Lesson 7: DNA is Packaged into Chromosomes

Introduction

You have learned that an individual's traits are determined by the combination of alleles they get from their parents. In the last lesson, you considered a single trait. In this lesson, you will think about how individuals inherit the alleles for multiple traits.

Process and Procedure

Lesson Focus Question

1. Write the focus question for this lesson in the box below. After you have written the focus question, turn and talk with your table group about your ideas. As you discuss your ideas, consider which ideas are similar and which are different. Be prepared to share your discussion with the whole class.

2. Fur color is one trait that jaguars have, but there are many other traits we could study. Each trait is determined by the structure and function of a protein that is coded for by the DNA sequence of the gene for that trait. Although scientists have not determined the exact amount of DNA in a jaguar cell, they know that tigers have 2.9 billion nucleotides that make up the DNA in each cell. It is likely jaguars have a similar amount of DNA in each cell.

   If you stretched the DNA in a single cell out into a single thread, it would be about 2 meters (6 feet) long. How does all that DNA fit into the nucleus of a cell that can only be seen with a microscope? Write your best ideas below.

3. You will have a chance to test your ideas by using a model with parts you can see. Follow your teacher's directions to learn more about how you will complete this task. As you work, write down notes about what works well as you fit your "DNA" into the "cell."

4. Read *Packing DNA into Cells* to learn more about how DNA fits into the nucleus of cells. As you read, underline any ideas that help explain the information you learned in previous lessons. Be ready to discuss the ideas you underlined.

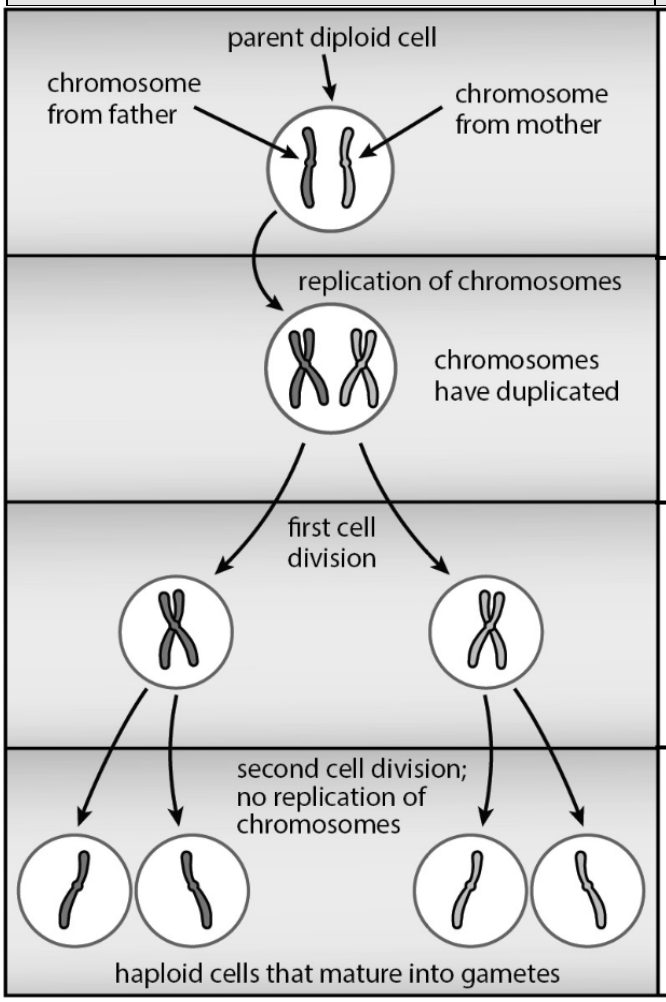
Packing DNA into Cells

In all multicellular organisms, the genetic material consists of one or more long DNA molecules. The DNA is tightly coiled intochromosomes. In each of your cells, except red blood cells and gametes (eggs and sperm), you have 23 pairs of chromosomes. One set of 23 chromosomes came from your father and one set of 23 chromosomes came from your mother. Each chromosome contains one long DNA molecule and many protein molecules. The DNA and proteins pack together tightly to form the structure of a chromosome. This is the compact structure we see when we look at dividing cells under a microscope.

Based on this reading, how might you change what you tried with the thread and the capsule?

5. Think back to the paragraph you wrote at the end of Lesson 6. How do you think chromosomes influence the traits that a jaguar, human, or other organism inherits?

6. We will learn more about one process that leads to the variation we see in individuals of the same species. To begin learning about this process, examine the table below. For each picture on the left, use the box on the right to describe what you observe happening.

Illustration	Observations
	

7. Read *The Process of Meiosis* to learn more about what happens to chromosomes as cells produce gametes, or eggs and sperm. As you read, add to your ideas in Step 6.

The Process of Meiosis

In sexual reproduction, genetic information is passed from parents to offspring by the **gametes** (egg and sperm). Gametes have only *half* the genetic information of other body cells. That means these cells have half the number of chromosomes (one copy of each chromosome) and thus half the alleles of other body cells. For example, in humans, the gametes have 23 chromosomes in each cell. Body cells have 46 chromosomes.

The process of reducing the number of chromosomes is called **meiosis**. Meiosis accomplishes three major tasks: (1) It forms cells that allow each parent to contribute equal amounts of genetic information to the offspring. (2) It reduces the number of chromosomes in the gametes to half the number of chromosomes found in body cells. (3) It is an important source of variation in offspring.

Following the chromosomes during meiosis provides a way to understand certain patterns of inheritance. In all cells other than gametes, chromosomes occur in matching pairs. For each pair, one chromosome came from the mother's egg cell and one chromosome came from the father's sperm cell. These cells are called **diploid** (*diplous = double*). The chromosomes of each pair contain genes that code for proteins for the same traits. As you learned in the previous lessons, the alleles for each gene may be different.

In contrast, gametes contain *one* chromosome from each matching pair. Gametes are **haploid** (*haploos = single*); they contain one copy of each chromosome. In sexual reproduction, a sperm fertilizes the egg, and the cells fuse to form a new cell with the same number of chromosomes found in body cells. The single cell that results from the joining of the egg and the sperm is called a *zygote*. In humans, the zygote will have 23 matching pairs of chromosomes. Each pair is composed of one chromosome from the egg and one chromosome from the sperm. In this way, fertilization restores the diploid number of chromosomes in the zygote.

Let's examine the process in more detail. Just before meiosis begins, each chromosome of each pair doubles to make two identical copies. During the first cell division, the doubled chromosomes separate into two cells.Each of the two new cells contains one doubled chromosome. That chromosome may have originally come from either the individual's mother or father.

During the second cell division, the doubled chromosomes in each cell separate, and the cell divides into two more cells. This second cell division results in a total of four haploid cells. Each cell contains one chromosome from the original pair.

The diagram in Step 6 showed one pair of chromosomes. However, a diploid human cell has 23 pairs of chromosomes (46 total). One chromosome of each pair came from the mother and the other chromosome came from the father. Through meiosis, the chromosome pairs are separated randomly. For example, in a human gamete, 20 chromosomes may have come from the mother and 3 may have come from the father. Or perhaps 8 chromosomes in the gamete came from the mother and 15 from the father. There are many different combinations of chromosomes that can be produced by meiosis. This leads to a great deal of variation between individuals in a population.

8. You will now consider how meiosis affects the alleles that an offspring inherits by modeling the process using craft sticks. To do this,
    a. Draw circles similar to those in Step 6 on your chart paper. Do not draw the chromosomes. Draw the correct number of circles for each row.
    b. Place two craft sticks, one labeled “F” and one labeled “f” in the top circle with the letters facing up.
    c. Model the process of meiosis, adding craft sticks and moving them down the rows as needed.
    d. When you have finished the process, record the alleles for each of the gametes in order, left to right, in the tablebelow:

Gametes Produced Through Meiosis			

9. Carry out the process of meiosis again. This time, you will use two different chromosomes to start.
    a. Use the same chart paper from Step 8.
    b. Place four craft sticks, one labeled “F”, one labeled “f”, one labeled “E”, and one labeled “e” in the top circle with the letters facing up.
    c. Model the process of meiosis, moving the craft sticks down the rows as needed. Remember that each cell will have one of each different chromosome.
    d. When you have finished the process, record the alleles for each of the gametes, in order, in the table below:

Gametes Produced Through Meiosis			

Synthesize and Summarize Key Science Ideas

10. Look back at your initial answer to the focus question. Revise or add to your ideas using a different color.

11. In Lesson 1, you saw three possible explanations to answer the unit central question, "What is the best explanation for the similarities and differences we see in individuals within a species—not only for one species, but for every species of plant and animal?"
    Look back over what you have learned in Lessons 6 and 7. In the table below, write evidence that will help you answer the unit central question.

    Place a check mark in the column for any explanation the evidence supports.

Lesson	Evidence	Parents	Genes	Mutation
6				
7				