13. What is the difference between replication forks in prokaryotes and eukaryotes?
14. What is transcription?
15. What is the difference between RNA and DNA
16. what is found in DNA that is not in RNA (bases)
17. In RNA molecules, adenine is complementary to
18. What are the types of RNA and what fo they do?
19. What is the product of transcription?
20. How does transcription begin?
21. Each nucleotide triplet in mRNA that specifies a particular amino acid is called a(n)

	U	C	A	G	
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

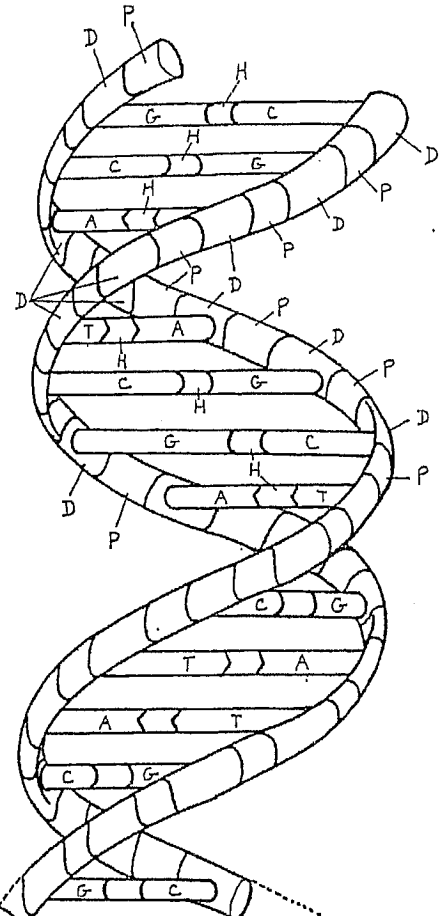
22. Refer to the illustration above. What is the portion of the protein molecule coded for by a piece of mRNA with the sequence CUCAAGUGCUUC?
23. Refer to the illustration above. Which of the following would represent the strand of DNA from which the mRNA strand CUCAAGUGCUUC was made?

mRNA codons	amino acid
UAU, UAC	tyrosine
CCU, CCC, CCA, CCG	Proline
GAU, GAC	aspartic acid
AUU, AUC, AUA	Isoleucine
UGU, UGC	Cysteine

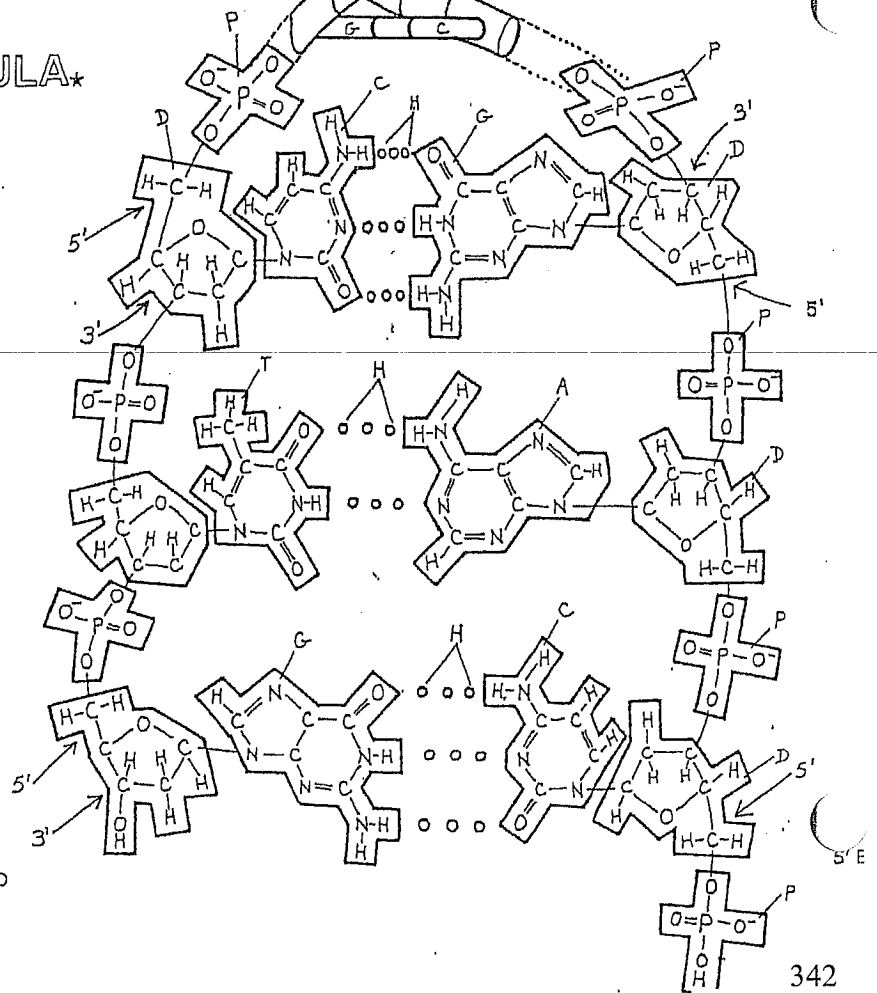
24. Refer to the illustration above. Suppose that you are given a protein containing the following sequence of amino acids: tyrosine, proline, aspartic acid, isoleucine, and cysteine. Use the portion of the genetic code given to determine which of the following contains a DNA sequence that codes for this amino acid sequence.
25. What is the function of rRNA
26. What is the function of tRNA

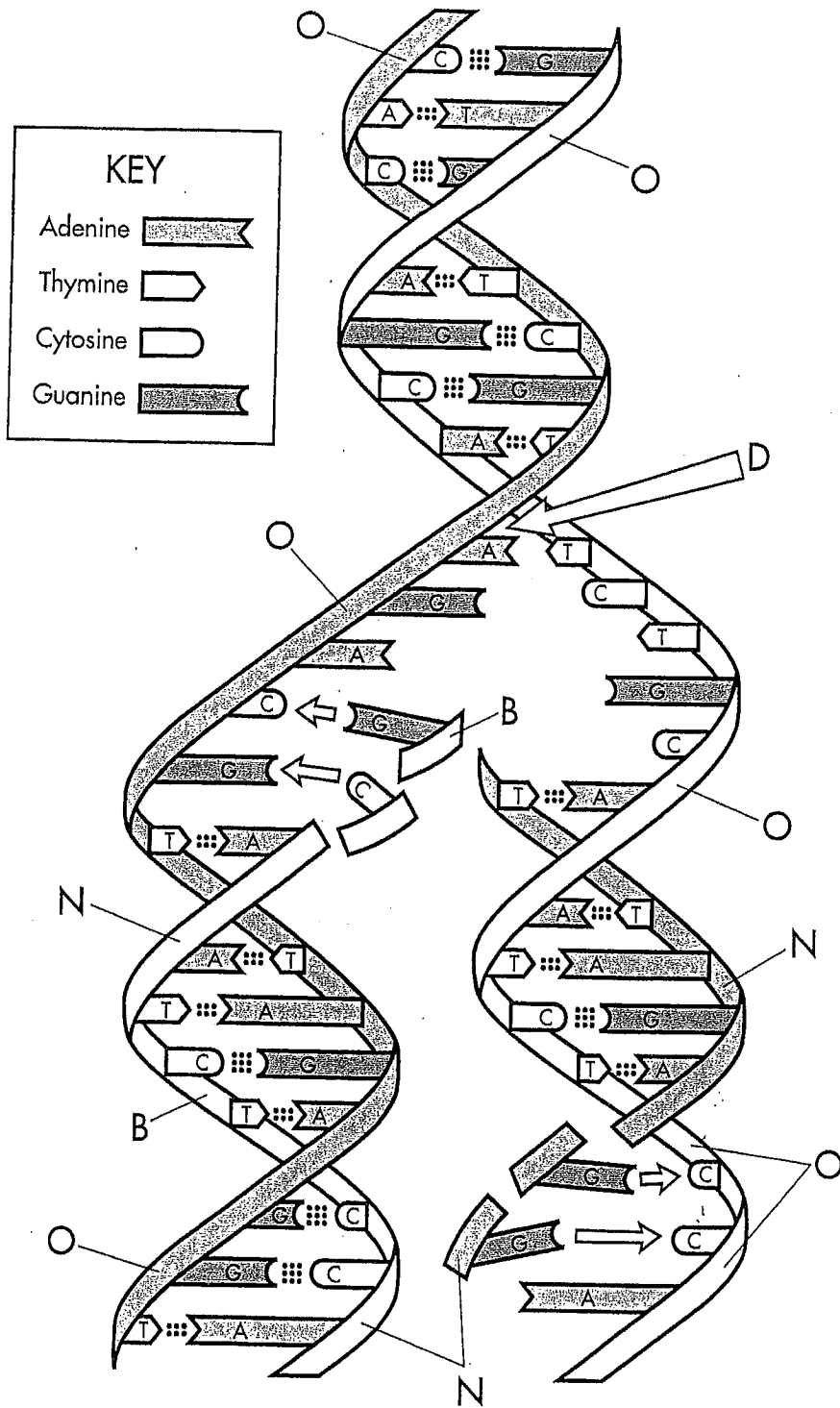
THE DOUBLE HELIX.

SIMPLIFIED STRUCTURE*
 UPRIGHTS/BACKBONE*
 DEOXYRIBOSE,
 PHOSPHATE,
 RUNGS/BASE PAIRS*
 ADENINE_A
 THYMINE_T
 CYTOSINE_C
 GUANINE_G
 HYDROGEN BOND_H



STRUCTURAL FORMULA*





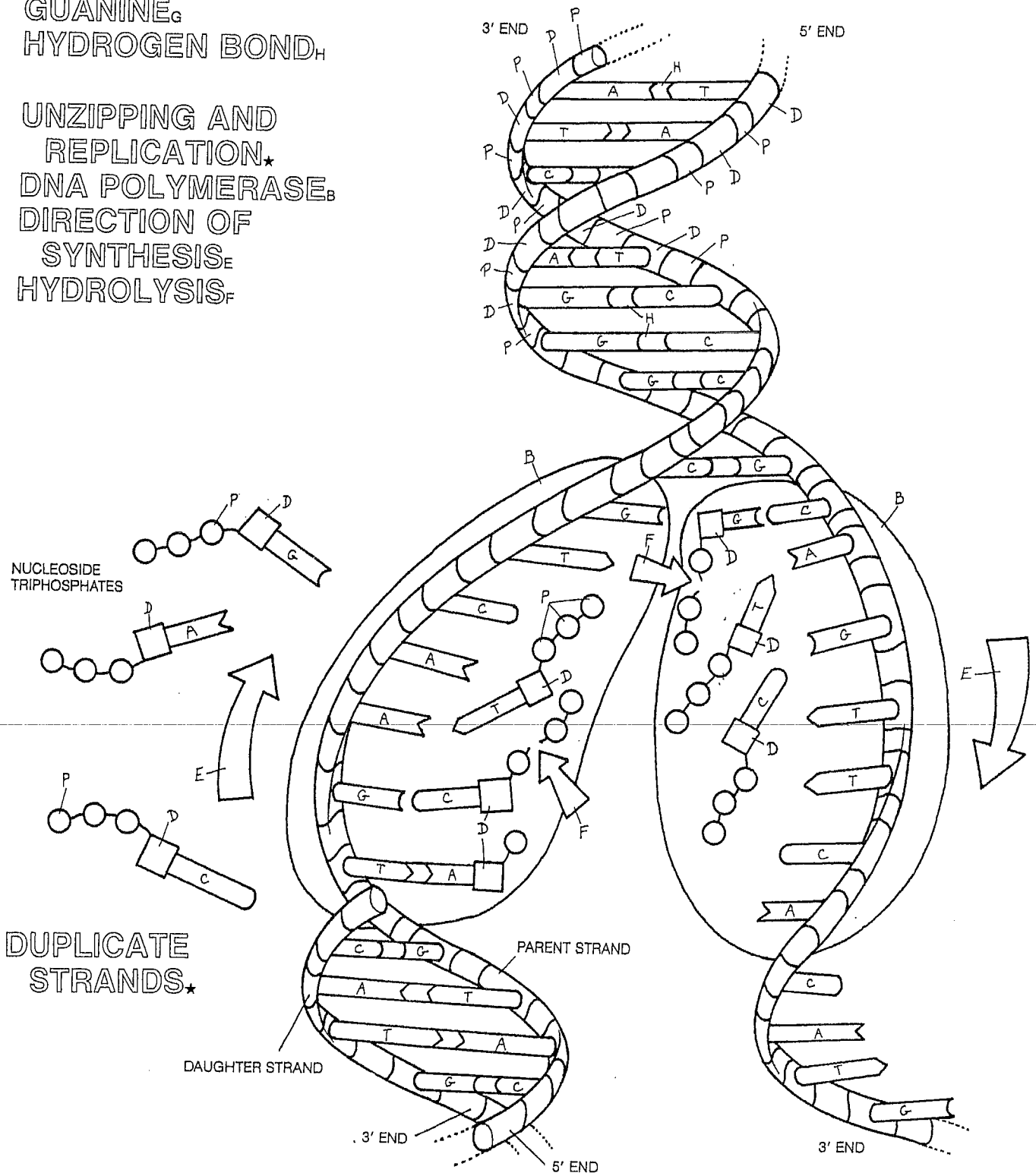
KEY	
Adenine	
Thymine	
Cytosine	
Guanine	

Replication of DNA		
○ Deoxyribose-Phosphate Backbone (Old)O	○ Adenine.....A	○ Guanine.....G
○ Deoxyribose-Phosphate Backbone (New)N	○ Thymine.....T	○ Replication ForkD
	○ CytosineC	

DNA REPLICATION.

DEOXYRIBOSE,
 PHOSPHATE,
 ADENINE,
 THYMINE,
 CYTOSINE,
 GUANINE,
 HYDROGEN BOND_H

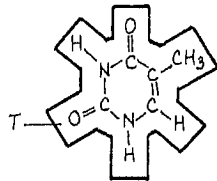
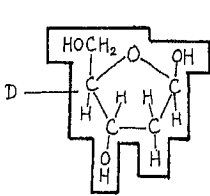
UNZIPPING AND
 REPLICATION*
 DNA POLYMERASE,
 DIRECTION OF
 SYNTHESIS_E
 HYDROLYSIS_F



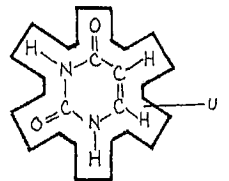
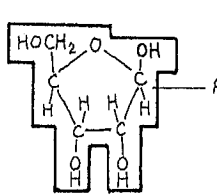
DUPLICATE
 STRANDS.*

DNA TRANSCRIPTION.

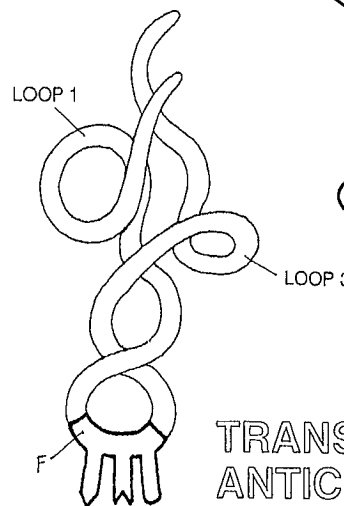
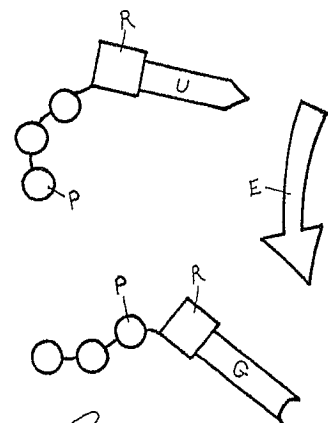
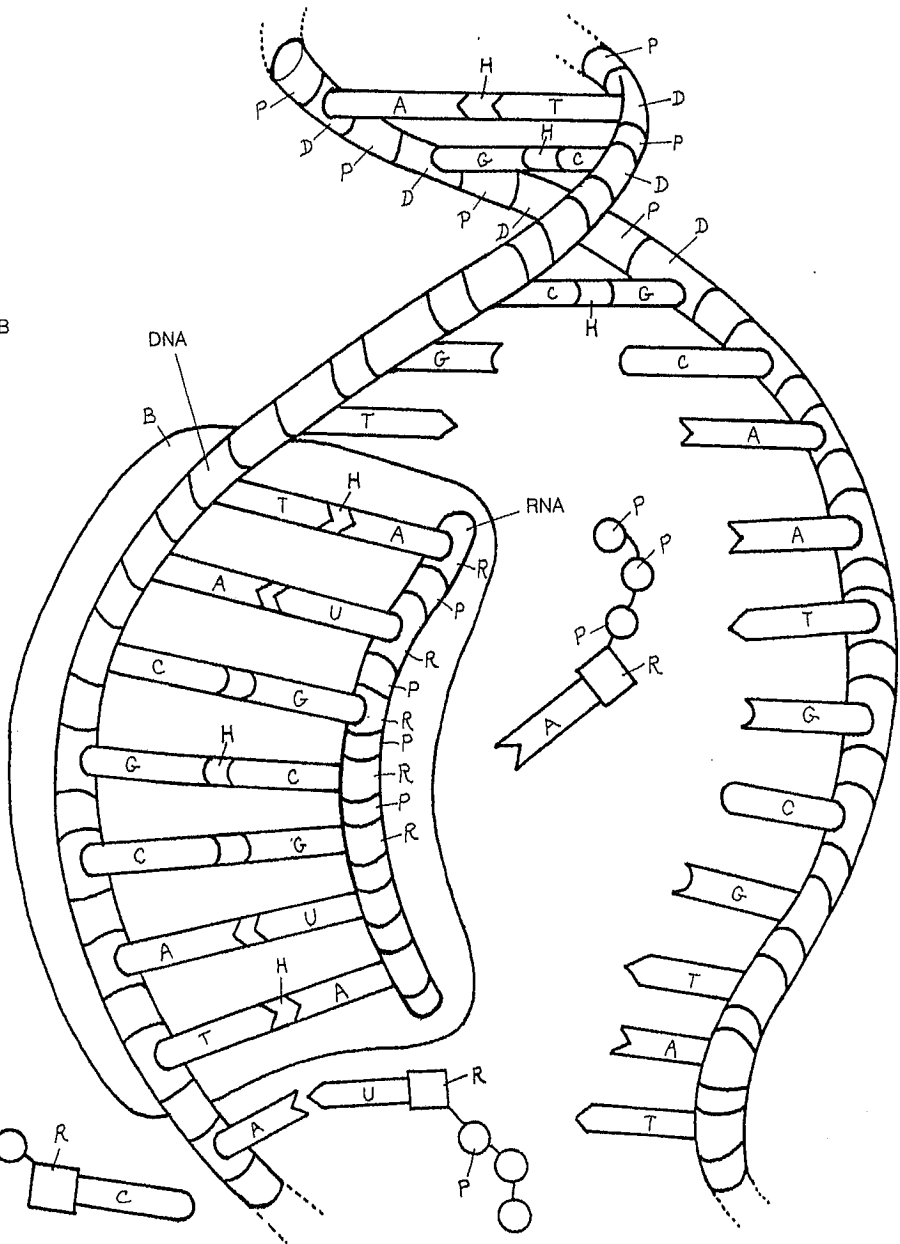
DNA★
DEOXYRIBOSE,
THYMINET



RNA★
RIBOSE_R
URACIL_U



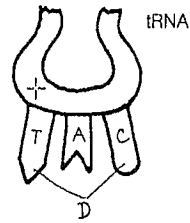
TRANSCRIPTION★
PHOSPHATE,
ADENINE_A
CYTOSINE,
GUANINE,
HYDROGEN BOND_H
RNA POLYMERASE_B
DIRECTION OF
TRANSCRIPTION_E



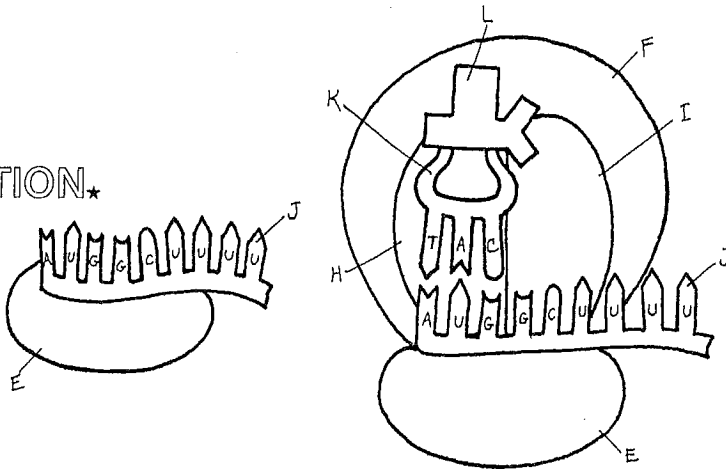
TRANSFER RNA★
ANTICODON_F

PROTEIN SYNTHESIS: TRANSLATION.

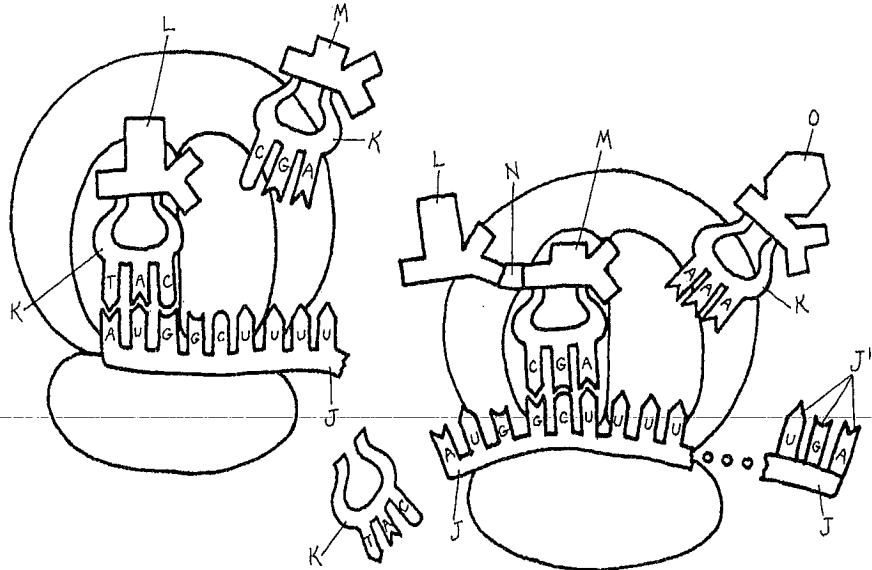
CODON:
ANTICODON:
RIBOSOME★
SMALL SUBUNIT:
LARGE SUBUNIT:
P SITE:
A SITE:



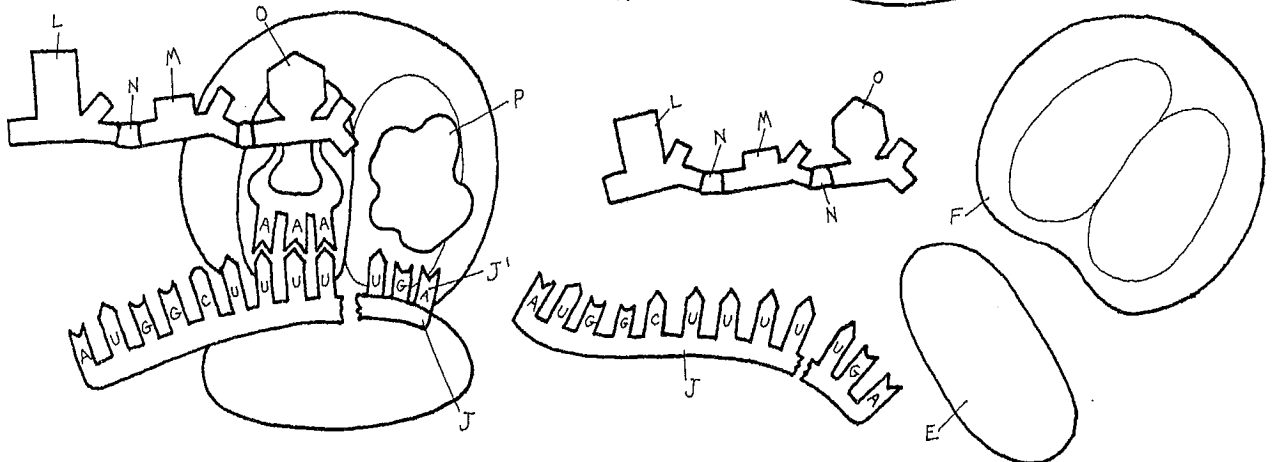
PHASES OF TRANSLATION★
INITIATION★
mRNA,
tRNA_k
METHIONINE.



ELONGATION★
ALANINE_M
PEPTIDE BOND_N
PHENYLALANINE.
STOP CODON_{J'}

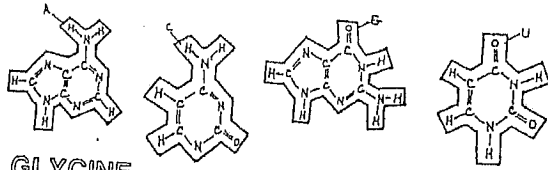


TERMINATION★
RELEASE
FACTOR.



THE GENETIC CODE

- RNA BASES:
- ADENINE
- GUANINE
- CYTOSINE
- URACIL
- NUCLEIC ACIDS:
- ADENINE
- GUANINE
- CYTOSINE
- URACIL
- THYMINE
- PARACITIC ACID
- DEOXYRIBOSE
- AMINO ACIDS:
- GLYCINE
- HISTIDINE
- ISOLEUCINE
- LEUCINE
- LYSINE
- METHIONINE
- PHENYLALANINE
- PROLINE
- SERINE
- THREONINE
- TRYPTOPHAN
- TYROSINE
- VALINE



- GLYCINE
- HISTIDINE
- ISOLEUCINE
- LEUCINE
- LYSINE
- METHIONINE
- PHENYLALANINE
- PROLINE
- SERINE
- THREONINE
- TRYPTOPHAN
- TYROSINE
- VALINE

FIRST mRNA BASE	SECOND mRNA BASE				STOP CODON
	U	C	A	G	
U	UUU → Phe	UCU → Ser	UAU → Tyr	UGU → Cys	U → Phe
	UUC → Phe	UCC → Ser	UAC → Tyr	UGC → Cys	
	UUA → Leu	UCA → Ser	UAA → Stop	UGA → Stop	
C	UUG → Leu	UCG → Ser	UAG → Stop	UGG → Trp	C → Leu
	CUU → Leu	CCU → Pro	CAU → His	CGU → Arg	
	CUC → Leu	CCC → Pro	CAC → His	CGC → Arg	
	CUA → Leu	CCA → Pro	CAA → Stop	CGA → Arg	
A	CUG → Leu	CCG → Pro	CAG → Stop	CGG → Arg	A → Ile
	AUU → Ile	ACU → Thr	AAU → Asn	AGU → Ser	
	AUC → Ile	ACC → Thr	AAC → Asn	AGC → Ser	
	AUA → Ile	ACA → Thr	AAA → Stop	AGA → Stop	
G	AUG → Met	ACG → Thr	AAG → Asn	AGG → Stop	G → Val
	GUU → Val	GCU → Ala	GAU → Asp	GGU → Gly	
	GUC → Val	GCC → Ala	GAC → Asp	GGC → Gly	
	GUA → Val	GCA → Ala	GAA → Asp	GGA → Gly	
	GUG → Val	GCG → Ala	GAG → Stop	GGG → Gly	

GENETIC MESSAGE: THE BIG DOG BIT TED AND RAN OFF

DELETION: THE BID OGB ITT EDA NDR ANO FF

↑ DELETION

BASE PAIRS:

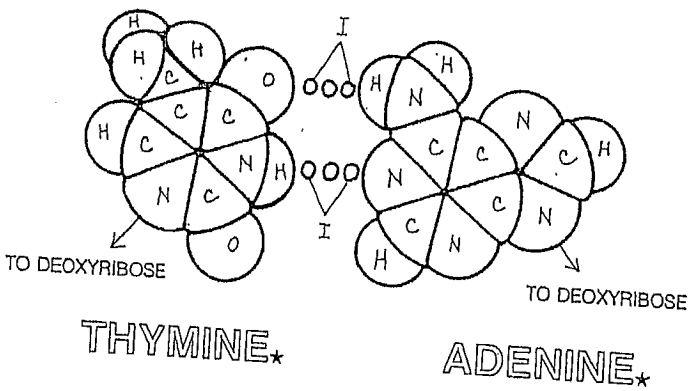
CARBON

NITROGEN

HYDROGEN

OXYGEN

HYDROGEN BONDS

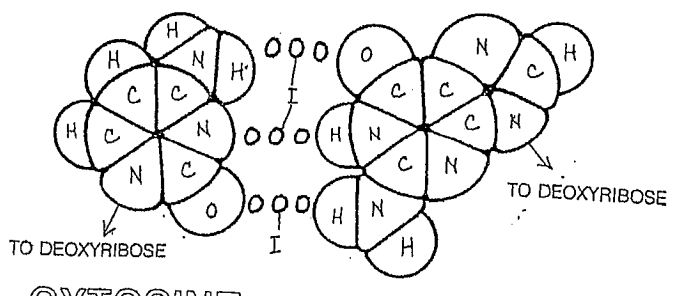


CHARGAFF'S RULE

DNA BASE PAIRING

ADENINE = THYMINE

CYTOSINE = GUANINE



Karyotyping—Genetic Disorders

It's not possible to predict with certainty the health of a newborn baby. However, some tests can be done before birth to detect certain genetic disorders. For example, Down syndrome, a genetic disorder that occurs in people who have an extra copy of chromosome 21, can be detected before birth.

A fetal karyotype can be used to check a fetus for normal chromosome number and shape (or structure). A *fetal karyotype* is a diagram, usually a photograph, that shows the chromosomes from the fetus's cells arranged in order from largest to smallest chromosome. The chromosomes are then examined for irregularities. Cells from the fetus are needed to make a fetal karyotype. There are two main ways of obtaining fetal cells for this procedure.

In *amniocentesis*, cells are taken from a sample of fluid surrounding the fetus. *Chorionic villi sampling* is a procedure similar to amniocentesis in which a tiny piece of embryonic membrane is removed. The cells obtained from either of these procedures can then be used to make a karyotype.

Each chromosome in a karyotype has dark and light bands on it. These bands are made using dyes so that the chromosomes are easier to see and compare. Different dyes are used to produce different banding patterns. When analyzing chromosomes in a karyotype, the technician compares the chromosomes band by band. If the bands do not match up, the chromosomes might have a structural mutation. For example, in a *deletion* mutation, part of a chromosome has broken off and is no longer present. This means that a cell will lack the genes on the missing part. In a *duplication* mutation, a piece of a chromosome breaks off and attaches to its homologous chromosome. This means that the homologous chromosome will now carry two copies of some genes.

A typical karyotype has 400 bands. Some have 650 bands. The number of bands and the pattern they make depends on the dye used. Each band can contain several hundred genes. Different dyes and banding patterns are used to detect different genetic disorders.

In this lab, you will observe different photomicrographs of fetal chromosomes. You will use one of the photomicrographs to produce and analyze a fetal karyotype. You will also identify the genetic disorder, if any, caused by an abnormal number of chromosomes seen in your karyotype. Finally, you will pool your data with those of your classmates.

OBJECTIVES

- **Make** a human karyotype by arranging chromosomes in order by length, centromere position, and banding pattern.
- **Identify** a karyotype as normal or abnormal.
- **Identify** any genetic disorder that is present and describe the effect of the genetic disorder on the individual.

MATERIALS

- chromosome spread
- human karyotyping form
- metric ruler
- photomicrograph of chromosomes
- scissors
- transparent tape



Procedure

1. Obtain a photomicrograph and note the letter identifying which individual the cells were taken from.
2. Carefully cut apart the chromosomes on each photomicrograph. Be sure to leave a slight margin around each chromosome.
3. Arrange the chromosomes in homologous pairs. The members of each pair will be the same length and will have their centromeres located in the same area. Use the ruler to measure the length of the chromosome and the position of the centromere. The banding patterns of the chromosomes may also help you pair up the homologous chromosomes.

FIGURE 1 NORMAL HUMAN KARYOTYPE

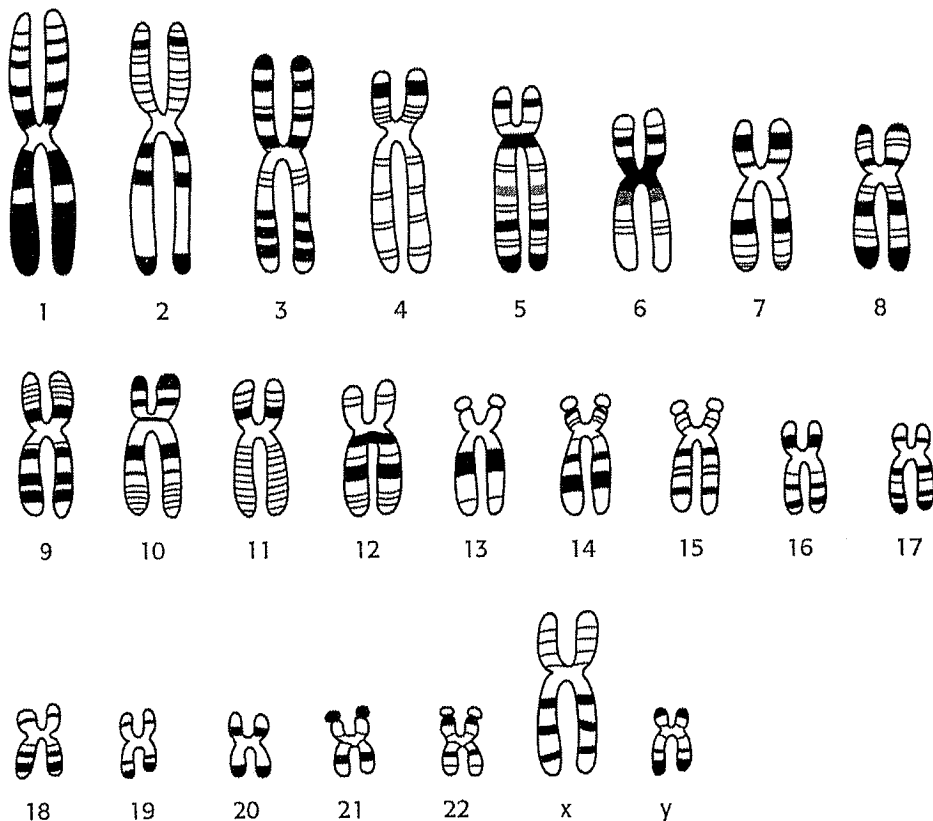


TABLE 1 GENETIC DISORDERS CAUSED BY AN ABNORMAL CHROMOSOME NUMBER

Name of abnormality	Chromosome affected	Description of abnormality
Down syndrome, or Trisomy 21	#21	47 chromosomes; mental retardation with specific characteristic features; may have heart defects and respiratory problems
Edwards' syndrome, or Trisomy 18	#18	47 chromosomes; severe mental retardation; very characteristic malformations of the skull, pelvis, and feet among others; die in early infancy
Patau syndrome, or Trisomy 13	#13	47 chromosomes; abnormal brain function that is very severe; many facial malformations; usually die in early infancy
Turner's syndrome	Single X in female (XO)	45 chromosomes; in females only; missing an X chromosome; do not develop secondary sex characteristics; are infertile
Klinefelter's syndrome	Extra X in male (XXY)	45 chromosomes; in males only; sterile, small testicles; otherwise normal appearance
XYY syndrome	Extra Y in male (XYY)	47 chromosomes; in males only; low mental ability; otherwise normal appearance
Triple X syndrome	Extra X in female (XXX)	47 chromosomes; sterility sometimes occurs; normal mental ability

4. Arrange the pairs according to their length. Begin with the largest chromosomes and move to the smallest.
5. Tape each pair of homologous chromosomes to a human karyotyping form. Place the centromeres on the lines provided. Place the longest chromosome at position 1, and the shortest at position 22. Place the two sex chromosomes at position 23.
6. The diagram you have made is a karyotype, as in **Figure 1**. Analyze your karyotype to determine the sex of the individual. Use the information in **Table 1** to guide your analysis.
7. Record your results in **Table 2**. Pool your data with that from the rest of the class.
8. Dispose of your materials according to the directions from your teacher.

TABLE 2 POOLED CLASS DATA

Letter identifier	Sex	Condition	Chromosome abnormality
A			
B			
C			
D			
E			
F			
G			
H			
I			

Analysis

1. **Analyzing Data** Is the baby represented by your karyotype male or female? How do you know?

2. **Analyzing Data** Will the baby have a genetic disorder? How do you know?

Karyotyping—Genetic Disorders *continued*

3. **Identifying Relationships** Assume that two students started with the same photomicrograph. One student concluded that the individual had Down syndrome. The other student concluded that the individual had Edwards' syndrome. Explain how this could happen.

Conclusions

1. **Drawing Conclusions** How is sex determined in a person who has more than two sex chromosomes? Explain your answer.

2. **Drawing Conclusions** In this lab, you examined karyotypes for the presence of abnormal chromosome numbers in both autosomes and sex chromosomes. Which condition seems to have a greater influence on a person's health: trisomy of an autosome or trisomy of a sex chromosome?

3. **Making Predictions** Assume that an individual has a deletion mutation in one of their chromosomes. What would the karyotype look like in this situation?

Karyotyping—Genetic Disorders *continued*

4. **Evaluating Methods** How might banding patterns be important to detecting an inversion mutation?

5. **Evaluating Methods** Some medical labs make karyotypes from several of an individual's cells before drawing conclusions about the individual's health. Do you think this is necessary? Why or why not?

Extensions

1. **Research and Communications** Trisomy occurs when an individual has three copies of the same chromosome. Monosomy occurs when an individual has only one copy of a chromosome. In this lab, you examined a fetal karyotype for the presence of three different trisomies. Find out why monosomies are rarely detected.
2. **Research and Communications** Some individuals have cells that produce both normal and abnormal karyotypes. This condition, in which an individual has both normal and abnormal cell lines, is called *mosaicism*. Find out more about mosaicism, how it is detected, and how it can affect an individual's health.

DNA Models

Deoxyribonucleic acid, or *DNA*, carries the hereditary information. DNA and proteins make up the chromosomes of cells. Although the chemical composition of DNA was known in the 1920s, its structure was not determined until the 1950s. James D. Watson and Francis H. C. Crick worked out the structure of DNA in 1953, after long months of research. Watson, Crick and Maurice Wilkins shared the 1962 Nobel Prize for this important discovery. DNA is made up of molecules of the sugar *deoxyribose*, *phosphate groups*, and *nitrogen bases*. The basic unit of DNA, the *nucleotide*, is made up of one of each. A molecule of DNA may contain as many as 200,000 nucleotides. The nucleotides make up two chains that are linked and twisted around one another in the form of a *double helix*. **OBJECTIVES** In this activity you will:

1. Learn the basic units and structure of DNA.
2. Use paper models to understand how the units making up DNA fit together.
3. Use paper models to learn how DNA makes copies of itself.

MATERIALS

scissors 1/2-in transparent tape, or glue stick
thumbtacks or masking tape sheets of different
colored construction paper cardboard

PROCEDURES AND OBSERVATIONS Part I. Structure and Composition of DNA

- a. Imagine that you can untwist the DNA ladder. Then study Figure 1, a diagram of the untwisted ladder. Note that the uprights of the ladder consists of alternating units-phosphate groups and deoxyribose molecules. Now study Figure 2 to see the structures of deoxyribose and phosphate, and how they chemically bond together. Their symbols are also shown.

Figure 1

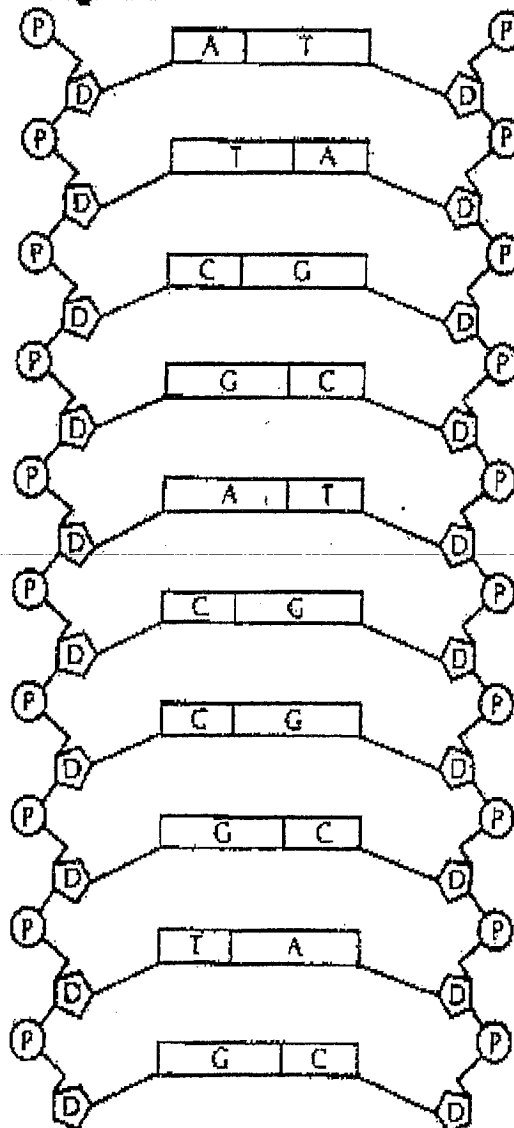
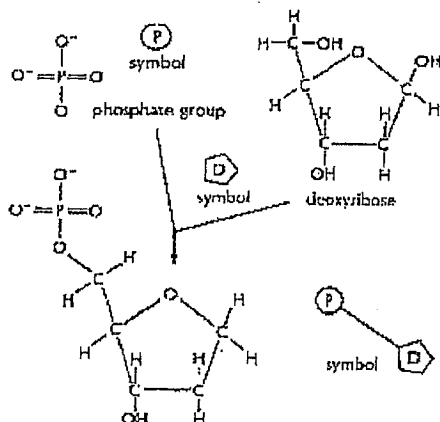


FIGURE 2



The rungs of the DNA ladder consist of pairs of nitrogen bases. There are two kinds of nitrogen bases: *purines* and *pyrimidines*. The purines have a two-ringed structure; they are *adenine* (A) and *guanine* (G). The pyrimidines have a one-ring structure; they are *cytosine* (C) and *thymine* (T).

- Figure 3 shows the structures of the four nitrogen bases found in DNA. Note the symbols for the bases.
- A nucleotide consists of one nitrogen base, one phosphate group, and one deoxyribose molecule.
- Study Figure 4 to see how the phosphate group, deoxyribose molecule, and nitrogen base are related in a nucleotide. Each nitrogen base is attached to the deoxyribose- side of a phosphate-deoxyribose combination. Note that because there are four different nitrogen bases there are four kinds of nucleotides.

FIGURE 3

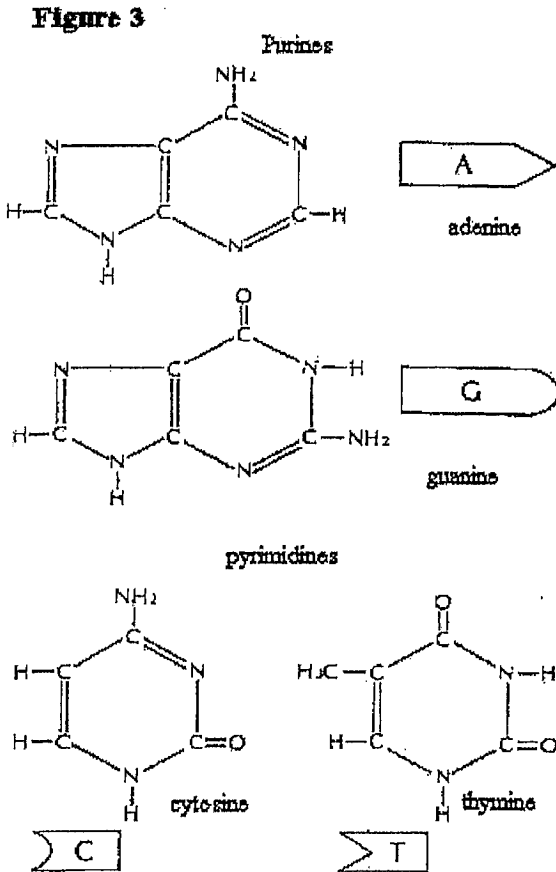
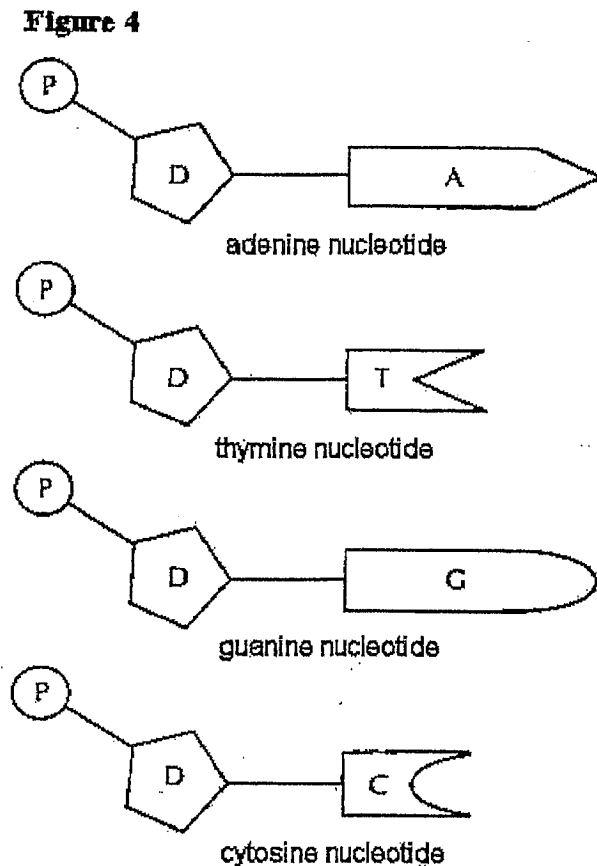


FIGURE 4



Part II. Making Models of DNA

1. Cut out the phosphate, deoxyribose, and nitrogen base symbols below. Paste them onto a piece of cardboard and cut them out.
2. Then rise the cardboard symbols to trace symbols on construction paper. Trace and cut out 20 each of the phosphate and deoxyribose symbols and 5 of each nitrogen base symbol. Use a different color paper for each symbol. Label each nitrogen base with its abbreviation.

3. Make a nucleotide model by laying a phosphate, a deoxyribose, and a nitrogen base symbol on the pattern in Figure 5. Fasten the symbols together with short pieces of transparent tape. Prepare 20 nucleotides. Be sure to attach the symbols at the correct angles to one another. Otherwise your DNA model will not fit together properly.
4. In DNA, a particular purine always bonds with a particular pyrimidine. Adenine bonds to thymine and guanine bonds to cytosine. The purines and pyrimidines are bonded together by hydrogen bonds.
5. Study Figure 6 to see how the nitrogen bases are bonded together in a DNA segment. Then construct a 10-rung model segment of DNA using the nucleotides you have assembled. Match up two nitrogen bases, either A-T or G-C, in each ladder rung. Use short pieces of tape for the bonds. The rungs of the ladder must be of equal length. The nucleotides of each strand can be in any sequence, as long as the two nitrogen bases paired together in the rung are correct. Attach the deoxyribose molecules and the phosphate groups of each strand with tape.
6. Label Figure 7 to show the nucleotide sequences of the DNA model that you constructed. Draw in the shapes of the nitrogen base symbols and label them A, T, G, or C.

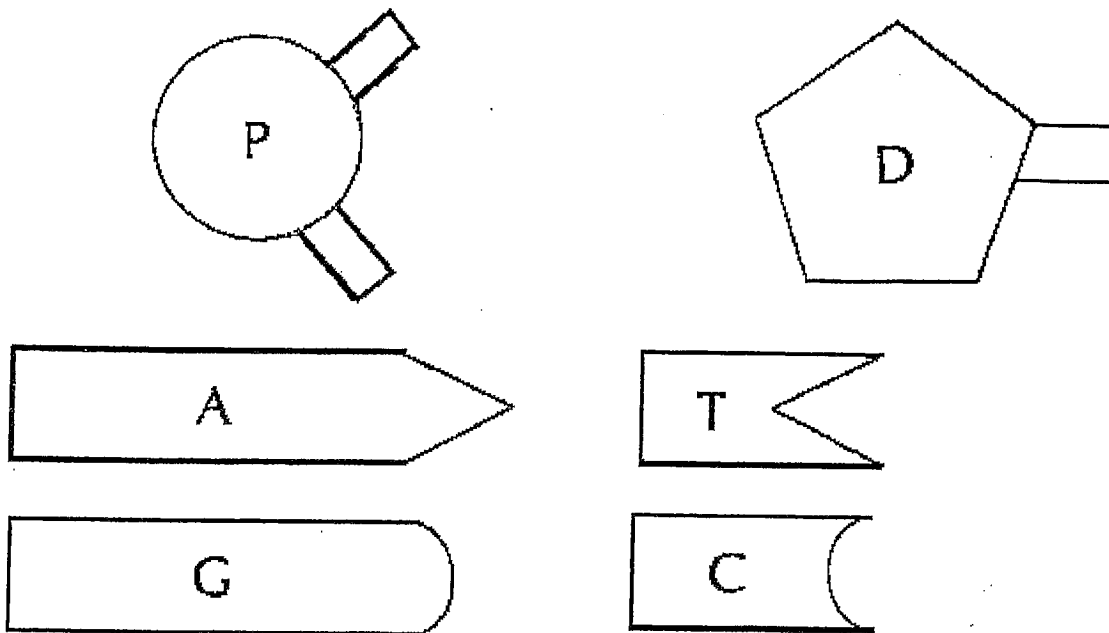
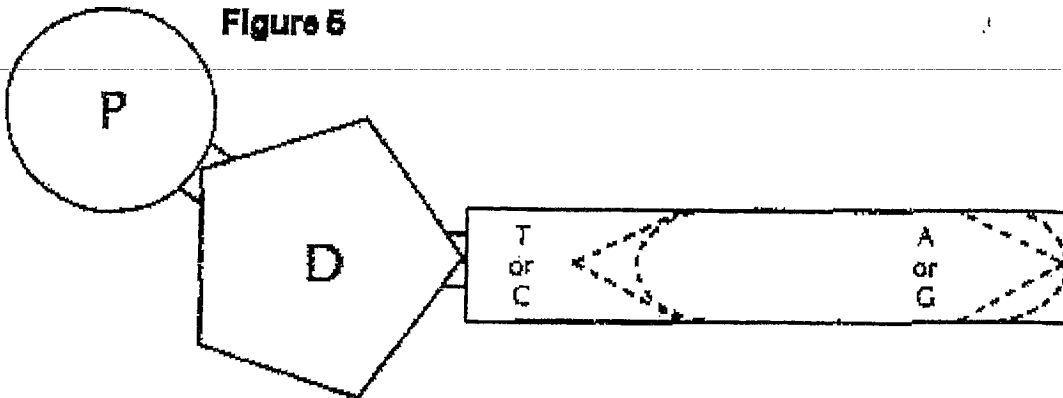
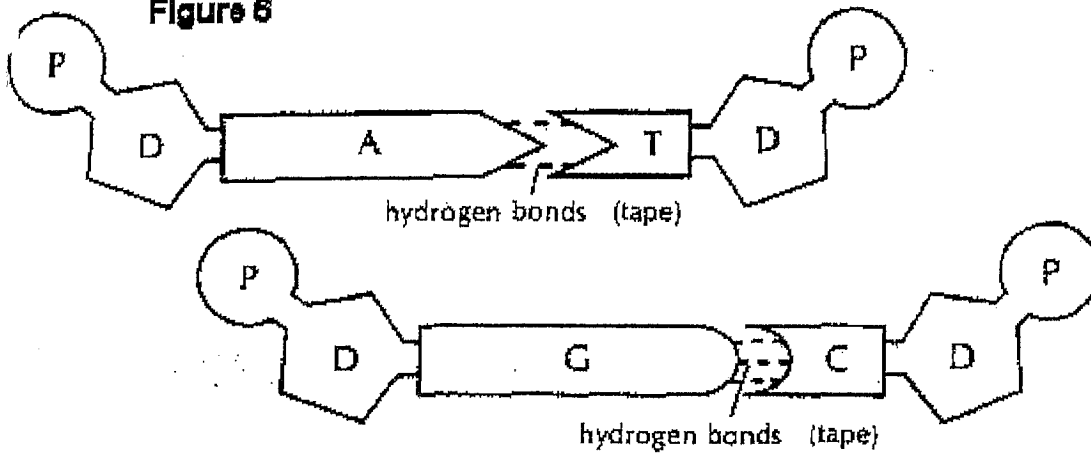


Figure 5



DO NOT CUT THESE ↓

Figure 6

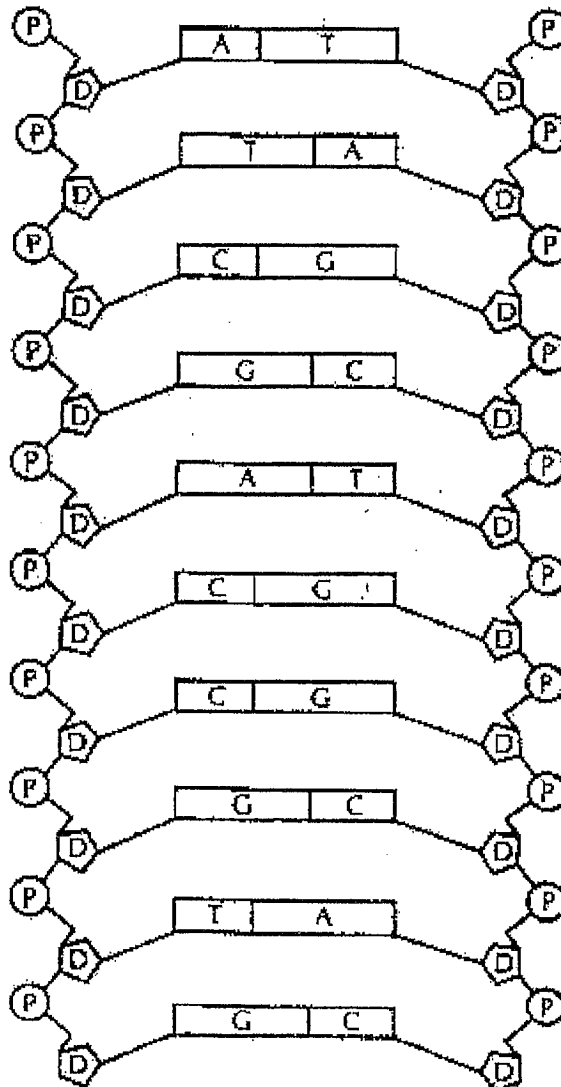


Part III. Learning About DNA Replication

DNA can replicate itself. In this way, the hereditary information encoded in its structure is passed on to new cells formed by mitosis. During replication, the DNA double helix untwists, and the hydrogen bonds between the nitrogen bases of each strand break. Nucleotides are normal constituents of cells, and as the DNA double helix splits apart, free nucleotides link up to matching nucleotides of each DNA strand according to the rules of base pairing. The two new double-stranded chains then twist into two separate double helices. In this way two identical DNA molecules are formed.

- Lay your *DNA* model flat on the table. Starting at one end of the model, cut the pieces of tape that connect the nitrogen bases on five of the rungs. Be careful not to cut the symbols. The effect is something like unzipping a zipper. Lay the unzipped model aside.
- Then prepare 20 more nucleotides as you did in Part II. Be sure to use the pattern to assemble the nucleotides at the proper angles.
- Matching C with G and A with T, attach new nucleotides to both strands of your *DNA* model, using short pieces of tape.
- Cut apart more rungs as you work along your model. Continue to add new

FIGURE 7



nucleotides to each strand until all the rungs have been cut and new nucleotides attached.

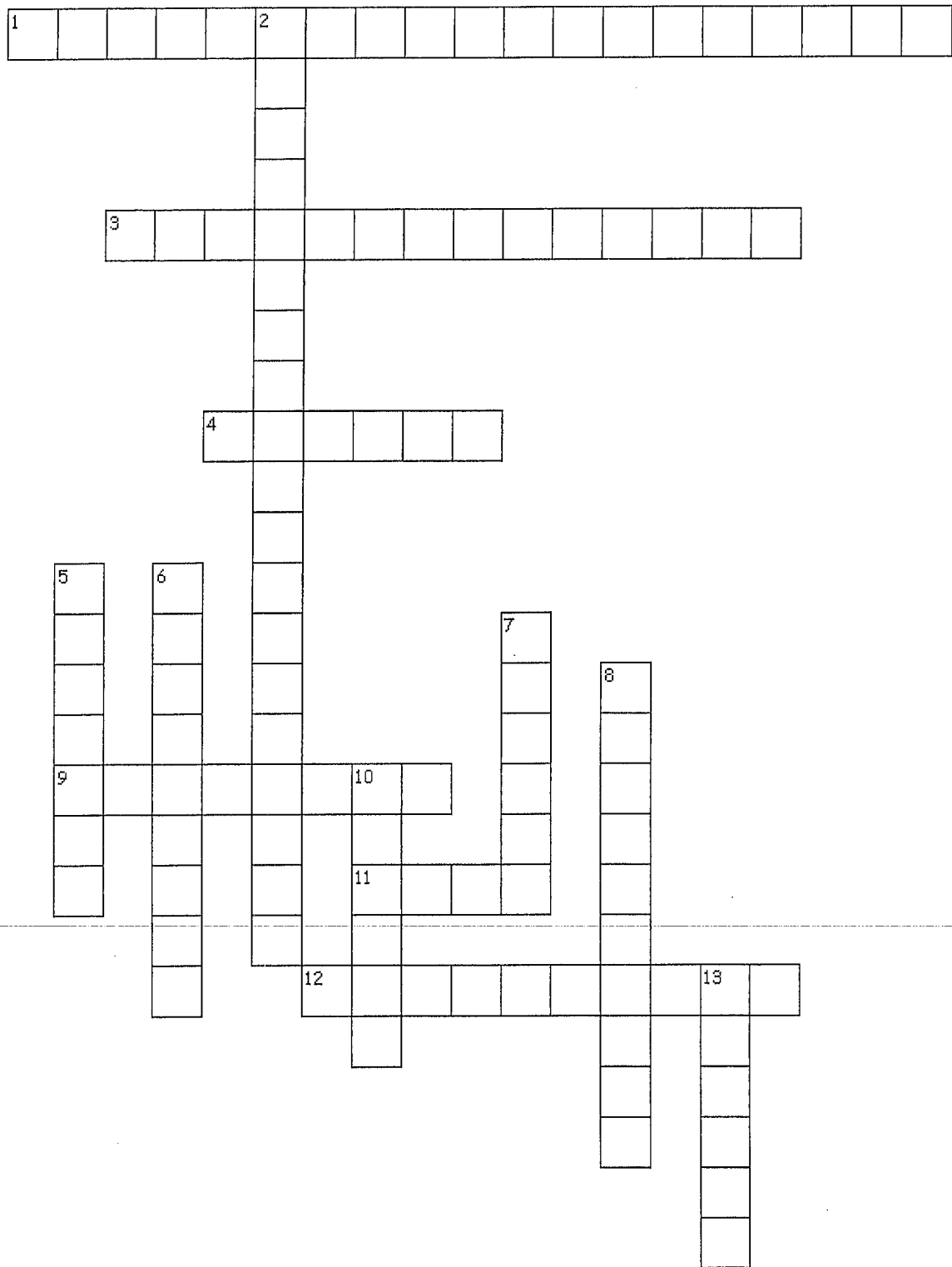
- e. Compare the sequences of the two new segments of *DNA* that you constructed.
 1. Are the two segments alike?
 2. How do their sequences compare with the sequences shown in figure 7?
- f. Toward the end of the class, carefully fasten one of your model segments of *DNA* to one of your neighbor's model segments. Work together with the rest of your classmates, fastening segments together until one long, ladderlike segment has been formed. With the help of your teacher, attach one end of the segment to the upper left corner of the classroom bulletin board. Use thumbtacks or heavy masking tape

to do it. Carefully twist the *DNA* model, starting near the attached end, as tightly as its structure permits. Twist it evenly along its entire length. Then fasten the end to the other side of the bulletin board, draping it as necessary to maintain its form.

CONCLUSIONS AND APPLICATIONS

1. What determines the sequence of the nitrogen bases in a new DNA strand?
2. Write out the sequence of the new DNA segment that would form next to the segment GGACTGTTA.
3. If an incorrect nucleotide is incorporated into a fanning strand of DNA, will this mistake be transmitted to the next generation of DNA molecules that forms from this strand?
4. When a DNA molecule replicates, are the two newly formed strands identical to each other? Why or why not?

Ch 14 Crossword/ Vocab



Across

1. an enzyme that is needed to begin and/or continue genetic transcription
3. a failure of homologous chromosomes to separate during meiosis I or the failure of sister chromatids to separate during mitosis or meiosis II
4. the complete genetic material contained in an individual or species
9. a change in the structure or amount of the genetic material of an organism
11. one of several nonadjacent nucleotide sequences that are part of one gene and that are transcribed, joined together, and then translated
12. an abnormal condition of having more than two sets of chromosomes

Down

2. the process by which a cell becomes specialized for a specific structure or function during multicellular development
5. a genetic structure that can replicate independently of the main chromosome(s) of a cell
6. in multicellular organisms, a genetically controlled process that leads to the death of a cell; programmed cell death
7. a nucleotide sequence that is part of a gene and that is transcribed from DNA into mRNA but not translated into amino acids
8. a genetic sequence that is randomly moved, in a functional unit, to new places in a genome
10. a unit of adjacent genes that consists of functionally related structural genes and their associated regulatory genes
13. in proteins, a functional unit that has a distinctive pattern of structural folding

Mutation

Nondisjunction

Polyploidy

Operon

transcription factor

intron

exon

domain

genome

plasmid

transposon

cell differentiation

apoptosis

Chapter 14 Genes in Action

I. **MUTATION: THE BASIS OF GENETIC CHANGE**- a mutation is a change in the structure or amount of the genetic material of an organism. A genetic _____ is an individual whose DNA or chromosomes differ from some previous or normal state. Every unique allele of every gene began as a mutation of an existing gene.

II. CAUSES OF MUTATIONS

A. Mutations occur naturally as accidental changes to DNA or to chromosomes during the cell cycle.

B. Enzymes repair most DNA that is mismatched during replication, but rarely, some DNA is not repaired.

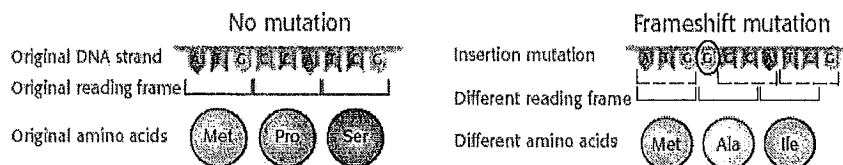
C. The rate of mutation can be increased by some environmental factors. Such factors, called _____, include many forms of radiation and some kinds of chemicals, including cigarette smoke.

II. **KINDS OF MUTATIONS**-Different kinds of mutations are recognized as either 1. changes in DNA or 2. changes in the results of genes. In eukaryotic cells, the process of meiosis creates the chance of mutations at the chromosomal level.

A. MUTATIONS AS CHANGES IN DNA SEQUENCE

1. **POINT MUTATION** -A point mutation is a change of a single nucleotide in a sequence from one kind of base to another.
2. **INSERTION/DELETION**- errors in replication can cause the insertion or deletion of one or more nucleotides in a sequence.

EFFECTS OF INSERTIONS AND DELETIONS



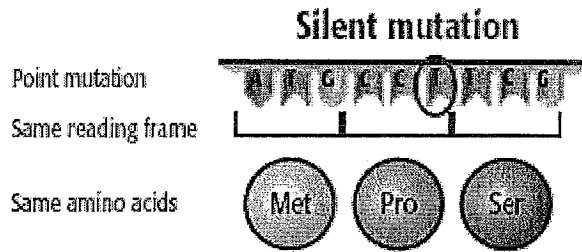
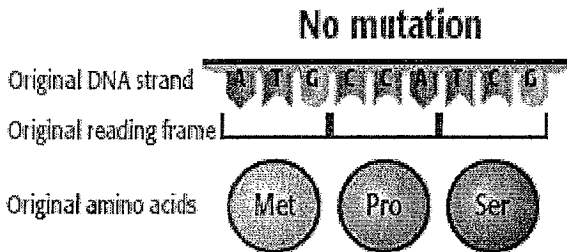
Remember that the genetic code is "read" in "words" of three letters each (codons). Insertions or deletions can change the *reading frame* by changing the groupings of nucleotides that are read during translation.

This insertion mutation has caused a *frameshift mutation*. It has changed the reading frame of the DNA sequence. As a result, the DNA codes for a different set of amino acids.

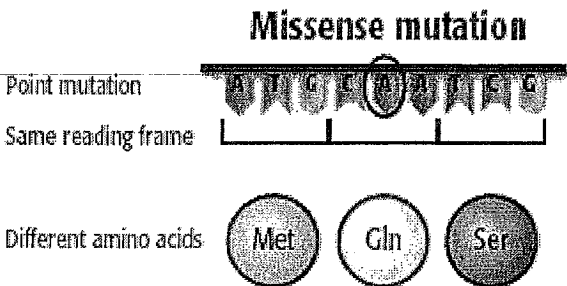
B. RESULTS OF SEQUENCE MUTATIONS

1. **SILENT**- A mutation is silent when it has no effect on a gene's function. Point mutations are often silent because the genetic code is redundant (each amino acid has multiple codons).
2. **MISSENSE**-A missense or replacement mutation results when a codon is changed such that the new codon codes for a different amino acid.
3. **NONSENSE**- A nonsense mutation results when a codon is changed to a "stop" signal. In this case, the resulting string of amino acids may be cut short, and the protein may fail to function.
4. **FRAMESHIFT**- The reading frame of a sequence depends on the starting point for reading. An insertion or deletion can shift the reading frame, or cause a frameshift. In frameshift mutations, the remaining sequence may be "read" as different codons. If an insertion or deletion is a multiple of 3, the reading frame will be preserved. However, the protein that results may have a few more or less amino acids in it.

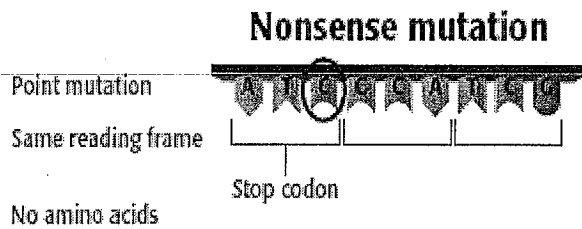
EFFECTS OF POINT MUTATIONS



A point mutation is a *silent mutation* if it does not affect the sequence of amino acids the gene codes for.



A point mutation is a *missense mutation* if it changes one of the amino acids in the sequence.



A point mutation is a *nonsense mutation* if it changes a codon to a stop codon.

C. CHROMOSOMAL MUTATIONS- During meiosis, chromosomes pair up and undergo crossover. Usually, the result is an equal exchange of alleles between homologous chromosomes. Errors in the exchange can cause chromosomal mutations. The following are types of mutations at the CHROMOSOMAL (condensed DNA=x) level

1. **DELETION-** A deletion occurs when a piece of a chromosome is lost. At the end of meiosis, one of the cells will lack the genes from that missing piece. Such deletions are usually harmful.
2. **DUPLICATION-** duplication occurs when a piece remains attached to its homologous chromosome after meiosis. One chromosome will then carry both alleles for each of the genes in that piece.
3. **INVERSION-** An inversion occurs when a piece reattaches to its original chromosome, but in a reverse direction.
4. **TRANSLOCATION-** A translocation occurs when a chromosome piece ends up in a completely different, nonhomologous chromosome.

IV. EFFECTS OF GENETIC CHANGE- Mutations that occur in gametes will be passed on to offspring, but mutations in body cells(somatic) affect only the individual in which they occur and die with the organism

A.If a mutation occurs in a somatic cell, the change may be silent or it may change the function of the cell.

B. Only a mutation in a germ cell may be passed on to the next generation. However, any such mutation may be silent or have little effect. Only rarely do mutations cause dramatic changes in future generations.

C. Certain genes control the normal growth, division, and specialization of cells in bodies. Mutations in these genes can cause a normal somatic cell to “lose control” and begin growing and dividing abnormally. The group of cells that grows will become a tumor.

D. Although cancers result from somatic cell mutations, not all somatic cell mutations cause cancer.

E. Genetic Disorders

1. Harmful effects produced by inherited mutations (defective alleles) are called genetic disorders. A disorder results because a mutation has altered the normal function of a gene.
2. Many disorders are recessive—that is, the disorder develops only in a person who is homozygous (double recessive) for the mutated allele. Two heterozygous people may be healthy, yet have children who develop a genetic disorder. A person who is _____ for such an allele is said to be a carrier of the disorder.

Disorder	Dominant or recessive?	Effect of mutant allele	Physical symptoms
Sickle cell anemia	recessive	The protein that carries oxygen in the blood is defective.	poor blood circulation; organ damage
Tay-Sachs disease	recessive in most cases	An enzyme in nerve cells is defective.	nervous system damage; early death
Cystic fibrosis	recessive	An enzyme in cells that secrete proteins is defective.	mucus buildup in certain organs; shortened life span
Hemophilia A	recessive (sex-linked)	A protein that helps blood clot is defective.	lack of formation of blood clots; can cause severe bleeding from minor injuries
Huntington disease	dominant	A protein in brain cells is abnormal.	brain damage; shortened life span

V. COMPLEXITIES OF GENE REGULATION- gene expression (transcription and translation) can be regulated. Not all genes are expressed in every cell. Through gene regulation, a genetic sequence can be expressed in different ways—in different bodies or tissues, under different conditions, or at different times. One benefit of gene regulation is that cells can use energy and materials efficiently.

VI. GENE REGULATION IN PROKARYOTES- The major form of gene regulation in prokaryotes depends upon operons that respond to environmental factors.

A. An _____ is a gene regulation system in which adjacent DNA segments control the expression of another group of genes

B. Operons are common in _____ but uncommon in eukaryotes.

C. The lac Operon Example

1. An example of gene regulation is found in the bacterium *Escherichia coli*.
2. Usually, when you eat or drink a dairy product, the chemical lactose (“milk sugar”) is digested by *E. coli* cells living in your gut. These cells can use the lactose for energy or for other needs. These tasks require three different enzymes, each of which is coded for by a different gene.
3. The system that involves the lac genes is called the lac operon.
4. This system includes the three genes plus a promoter site and an operator site.
5. When lactose is available, the system “turns on” and the three genes are transcribed. When lactose is absent, the system “turns off” and transcription is blocked.

VII. GENE REGULATION IN EUKARYOTES- Gene regulation in eukaryotes is more complex and variable than gene regulation in prokaryotes. _____ are

very rare in eukaryotic cells. Regulation can occur before transcription, after transcription, or after translation.

A. CONTROLLING TRANSCRIPTION- The genetic switch involves the first step of transcription, when RNA polymerase binds to the promoter region. The proteins involved in this kind of genetic switch are called transcription factors. Some transcription factors act as activators, and some act as repressors.

B. PROCESSING RNA AFTER TRANSCRIPTION- In eukaryotes, many genes contain noncoding sequences, or segments of code that will not be translated into amino acids. The noncoding segments are called _____, while those portions of the gene that do code for amino acids and will be translated are called exons. Exons and introns are handled in a process called RNA splicing. The introns are removed the exons that remain are spliced together. Finally, the spliced mRNA leaves the nucleus and is then translated.

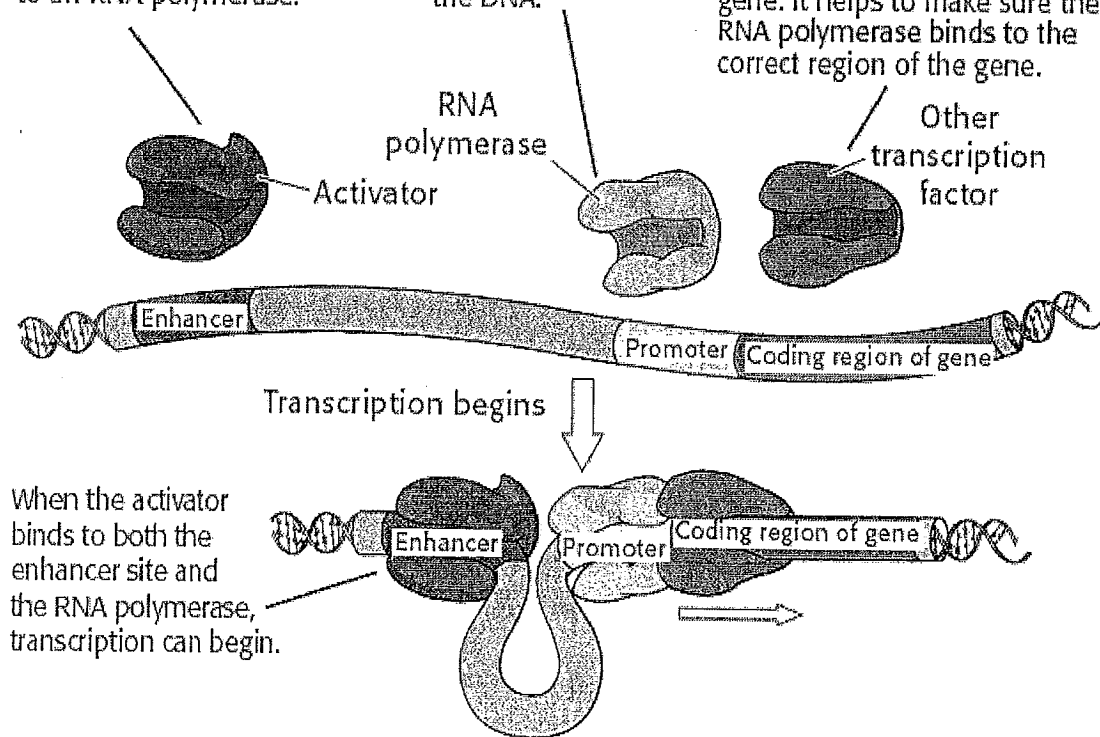
C. PROCESSING PROTEINS AFTER TRANSLATION- After translation, a chain of amino acids is formed, but the protein may not go directly into action. The process of getting proteins to their correct destination is called protein sorting. Protein sorting occurs in many parts of the cell, such as the _____.

An Example of Gene Regulation in Eukaryotes

This transcription factor is an *activator*. It can bind both to an enhancer site on the DNA and to an RNA polymerase.

This RNA polymerase can bind to the promoter site on the DNA.

This transcription factor can bind to the RNA polymerase and to the coding region of the gene. It helps to make sure the RNA polymerase binds to the correct region of the gene.



When the activator binds to both the enhancer site and the RNA polymerase, transcription can begin.

VIII. **GENOMES AND THE DIVERSITY OF LIFE**- genetic comparisons of many organisms reveal basic biological similarities and relationships. A

_____ is all of the DNA that an organism or species has within its chromosomes. With few exceptions, the genetic code is the same in all organisms. The genetic code is often described as being _____.

A. Genome Size- Genome size can be measured as an amount of DNA or a number of genes.

1. Genomes in microbes range from 400,000 to millions of base pairs and include from 400 to 9,300 genes.
2. Eukaryote genomes range from 100 million to more than 3 billion base pairs with 6,000 to 100,000 genes. The human genome has about 30,000 genes. Some plants have more than 100,000 genes.

B. DNA Versus Genes- Not all DNA in a cell is part of a gene or even part of a chromosome.

1. However, most bacteria have extra pieces of DNA called plasmids. Plasmids are small, circular DNA segments that are replicated independently and can be transferred between cells.
2. Plasmids are an important source of genetic variation in bacteria.
3. Eukaryotes have a great deal of noncoding DNA. Introns are non-coding pieces of DNA. Also, long stretches of repeating sequences exist that are never transcribed.
4. Mitochondria and chloroplasts are organelles that have small genomes that are separate from nuclear DNA. Remember - chloroplasts perform photosynthesis and mitochondria are respiration centers (glucose to ATP)

IX. **ENDOSYMBIOTIC THEORY**- Chloroplast-like bacteria could have been engulfed, but not killed, by larger cells. The cells would live together in a close relationship called symbiosis. This idea is known as the endosymbiotic theory

X.

XI. **MOBILE GENETIC ELEMENTS**- Small bits of genetic material can be stored, moved, and changed by a variety of interactions. MGEs are units of DNA or RNA that are transposed, or moved from one place to another. MGEs cause genetic change by bringing together new combinations of genes. MGEs can transfer genetic material between individuals and even between species. (ex- swine flu)

A. Plasmids- Plasmids are just one kind of mobile genetic element (MGE). Plasmids carry antibiotic resistance between bacteria and are responsible for antibiotic resistant strains of MRSA

B. Transposons- Sets of genes that are transposed randomly are jumping genes, or transposons. When a transposon moves to a new place, it may inactivate a nearby gene, much like an operon does. Some bacteria have transposons that jump between plasmids and chromosomes.

C. Viruses- Viruses infect cells by using the cells' own replication processes to make new virus copies. Certain kinds of RNA viruses, called retroviruses, produce DNA that becomes part of the host cell's genome.

Type of MGE	Description
Plasmid	small, circular piece of DNA; can be transferred between bacterial cells
Transposon	set of genes that move randomly between chromosomes; also called "jumping genes"
Virus	small, nonliving particle consisting of DNA or RNA inside a protein coating

XII. MULTICELLULAR DEVELOPMENT AND AGING-Each cell within a developing body will express specific genes. Gene expression depends on the cell's age and location within the body.

A. CELL DIFFERENTIATION- In cell differentiation, each new cell is modified and specialized as the cells multiply to form a body. _____ genes are examples of genes that regulate differentiation. Mutations in homeotic genes can cause one body part, such as a leg, to develop in place of another body part. All homeotic genes code for proteins that regulate the expression of other genes. Many homeotic genes contain a similar sequence of 180 bases. This sequence, called a homeobox, determines where in the DNA the protein binds to regulate transcription

B. CELL GROWTH AND MAINTENANCE-two kinds of proteins regulate the cell cycle: CDK and cyclin. These proteins are present in all eukaryotes and drive the cell cycle forward. The CDK molecules function like an engine, and the cyclins function like gears. They control the speed of the cell cycle. Cancer results when control of cells has been lost because either the "engine" or the "gears" malfunction.

C. CELL DEATH AND AGING- Almost all body cells are "programmed" to age and die. This process of cellular "suicide" is known as _____. Apoptosis seems to occur in consistent steps, much like other cellular processes, such as mitosis. The effect of aging is seen on the ends of chromosomes (called _____). As cells divide repeatedly, the telomeres lose nucleotides and become shortened.

1. How are nondisjunction and polyploidy related?

2. What is the origin of almost all genetic differences between organisms?

3. Explain the difference between point mutations, insertion mutations, and deletion mutations.

4. How is a missense mutation different from a nonsense mutation? How are they similar?

5. Skin cancer can occur if the DNA in skin cells is mutated by ultraviolet radiation in sunlight. Can the mutation that causes skin cancer be passed on to offspring? Explain your answer.

6. List Describe three types of chromosomal mutations.

Bellringer:Day M T W Th F Date _____ Question _____
Answer _____

1. What is the difference between an intron and an exon?

2. What controls most gene regulation in prokaryotes?

3. Give three differences between gene regulation in eukaryotes and gene regulation in prokaryotes.

4. Fill in the blank spaces in the table to describe ways that genes are regulated in eukaryotic cells.

When regulation occurs	Example and description
	transcription factors determine when a gene is transcribed
After transcription, but before translation	
After translation	

5. Give two ways that proteins are important to cells.

Bellringer: Day M T W Th F Date _____ Question _____
Answer _____

1. What is the difference between a genome and a gene?

2. A scientist is studying three different species. The scientist concludes that species A is more closely related to species B than to species C. How might the scientist have come to this conclusion?

3. Give three examples of MGEs.

When regulation occurs	Example and description
	transcription factors determine when a gene is transcribed
After transcription, but before translation	
After translation	

4. What can happen to an organism if its hox genes are mutated?

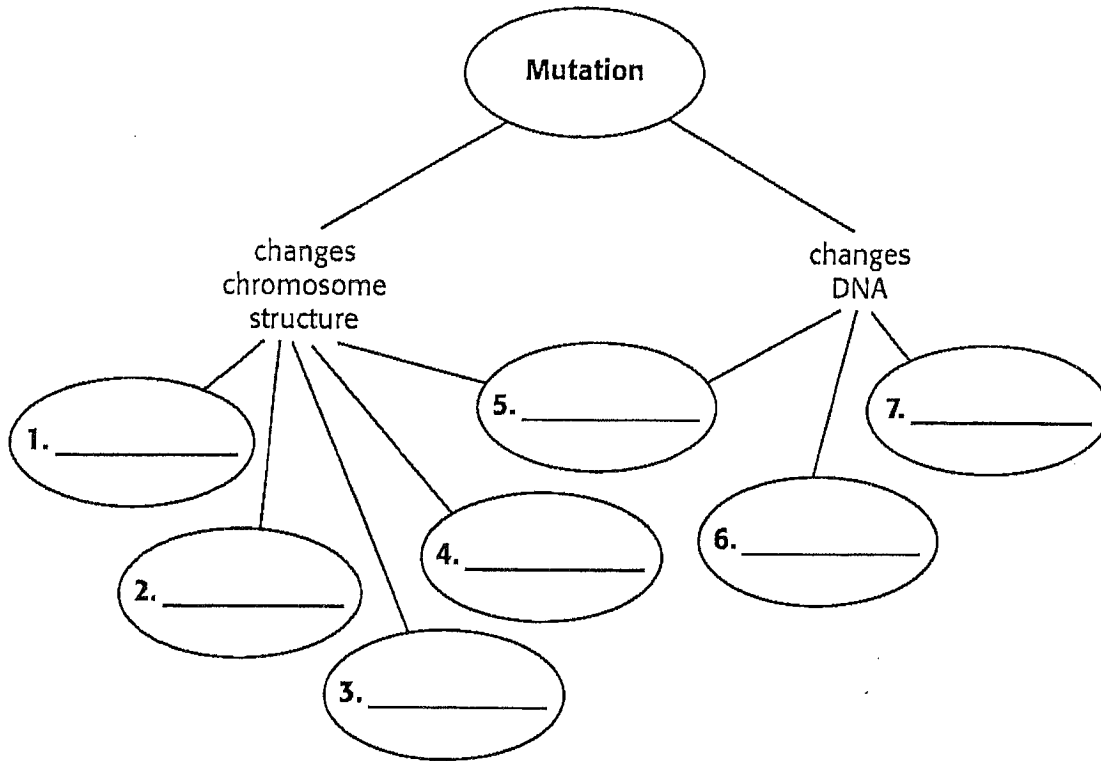
5. Most cells undergo apoptosis if their DNA is damaged. How can this be beneficial to an organism?

6. Give two groups of proteins that help to regulate the cell cycle

Concept Mapping

Using the terms provided below, complete the concept map showing the types of mutations.

- deletion
- insertion
- translocation
- duplication
- inversion
- gene rearrangement
- point



Chapter 14 Review

1. A mutation caused by a piece of DNA breaking away from its chromosome and becoming attached to a nonhomologous chromosome is called
2. What is nondisjunction? What happens when this occurs?
3. What is trisomy?
4. How many chromosomes do people with Down's syndrome have?
5. Why do cells control gene expression?
6. Define a repressor protein
7. In bacteria, a group of genes that code for functionally related enzymes, their promoter site, and the operator that controls them all function together as a(n)
8. What is the function of an operon?
9. The presence of a repressor protein prevents the action of what enzyme?
10. What are transcription factors?
11. What is an intron? An exon?
12. How do different proteins get formed from a limited number of exons?
13. What is a plasmid? Where is it found?
14. Which cell organelle contains its own DNA?
15. What is a MGE?
16. What is a virus made out of?
17. What could result from a mutation in a homeotic gene?
18. Which disease is caused by a problem in the regulation of the cell cycle?

A Model of Introns and Exons

You can model introns and exons with masking tape.

Procedure

1. Place a 15 to 20 cm strip of masking tape on your desk. The tape represents a gene.
2. Use two colored pens to write letters on the tape, exactly as shown in the example here. Space the letters to take up the entire length of the tape. The segments in one color represent introns; those in the other color represent exons.
3. Lift the tape. Working from left to right, use scissors to cut apart each group of letters of the same color.
4. Stick the pieces of tape to your desk as you cut them. Make two strips of matching colors, and join the pieces in their original order.

Analysis

1. **Determine** from the resulting two strips which strip represents “introns” and which represents “exons.”

2. **Critical Thinking Predicting Results** What might happen to the protein if an intron were not removed?

Make a Model of Mutations

You have learned about (and may have built models of) DNA replication and gene expression. Now, challenge yourself to build (or add to) a model that demonstrates each type of mutation described in this section.

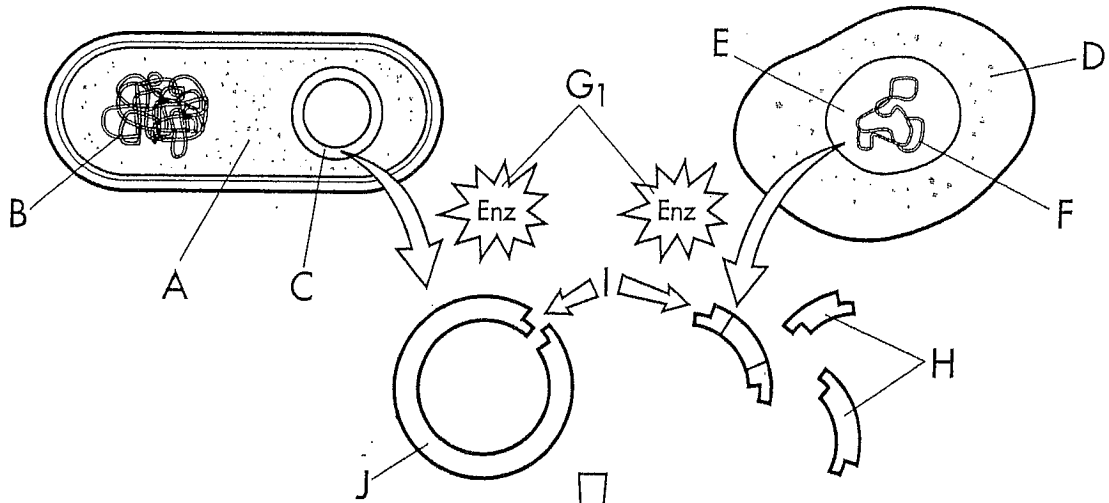
Analysis

1. **List** each mutation type on 12 separate sheets of paper. Work with a partner.

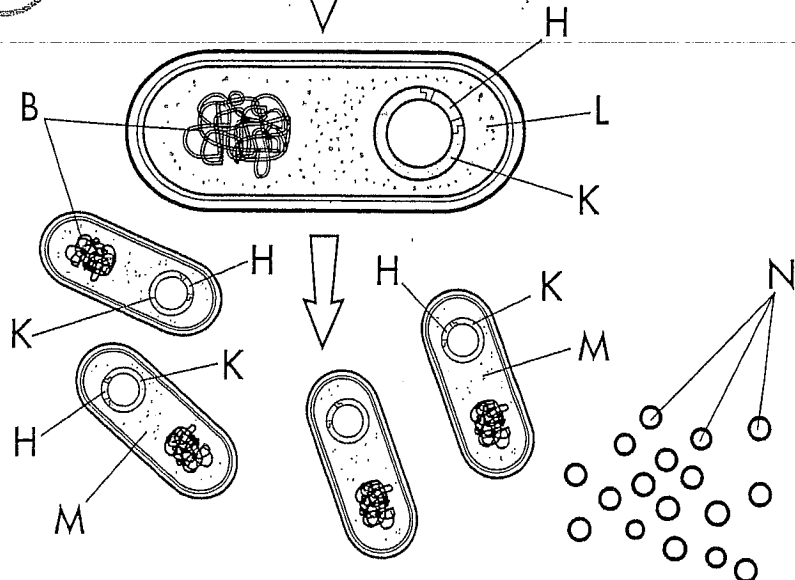
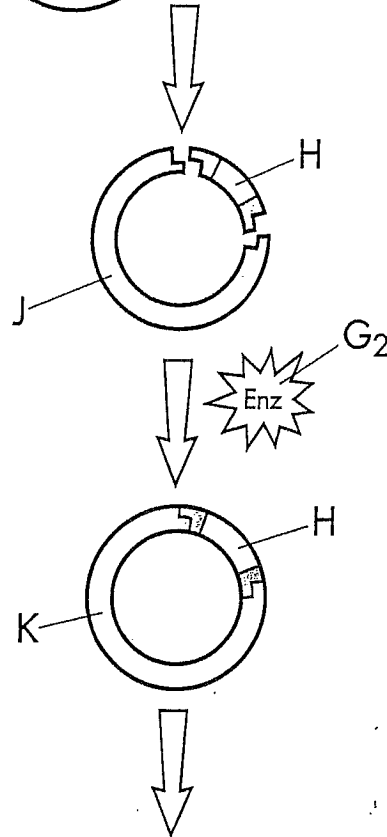
2. **Demonstrate** each mutation type by using assorted materials (or models that you have built previously).

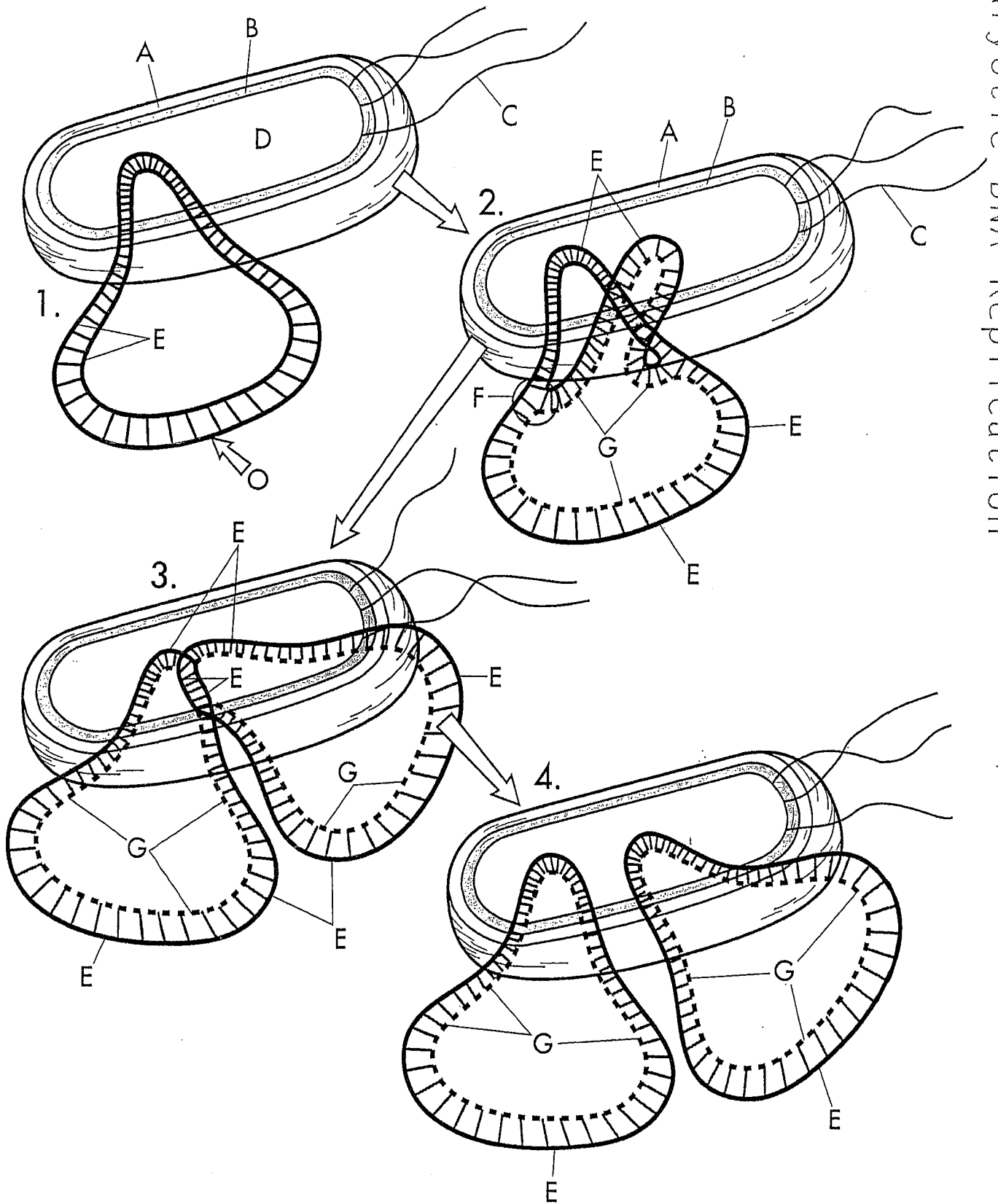
3. **Draw** the “before” and “after” state for each mutation.

4. Trade your drawings with another group. What is accurate and useful about their model? What could be improved? Write down your comments for the other group.



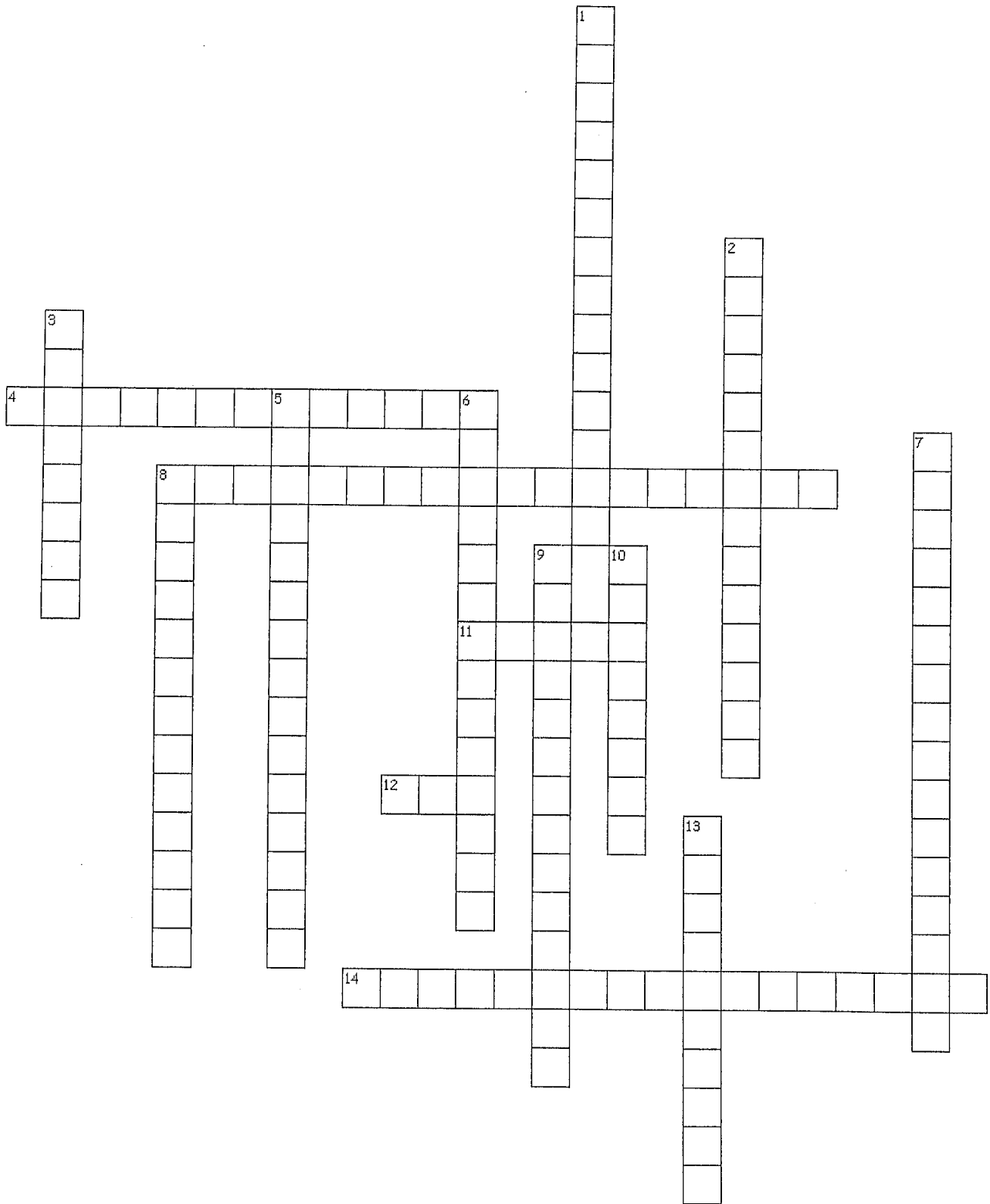
- Genetic Engineering**
- Bacterium.....A
 - Bacterial ChromosomeB
 - Plasmid.....C
 - Human CellD
 - Nucleus.....E
 - Human ChromosomeF
 - Restriction Enzyme....G₁
 - Ligase.....G₂
 - Insulin Genes.....H
 - Sticky Ends.....I
 - Opened PlasmidJ
 - Recombined Plasmid (Chimera).....K
 - New Bacterium.....L
 - Metabolizing BacteriaM
 - Insulin.....N







Ch 15 Crossword/ Vocab



Across

4. the process of determining the order of every nucleotide in a gene or genetic fragment
8. a technology in which the genome of a living cell is modified for medical or industrial use
11. an organism, cell, or piece of genetic material that is genetically identical to one that was preexisting; to make a genetic duplicate
12. a technique that is used to make many copies of selected segments of DNA
14. an enzyme that cuts double-stranded DNA into fragments by recognizing specific nucleotide sequences and cutting the DNA at those sequences

Down

1. a pattern of DNA characteristics that is unique, or nearly so, to an individual organism
2. DNA molecules that are artificially created by combining DNA from different sources
3. the study of entire genomes, especially by using technology to compare genes within and between species
5. the process by which electrically charged particles suspended in a liquid move through the liquid because of the influence of an electric field
6. a collection of genetic sequence clones that represent all of the genes in a given genome
7. variations in DNA sequences; used as a basis for comparing genomes
8. the process of determining the relative position of genes in a genome
9. the application of information technologies in biology, especially in genetics
10. a cell that can divide repeatedly and can differentiate into specialized cell types
13. a device that contains a micro-scale, orderly arrangement of biomolecules; used to rapidly test for the presence of a range of similar substances, such as specific DNA sequences

Genomics

Microarray

DNA fingerprint

Genetic engineering

recombinant DNA

clone

stem cell

restriction enzyme

DNA polymorphisms

Electrophoresis

PCR

DNA sequencing

Bioinformatics

genome mapping

genetic library

MGE

GMO

Chapter 15 Gene Technologies and Human Applications

I. **APPLICATIONS OF HUMAN GENETICS**-Genomics and gene technologies have many applications in human healthcare and society.

A. Diagnosing and Preventing Disease

1. A _____ shows which genes are being actively transcribed in a sample from a cell.
2. _____ informs people about the risk of genetic problems that could affect them or their offspring.
3. Various vaccines are now produced through genetic engineering•

B. Treating Disease

1. Some genetic disorders can be treated by supplying a genetically engineered protein.
2. Another possible treatment is _____, to insert a replacement gene into a person's cells by using a genetically engineered virus.

C. Identifying Individuals-DNA fingerprints are now used regularly to confirm the identity of criminals, family members, or dead bodies.

II. **MANIPULATING GENES** -Gene technologies are now widely applied to study organisms in new ways, to alter organisms for human use, and to improve human lives.

1. _____ Genetic engineering is the deliberate alteration of the genetic material of an organism.

2. DNA that has been recombined by genetic engineering is called recombinant DNA.

3. Organisms with recombinant genes may be called _____, or _____.

4. In everyday use, they are often referred to as genetically modified organisms (_____).

B. Genetic engineering was first applied to bacteria, viruses, and plants and is now applied to many life forms.

C. Manipulating Cell Interactions

1. Gene technologies are also used to control the expression of genes or to redirect the products.
2. The study of how proteins interact within cells is called _____.
3. Tissue culture cells can be studied closely and experimentally controlled.

III. **MANIPULATING BODIES AND DEVELOPMENT**-Cloning and stem cell techniques are used in research on animal development and have potential for treating certain diseases.

A. _____ -A clone is an organism or piece of genetic material that is genetically identical to one that was preexisting. – Making a clone in a lab is called cloning, but the process does also occur in nature.

1. The first clone made from an adult mammal was made using a process called _____ (SCNT).
2. Although scientists have successfully cloned many kinds of animals, only a few of the cloned offspring have survived for long.
3. Some problems with cloning may be related to the ways that eggs and sperm normally develop.

B. Using Stem Cells-A stem cell is a cell that can continuously divide and differentiate into various tissues.

1. Some stem cells have more potential to _____ than others.
2. Adults' bodies have some _____ cells that can be removed, frozen or cultured, and used for medical treatments.
3. The cells of new embryos have more potential uses.
4. The use of embryos for stem cell research poses ethical problems.
5. An alternative source of embryonic stem cells is through SCNT.

IV. **ETHICAL AND SOCIAL ISSUES**-Ethical issues can be raised for every use of gene technologies.

A. Safety

1. GMOs can have unforeseen effects.
2. Ecologists worry that we do not know enough to safely manipulate genes on a large scale.

B. Human Rights

1. The DNA of individuals can be tested for risks of genetic disorders.
2. This possibility raises many ethical questions.

C. Property Laws

1. Gene technologies have also created new issues for old laws.
2. GMOs and specific DNA sequences can be patented.

Question	How scientists are answering the question
How do our genes interact?	Scientists are studying how the proteins made from one gene affect other genes.
How unique are we?	Scientists are comparing the human genome with genomes of other organisms.
Can genetics help us live longer?	Scientists are learning about how genes are involved in diseases.
How do we deal with ethical issues?	Scientists are discussing who should own genetic information and how it should be used.

V. **BASIC TOOLS FOR GENETIC MANIPULATION**-The basic tools of DNA manipulation rely on the chemical nature of genetic material and are adapted from natural processes discovered in cells. These tools include restriction enzymes, polymorphisms, gel electrophoresis, denaturation, and hybridization.

1. _____ A restriction enzyme cuts double-stranded DNA into fragments by recognizing specific nucleotide sequences and cutting the DNA at those sequences.
2. These enzymes can be used to cut up a DNA sample in specific ways and to create sticky ends for splicing DNA.
3. _____ Differences between the DNA sequences of individuals are called DNA polymorphisms.
4. Differences of just one nucleotide are called single nucleotide polymorphisms (SNPs).

5. Differences in restriction sites results in restriction fragment length polymorphisms (RFLPs).
6. _____ Electrophoresis is a process in which electrically charged particles move through a liquid or semisolid
7. Often, DNA fragments are forced though a gel.
8. Shorter fragments will move faster through the gel.
9. The result is a lane of fragments sorted by size.
10. _____ Some conditions can cause DNA to denature, or untwist and split into single strands.
11. Scientists can easily denature and renature DNA for further manipulations. •
12. _____ Under the right conditions, complementary segments of DNA or RNA will bind together, or hybridize.
13. Genetic tools that take advantage of this natural process include primers, probes, and cDNA.

Basic tool	Description
Restriction enzymes	Bacteria make restriction enzymes to cut DNA from invading viruses. Restriction enzymes cut DNA at specific places called <i>restriction sites</i> . Scientists use these restriction enzymes to cut DNA samples in specific ways.
DNA polymorphisms	Differences between the DNA sequences of individuals are called DNA polymorphisms . A difference of just one nucleotide is a single <i>nucleotide polymorphism</i> . Scientists use polymorphisms to create DNA fingerprints and to compare individuals and species.
Gel Electrophoresis	DNA carries an electric charge. The process of electrophoresis uses an electric current to pull DNA fragments through a partly solid material - called a <i>gel</i> . Shorter fragments move faster through a gel than longer fragments. Scientists use gel electrophoresis to separate DNA fragments by size.
Denaturation	DNA is usually double-stranded. Scientists can use heat or strong chemicals to <i>denature</i> DNA. Denaturing splits DNA into two single strands.
Hybridization	Scientists can <i>hybridize</i> , or bind, complementary single strands of DNA. Short single strands of DNA, called <i>primers</i> , hybridize to denatured DNA to start replication.

VI. **MAJOR GENE TECHNOLOGY PROCESSES**-The major methods for working with genes use some combination of the basic tools and mechanisms of cellular machinery. These methods include PCR, blotting, DNA sequencing, and gene recombination.

A. Polymerase Chain Reaction (PCR)

1. The _____ process is widely used to clone DNA sequences for further study or manipulation.
2. _____ imitates the normal process of DNA replication in cells.
3. The process is called a chain reaction because it is repeated over and over.

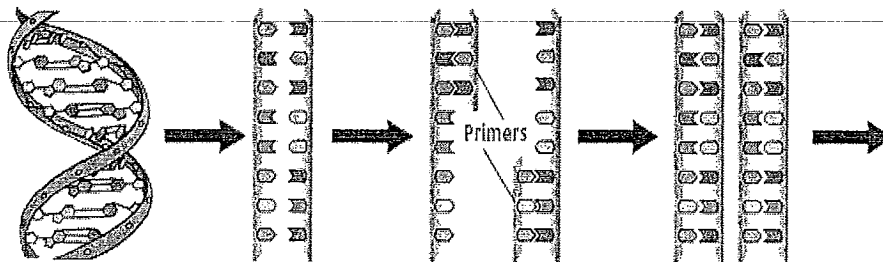
B. Several gene technologies use a combination of restriction enzymes, gel electrophoresis, and hybridization with probes.

C. **DNA sequencing** is the process of determining the exact order of every nucleotide in a gene. The major modern method is _____.

D. The first attempts at gene recombination and cloning were done by inserting a gene into an organism that replicates easily.

Polymerase Chain Reaction (PCR)

- 1 Add DNA polymerase, nucleotides, and primers. Heat to denature, or separate, the DNA strands.
- 2 Cool to allow the primers to bind, or hybridize, to complementary regions on the original strands.
- 3 DNA polymerase will then add nucleotides to complete a copy of the original strands.
- 4 Repeat the process by heating and cooling the DNA.



VII. EXPLORING GENOMES

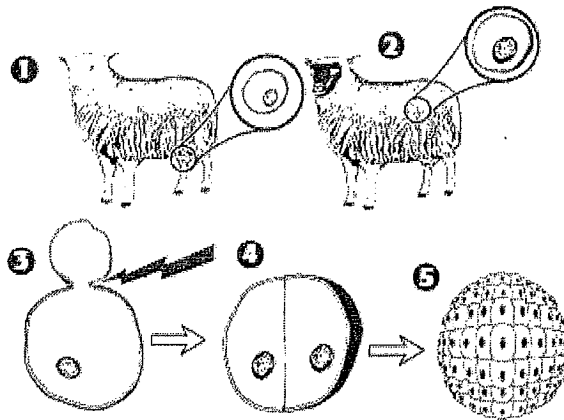
A. Mapping Methods

1. Genome mapping is the process of determining the _____ of all of the genes on chromosomes in an organism's genome.
2. To help track genes, any detectable physical, behavioral, or chemical trait can be used as a marker.
3. To determine the relative locations, genome mapping may use several methods—_____ methods identify the relative order of genes along a chromosome.
4. _____ methods determine the exact number of base pairs between specific genes.
5. Human chromosome mapping has mostly used historical family records.

B. Genome Sequence Assembly

1. The process of deducing and recording the exact order of every base and gene in a genome is called _____.
2. A collection of clones that represent all of the genes in a given genome is called a _____.
3. Two kinds of genetic libraries are made: a _____ or an _____ (EST) library.
4. The data can be searched for any specific gene or sequence.
5. Robotic devices are now used to sequence genomes rapidly.

DOLLY



- 1 Scientists extracted somatic cells from the adult sheep being cloned.
- 2 Scientists also extracted egg cells from another sheep. They removed the nucleus from these cells.
- 3 Scientists placed a somatic cell and an "empty" egg cell near each other. They applied an electric shock that caused the two cells to fuse.
- 4 Scientists then triggered the cell to divide and begin to form an embryo.
- 5 Scientists implanted the embryo into a surrogate mother where it developed into a baby sheep. This sheep had the same genetic information as the sheep in step 1.

1. What was the goal of the Human Genome Project?

2. What percentage of DNA in the human genome does not code for proteins?

3. How can a genome be used to identify a person if the DNA sequence of any two people is 99.9% identical?

4. How are scientists studying how the genes in the human genome interact?

5. Genes code for proteins. Humans have many of the same genes as other species. What does this imply about the proteins in humans and other species?

7. About how many fewer genes do humans have than scientists expected?

Bellringer: Day M T W Th F Date _____ Question _____

Answer _____

1. What kind of DNA do genetically modified organisms have?

2. How can genetically modified bacteria with human genes be used to treat human diseases?

3. What can a stem cell do that most body cells cannot do?

4. Complete the following table to illustrate the advantages and disadvantages of GMOs, cloning and stem cell research

Technology	Advantage	Disadvantage
GMOs	GMOs improve the yield and nutrition of food crops and livestock.	
Cloning		Most cloned animals do not develop normally or live long.
Stem cell research	Stem cells enable scientists to create cell types for treating individuals with missing or damaged tissue.	

1. What basic tools do scientists use to manipulate genetic material?

2. How are denaturation and hybridization used in PCR?

3. What tool of genetic manipulation do bacteria make, and why do they make it?

4. A scientist is separating three fragments of DNA by gel electrophoresis. The first fragment is 500 base pairs long, the second is 5,000 base pairs long, and the third is 1,500 base pairs long. Which fragment will move the fastest through the gel?

5. Name three ways that bioinformatics helps scientists explore genomes.

6. How can scientists determine the location of genes on a chromosome?

Bellringer: Day M T W Th F Date _____ Question _____

Answer _____

CHAPTER 15 REVIEW

What was the goal of the Human Genome Project

What is DNA fingerprinting? How can it be useful for solving crimes

What is Genetic Engineering?

What uses do human genes inserted into bacteria have?

What is recombinant DNA? How is this done?

What is cloning?

Who was Dolly? Why was this important?

What are stem cells? What are totipotent stem cells? Omnipotent? Multipotent? Pluripotent?

What are restriction enzymes? How do they work? Where do they come from?

DNA made to match mRNA is called _____

Radioactive or fluorescent-labeled RNA or single-stranded DNA pieces that are complementary to the gene of interest and are used to confirm the presence of a cloned gene are called _____

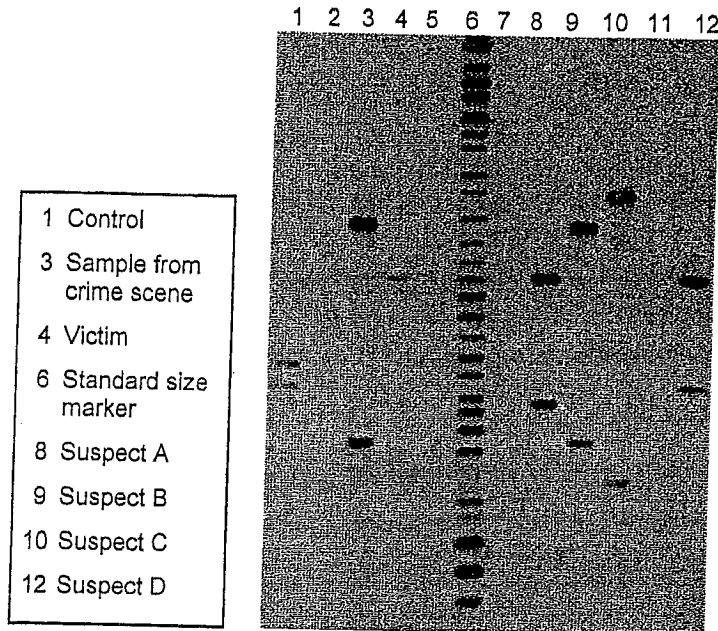
How are genetic engineering experiments carried out? What do they usually start with?

What are plasmids? How are they useful?

A technique that uses radioactively labeled DNA to identify specific genes in a piece of DNA is called the _____

Forensic DNA Fingerprints

DNA “fingerprinting” is useful in forensics because it can be performed on a sample of DNA from body tissues such as hair or blood. Samples can be compared to find genetically identical or closely related people. Identical segments of DNA will form identical patterns of bands in the columns of a DNA fingerprint, as shown here.



Analysis

1. **Identify** the number of individuals whose DNA samples are being analyzed in this DNA fingerprint.

2. **Critical Thinking Interpreting Graphics** Identify the suspect sample that matches the sample from the crime scene.

3. **Critical Thinking Analyzing Methods** Column 6 shows an array of DNA segments sorted by increasing length. Propose a purpose for these columns in this method.

DNA Whodunit

In the early 1970s, scientists discovered that some bacteria have enzymes that are able to cut up DNA in a sequence-specific manner. These enzymes, now called *restriction enzymes*, recognize and bind to a specific short sequence of DNA, and then cut the DNA at specific sites within that sequence. Biologists found that they could use restriction enzymes to manipulate DNA. This ability formed the foundation for much of the biotechnology that exists today.

DNA *fingerprinting* is one important use of biotechnology. With the exception of identical twins, no two people have the same DNA sequence. Because each person has a DNA profile that is as unique as his or her fingerprints, DNA fingerprinting can be used to compare the DNA of different individuals.

In the first step of DNA fingerprinting, known and unknown samples are obtained and then digested, or cut into small fragments, by the same restriction enzyme. These short fragments are called *restriction fragment length polymorphisms (RFLPs)*. The next step in DNA fingerprinting is to separate the RFLPs by size. This is done with a technique called *gel electrophoresis*. The DNA is placed on a jellylike slab called a gel, and the gel is exposed to an electrical current. DNA has a negative electrical charge, so the RFLPs are attracted to the positive pole when an electric current is applied. Smaller fragments travel farther through the gel than longer ones. The length of a given DNA fragment can be determined by comparing its mobility on the gel with that of a sample containing DNA fragments of known sizes. The resulting pattern is unique for each individual.

In this lab, you will model experimental procedures involved in DNA fingerprinting and use your results to identify a hypothetical murderer.

OBJECTIVES

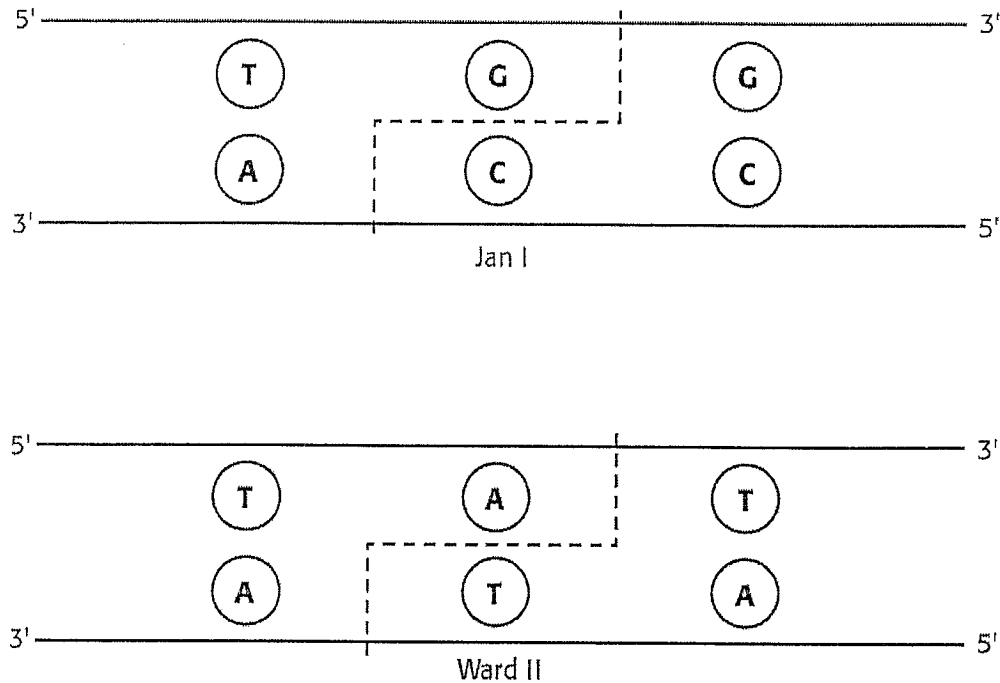
- Use pop beads to model restriction enzyme digestion and agarose gel electrophoresis.
- **Evaluate** the results of a model restriction enzyme digestion (DNA fingerprint).
- **Identify** a hypothetical murderer by analyzing the simulated DNA fingerprints of suspects and DNA samples collected at the scene of the crime.

MATERIALS

- pop beads, blue (cytosine) (15)
- pop beads, red (phosphate) (60)
- paper gel electrophoresis lane
- pop beads, white, 5-hole (deoxyribose) (60)
- paper, legal size (8.5 × 14 in.)
- pop beads, yellow (adenine) (15)
- plastic connectors (hydrogen bonds) (30)
- restriction enzyme card Jan I
- pop beads, green (guanine) (15)
- restriction enzyme card Ward II
- pop beads, orange (thymine) (15)
- ruler

- Use the model restriction enzymes Jan I and Ward II to chop up the DNA. Look at your two Restriction Enzyme Cards; they look like the cards in **Figure 2**. These “enzymes” will make cuts in the DNA in the manner indicated by the dotted lines.

FIGURE 2 RESTRICTION ENZYME CARDS



- Place Restriction Enzyme Card Jan I on top of the left side of the DNA chain so that its label is right side up.
- Move the card along the surface of the DNA until you match the precise sequence shown on the card. When you reach a sequence that matches the card, stop and break the beads apart in the manner indicated by the dotted lines.
- Move the enzyme card until you reach the right end of the DNA. Double check the sequence with the enzyme card to ensure that you have made all the possible cuts.
- Repeat the procedure on the remaining DNA fragments using the restriction enzyme card Ward II. Be sure to keep the DNA fragments in the orientation described above (5' orange thymine beads on the top left) throughout this exercise. In reality, the fragments created in steps 6 and 7 might be thousands of base pairs long.
- Create a gel electrophoresis area out of a legal size (8.5 by 14 in.) sheet of paper. On the left side of the paper, use a ruler to mark one inch increments from the bottom of the paper to the top of the paper. Starting at the bottom mark, label each mark from “0” (for the bottom mark) through “24” (for the top mark).

10. Write a plus sign (+) at the bottom of the page and a minus sign (-) at the top of the page. Label the Y-axis (left hand margin) "Length of RFLPs (number of nucleotides)."
11. Place the RFLPs at the negative pole of the gel electrophoresis page, taking care to retain the proper 5' to 3' orientation. Remember, DNA has a negative electrical charge, so the RFLPs are attracted to the positive end of the gel/page when an electric current is applied.
12. Simulate separating the RFLPs by electrophoresis by sliding your RFLPs along the gel/page. Shorter fragments are lighter and move farther than longer fragments. To determine the final position of each RFLP, count the number of nucleotides on the longest side of each fragment. Place each measured RFLP next to its corresponding length marked on the gel/page.
13. In the nine gel electrophoresis lanes in **Figure 3**, sketch dark bands at the correct positions in the gel lane reserved for your sample. Also, record the position of your bands on the seven lanes your teacher has provided for class data (on the blackboard).
14. Obtain the banding patterns for each of the other DNA samples by copying them from the blackboard after each team has recorded their data.

FIGURE 3 GEL ELECTROPHORESIS LANES

Victim's Blood	Suspect 1	Suspect 2	Suspect 3	Suspect 4	Suspect 5	Crime Scene Sample 1	Crime Scene Sample 2
22	22	22	22	22	22	22	22
20	20	20	20	20	20	20	20
18	18	18	18	18	18	18	18
16	16	16	16	16	16	16	16
14	14	14	14	14	14	14	14
12	12	12	12	12	12	12	12
10	10	10	10	10	10	10	10
8	8	8	8	8	8	8	8
6	6	6	6	6	6	6	6
4	4	4	4	4	4	4	4
2	2	2	2	2	2	2	2

Analysis

1. **Examining Data** Are the RFLPs of the other DNA samples the same length as yours? Explain why or why not.

2. **Identifying Relationships** Explain the role that restriction enzymes and gel electrophoresis play in DNA fingerprinting.

Conclusions

1. **Drawing Conclusions** Based on class data, which of the suspects is probably the murderer? Explain.

2. **Interpreting Information** How did you show that the other sample found at the crime scene did not belong to the murderer?

3. **Interpreting Information** Imagine you are on a jury and that DNA fingerprinting evidence is introduced. Explain how you would regard such evidence.

Extensions

1. **Research and Communications** Look through newspapers and news magazines to find articles about actual court cases in which DNA fingerprinting was used to determine the innocence or guilt of a suspect in a crime. Share the articles with your classmates.
2. **Research and Communications** Do library research or search the Internet to find out more information about restriction enzymes and what role they play in bacteria.