SKILL: USING EXPONENTS

Divide and Multiply

Each time a parent cell divides, the result is two new cells. The new cells are a new generation that in turn divides again. The increase in the number of cells can be shown using exponents. Each cell of each new generation produces two cells. This type of increase in the number of objects is often called exponential growth.

Example

What is the numerical sequence when cells divide to form new cells? You can model this type of progression by using a plain piece of paper.

(1) To represent the first division, fold the piece of paper in half.

(2) Fold it in half again, and it will show the second division. Fold it again and again to represent succeeding divisions.

(3) Write the sequence that shows the number of boxes on the paper after each fold.

2, 4, 8, 16, . . .

(4) Notice that after one division (fold), there are 2 cells (boxes), or 2^1. Two divisions yield 2 • 2 cells, or 2^2. And after three divisions, there are 2 • 2 • 2 cells, or 2^3.

ANSWER The sequence can be written with exponents:
$2^1, 2^2, 2^3, 2^4, . . .$

Answer the following questions.

1. Suppose the cells divide for one more generation after the 4 described above. How can this be written as an exponent of 2? How many cells will there be?

2. How many cells would exist in the tenth generation? Write the number using an exponent.

3. Suppose you took the paper in the example and folded it in thirds each time, rather than in half. Make a table showing the number of boxes after each folding. Use numbers with exponents to write the sequence.

4. Write the following number sequence as a sequence of numbers with exponents: 5, 25, 125, 625, . . .

5. Write the following number sequence as a sequence of numbers with NO exponents: $10^1, 10^2, 10^3, 10^4, . . .$

CHALLENGE Before you begin folding, you have a single sheet of paper, or 1 box. The parent cell is also a single unit. Use this information to explain why $2^0 = 3^0$.

the **BIG** idea

Organisms grow, reproduce, and maintain themselves through cell division.

KEY CONCEPTS SUMMARY
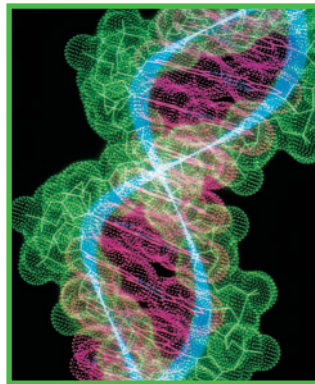
1 Cell division occurs in all organisms.

- In unicellular organisms functions of cell division include reproduction
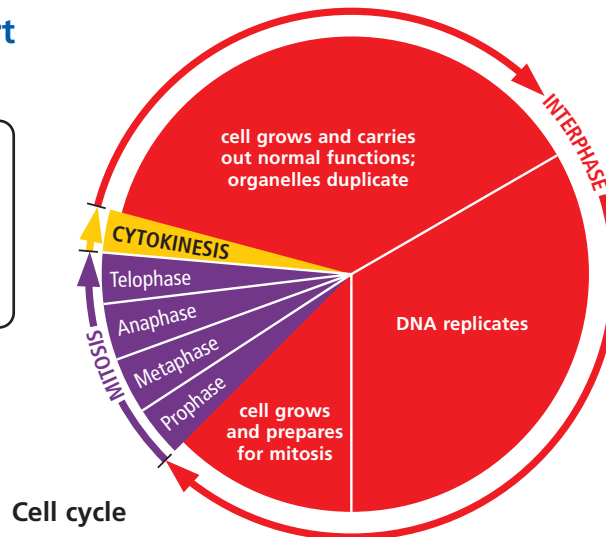- In multicellular organisms functions of cell division include growth, development, and repair.

VOCABULARY
DNA p. 74
chromosome p. 75

2 Cell division is part of a cell cycle.

The **cell cycle** has two main phases, **interphase** and **mitosis.** Most of the life cycle of a cell is spent in interphase. During mitosis, cells divide.

INTERPHASE

cell grows and carries out normal functions; organelles duplicate

CYTOKINESIS
Telophase
Anaphase
Metaphase
Prophase
MITOSIS

DNA replicates

cell grows and prepares for mitosis

Cell cycle

VOCABULARY
cell cycle p. 80
interphase p. 81
mitosis p. 81
cytokinesis p. 81

3 Both sexual and asexual reproduction involve cell division.

Some organisms reproduce asexually. Both asexual and sexual reproduction involve cell division.

Comparing Asexual and Sexual Reproduction	
Asexual Reproduction	**Sexual Reproduction**
Cell Division	Cell division and other processes
One parent organism	Two parent organisms
Rate of reproduction is rapid	Rate of reproduction is slower than rate for asexual reproduction
Offspring identical to parents	Offspring have genetic information from two parents

VOCABULARY
asexual reproduction p. 88
binary fission p. 89
regeneration p. 90

Reviewing Vocabulary

On a separate sheet of paper, write a sentence describing the relationship between the two vocabulary words in each pair.

1. cell cycle, interphase

2. mitosis, cytokinesis

3. chromosome, DNA

4. parent, offspring

Reviewing Key Concepts

Multiple Choice *Choose the letter of the best answer.*

5. Most of the growth in your body occurs because your cells
 a. grow larger   **c.** make proteins
 b. take in oxygen   **d.** divide

6. The stage in a cell's life when it is not in the process of dividing is called
 a. interphase   **c.** mitosis
 b. the cell cycle   **d.** cell division

7. What material in the cell makes up chromosomes?
 a. carbohydrates   **c.** the nucleus
 b. chromatids   **d.** nucleic acids

8. What ratio increases when a cell divides into two smaller cells?
 a. volume to length
 b. length to width
 c. surface area to volume
 d. width to surface area

9. The process of cytokinesis results in
 a. two daughter cells that are different from one another
 b. two genetically identical daughter cells
 c. identical pairs of chromosomes
 d. identical pairs of chromatids

10. What is the step that follows mitosis, in which the cytoplasm divides?
 a. prophase   **c.** anaphase
 b. synthesis   **d.** cytokinesis

11. A cell's chromosomes must be duplicated before mitosis occurs so that
 a. they can form chromatids
 b. they can attach to the spindle
 c. each daughter cell gets a full number of chromosomes
 d. each daughter cell does not have to duplicate its own chromosomes

12. Binary fission differs from mitosis because the new cells
 a. cannot function without the parent
 b. grow from missing limbs
 c. have half the normal number of chromosomes
 d. live independently of the parent cell

13. If a starfish is cut in half, it can regrow its missing body through
 a. binary fission   **c.** healing
 b. budding   **d.** regeneration

14. Which is an example of reproduction?
 a. binary fission in unicellular organisms
 b. cell division in a multicellular organism
 c. cell division around a broken bone
 d. division of cytoplasm

15. Which sequence is correct for mitosis?
 a. chromosomes form, chromosomes separate, chromosomes line up, nuclei form
 b. chromosomes form, chromosomes line up, chromosomes separate, nuclei form
 c. chromosomes line up, nuclei form, chromosomes separate, chromosomes form
 d. chromosomes separate, chromosomes form, nuclei form, chromosomes line up

Short Answer *Write a short answer to each question.*

16. What is the difference between cytokinesis in plant and animal cells?

17. Describe what happens in a cell during interphase. Your answer should mention DNA.

18. Describe the functions of cell division in both unicellular and multicellular organisms.

Thinking Critically

19. IDENTIFY CAUSE Describe some of the reasons that cells divide.

This illustration shows a plant and the cutting that was taken from it, which is growing in a container of water. Use the illustration to answer the next six questions.
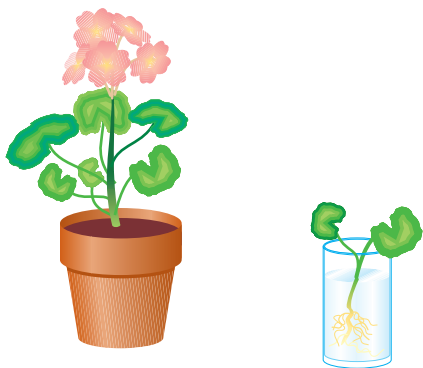
20. OBSERVE From which part of the plant was the cutting taken?

21. INFER Where did the cutting get the genetic information that controls its development?

22. INFER What is the genetic relationship between the original plant and the cutting?

23. SYNTHESIZE What process causes both the cutting and the original plant to grow?

24. SUMMARIZE Write a brief summary of the process that causes growth in both plants.

25. PREDICT These plants can also reproduce from fertilized seeds. How is the cutting the same as the plant that would grow from a seed? How is the cutting different?

26. CALCULATE A single bacterium enters your body at 10:00 A.M. These bacteria reproduce at a rate of one generation every 30 minutes. How many bacteria of this type will be in your body by 8:00 P.M. that evening?

The diagrams below show 4 parts of a process. Use them to answer the following three questions.

a.

c.

b.

d.
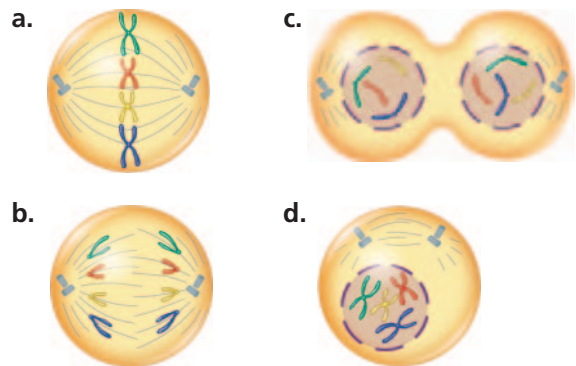
27. SEQUENCE What is the correct order of the four diagrams above?

28. SYNTHESIZE Draw two diagrams, one showing what you would see before the process shown above begins, and one showing what you would see after the conclusion of the process.

29. MODEL On a separate sheet of paper, draw your own simple model of the process of mitosis.

the BIG idea

30. SUMMARIZE Look again at the question on the photograph on pages 70–71. Now that you have studied this chapter, how would you change your answer to the question?

31. SYNTHESIZE How do the concepts in this chapter relate to the concepts in the cell theory?
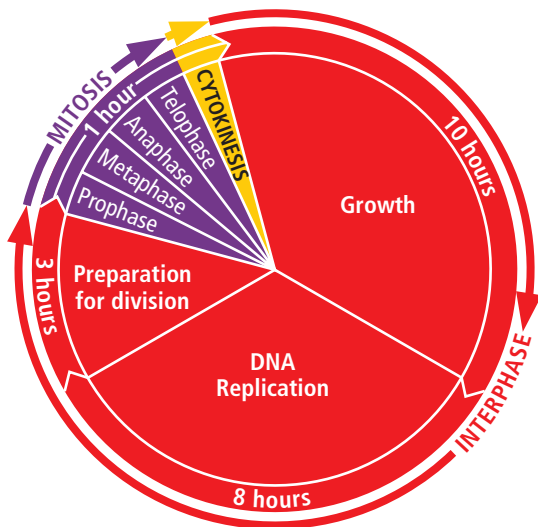
UNIT PROJECTS

If you need to do an experiment for your unit project, gather the materials. Be sure to allow enough time to observe results before the project is due.

Analyzing Data

This diagram shows the length of the cell cycle for a typical skin cell in the human body.

Use the diagram to answer the questions below.

1. How long does the growth phase of the cell cycle take?
a. 1 hour
c. 8 hours
b. 3 hours
d. 10 hours

2. How much time does the cell cycle spend in interphase?
a. 1 hour
c. 21 hours
b. 10 hours
d. 22 hours

3. What is the total length of time it takes for the skin cell to complete one full cell cycle?
a. 10 hours
c. 21 hours
b. 18 hours
d. 22 hours

4. What phase of the cell cycle takes about 8 hours?
a. DNA replication
b. mitosis
c. growth
d. preparation for cell division

5. Suppose another type of skin cell takes 44 hours to complete one cell cycle. If all of the phases are proportional to the length of time shown in the diagram, how long will the preparation for cell division phase last?
a. 3 hours
c. 10 hours
b. 6 hours
d. 20 hours

6. According to the diagram, what is the second stage in mitosis?
a. prophase
c. telophase
b. metaphase
d. cytokinesis

Extended Response

Answer the two questions. Include some of the terms shown in the word box. Underline each term you use in your answers.

cell cycle	metaphase	mitosis
anaphase	prophase	telophase

7. A scientist is studying the stages of cell division in the cells of an onion root. The scientist counts 100 cells and identifies which stage of cell division each cell is in at a given moment. He counts a total of 85 cells in interphase, 8 cells in prophase, 3 cells in metaphase, and 2 cells each in anaphase and telophase. A typical onion cell takes about 12 hours to complete the cell cycle. Using the information in the diagram and the data given here, how can you account for these numbers?

8. Your science class is investigating the effect of temperature on the rate of mitosis in onion plants. You hypothesize that the higher the temperature, the faster cells undergo mitosis. How could you set up an experiment to support your hypothesis? Describe the materials you would use and the steps you would take in your procedure.