

## Extension

**A**

Have students list powers for each base from 2 to 9 and look for patterns in the final digits. Invite them to use these patterns to answer the following questions and then create and answer similar questions of their own.

- (a) What is the last digit in the standard form of  $2^{109}$ ?
- (b) What are the last three digits in the standard form of  $5^{32}$ ?

## Enrichment

**A**

Through research, students could find out about some of the jobs done by genetic engineers. They might search for resources on the Internet, look through related periodicals, or contact a university department of biomedical engineering or agriculture for more information. Help might also be available from a pharmaceutical company. Have students present their information in a class report.

**B**

Students might be interested in finding out about uses of bacteria in the field of biotechnology. Since the discovery that bacteria can be used as host cells to introduce DNA from one organism into another, many important discoveries have been made, including: new ways to produce substances such as insulin and interferon; altered types of bacteria that can decompose garbage more efficiently, including some that can break down oil slicks; a more

effective method of processing cheese; a method of converting corn stalks and sawdust into sugar; methods of altering food crops to dramatically increase production; a spray made with genetically altered bacteria that protects plants from light frost.

A science instructor may be able to help you direct students to useful sources of information. Students could also con-

tact a university department of biomedical engineering or agriculture.

**C**

The **Examples** menu picture introduces the googol. Ask students to investigate other names for large numbers, such as the googolplex or 10 raised to the power of one googol ( $10^{\text{googol}}$ ).

**Summing Up**

To summarize the three exponent laws you have just learned, drag the items to fill in the appropriate cells of the chart.

Name of Law	Statement of Law	When Used	Action
Product Law	$x^m x^n = x^{m+n}$	Powers whose bases are equal are multiplied.	Add the exponents.
Power of a Product Law	$(xy)^m = x^m y^m$	The base of a power is a product.	Each factor of the base forms the base of a power.
Power of a Power Law	$(x^m)^n = x^{mn}$	The base of a power is itself a power.	The exponents are multiplied.


Copy the summary chart into your notebook.

Exponents  
Laws of Exponents: Product Laws  
Tutorial

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1 2 3 4 5 6 7 8 9 10

**Big Numbers**



The number  $10^{100}$  (the digit 1 followed by 100 zeros) is a **googol**. The googol was first introduced by the mathematician Edward Kasner after it was used by his nine-year-old nephew.

Astronomers are used to working with very large numbers. The picture shown here was taken by the Hubble space telescope while in orbit around the earth. Our galaxy, the Milky Way, has about  $10^{11}$  stars. This photo shows hundreds of other galaxies outside our own, each with billions of stars.

The distance that the telescopes can see is considered to be about one tenth of the diameter of the universe. There are estimated to be about  $10^{11}$  galaxies. This means there are about  $10^{11} \times 10^{11} = 10^{22}$  stars in the universe.

Exit

PICTURE INFORMATION

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