Got It? **4.** A population of insects triples every week. The number of insects is modeled by the expression $5400 \cdot 3^w$, where w is the number of weeks after the population was measured. Evaluate the expression for $w = -2$, $w = 0$, and $w = 1$. What does each value of the expression represent in the situation?

Lesson Check

Do you know HOW?

Simplify each expression.

1. 2^{-5}

2. m^0
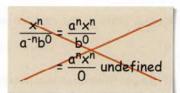
3. $5s^2t^{-1}$

4. $\frac{4}{x^{-3}}$

Evaluate each expression for $a = 2$ and $b = -4$.

5. a^3b^{-1}

6. $2a^{-4}b^0$

Do you UNDERSTAND? © MATHEMATICAL PRACTICES

© **7. Vocabulary** A positive exponent shows repeated multiplication. What repeated operation does a negative exponent show?

© **8. Error Analysis** A student incorrectly simplified $\frac{x^n}{a^{-n}b^0}$ as shown below. Find and correct the student's error.

$$\frac{x^n}{a^{-n}b^0} = \frac{a^n x^n}{b^0}$$

$$= \frac{a^n x^n}{0} \text{ undefined}$$

Practice and Problem-Solving Exercises © MATHEMATICAL PRACTICES

A Practice Simplify each expression. ◆ **See Problem 1.**

9. 3^{-2}

10. $(-4.25)^0$

11. $(-5)^{-2}$

12. -5^{-2}

13. $(-4)^{-2}$

14. 2^{-6}

15. -3^0

16. -12^{-1}

17. $\frac{1}{2^0}$

18. 58^{-1}

19. 1.5^{-2}

20. $(-5)^{-3}$

Simplify each expression. ◆ **See Problem 2.**

21. $4ab^0$

22. $\frac{1}{x^{-7}}$

23. $5x^{-4}$

24. $\frac{1}{c^{-1}}$

25. $\frac{3^{-2}}{n}$

26. $k^{-4}j^0$

27. $\frac{3x^{-2}}{y}$

28. $\frac{7ab^{-2}}{3w}$

29. $c^{-5}d^{-7}$

30. $c^{-5}d^7$

31. $\frac{8}{2s^{-3}}$

32. $\frac{7s}{5t^{-3}}$

33. $\frac{6a^{-1}c^{-3}}{d^0}$

34. $2^{-3}x^2z^{-7}$

35. $12^0t^7u^{-11}$

36. $\frac{7s^0t^{-5}}{2^{-1}m^2}$

Evaluate each expression for $r = -3$ and $s = 5$.

37. r^{-3} **38.** s^{-3} **39.** $\dfrac{3r}{s^{-2}}$ **40.** $\dfrac{s^0}{r^{-2}}$

41. $4s^{-1}$ **42.** $r^0 s^{-2}$ **43.** $r^{-4}s^2$ **44.** $2^{-4}r^3 s^{-2}$

45. Internet Traffic The number of visitors to a certain Web site triples every month. The number of visitors is modeled by the expression $8100 \cdot 3^m$, where m is the number of months after the number of visitors was measured. Evaluate the expression $m = -4$. What does the value of the expression represent in the situation?

STEM **46. Population Growth** A Galápagos cactus finch population increases by half every decade. The number of finches is modeled by the expression $45 \cdot 1.5^d$, where d is the number of decades after the population was measured. Evaluate the expression for $d = -2$, $d = 0$, and $d = 1$. What does each value of the expression represent in the situation?

B Apply

© Mental Math Is the value of each expression *positive* or *negative*?

47. -2^2 **48.** $(-2)^2$ **49.** $(-2)^3$ **50.** $(-2)^{-3}$

Write each number as a power of 10 using negative exponents.

51. $\dfrac{1}{10}$ **52.** $\dfrac{1}{100}$ **53.** $\dfrac{1}{1000}$ **54.** $\dfrac{1}{10,000}$

Galápagos cactus finch

© 55. a. Patterns Complete the pattern using powers of 5.

$$\dfrac{1}{5^2} = \blacksquare \qquad \dfrac{1}{5^1} = \blacksquare \qquad \dfrac{1}{5^0} = \blacksquare \qquad \dfrac{1}{5^{-1}} = \blacksquare \qquad \dfrac{1}{5^{-2}} = \blacksquare$$

b. Write $\dfrac{1}{5^{-4}}$ using a positive exponent.

c. Rewrite $\dfrac{1}{a^{-n}}$ as a power of a.

Rewrite each fraction with all the variables in the numerator.

56. $\dfrac{a}{b^{-2}}$ **57.** $\dfrac{4g}{h^3}$ **58.** $\dfrac{5m^6}{3n}$ **59.** $\dfrac{8c^5}{11d^4 e^{-2}}$

© 60. Think About a Plan Suppose your drama club's budget doubles every year. This year the budget is $500. How much was the club's budget 2 yr ago?
- What expression models what the budget of the club will be in 1 yr? In 2 yr? In y years?
- What value of y can you substitute into your expression to find the budget of the club 2 yr ago?

61. Copy and complete the table at the right.

© 62. a. Simplify $a^n \cdot a^{-n}$.
  b. Reasoning What is the mathematical relationship between a^n and a^{-n}? Explain.

n	3	■	■	$\frac{5}{8}$	■
n^{-1}	■	6	$\frac{1}{7}$	■	0.5