



"The embryo grows from a zygote about 0.1mm in diameter to a complicated embryonic body approximately 3mm in length at 4 weeks."

O'Rahilly & Muller, *Human Embryology and Teratology*, 2nd Edition, p33.



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Understanding Large Numbers

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Whether describing the vastness of the stars or the microscopic intricacies of the human body, the need to use large numbers is often inevitable. When we consider the estimated 200,000,000,000 (200 billion) stars in the Milky Way Galaxy or the estimated 150,000,000,000 (150 billion) galaxies in the universe or the estimated 100,000,000,000,000 (100 trillion) cells in the adult human body, we are forced to use numbers so large we cannot comprehend their meaning. Let's try to use our imaginations to place some of these large numbers in perspective. (In so doing, we will use the American nomenclature for large numbers described below.)

We will use money as a teaching tool to illustrate the magnitude of large numbers. Whether you stack it, spread it, line it up, or spend it, we hope you'll think of money and large numbers in a new way after you read this section.

Money Stacks

One way to better understand large numbers is to compare the heights of stacks of varying numbers of dollar bills. The thickness of a single one dollar bills measures .0043 inches or .0000000679 miles.

The height of a stack of 100 one dollar bills measures .43 inches.

The height of a stack of 1,000 one dollar bills measures 4.3 inches.

The height of a stack of 1,000,000 one dollar bills measures 4,300 inches or 358 feet – about the height of a 30 to 35 story building.

The height of a stack of 100,000,000 (one hundred million) one dollar bills measures 35,851 feet or 6.79 miles. This would reach from the earth's surface to the approximate altitude at which commercial jetliners fly.

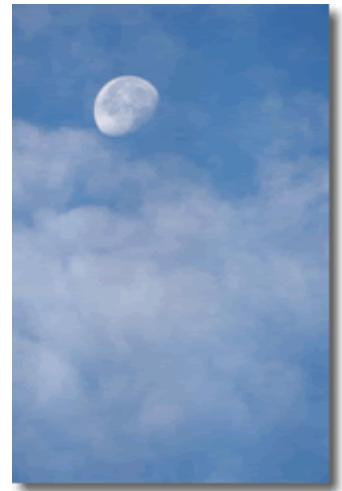
The height of a stack of 1,000,000,000 (one billion) one dollar bills measures 358,510 feet or 67.9 miles. This would reach

from the earth's surface into the lower portion of the troposphere – one of the major outer layers of earth's atmosphere.

The height of a stack of 100,000,000,000 (one hundred billion) one dollar bills measures 6,786.6 miles. A column of bills this high would extend 28 times higher than the orbiting International Space Station.

The height of a stack of 1,000,000,000,000 (one trillion) one dollar bills measures 67,866 miles. This would reach more than one fourth the way from the earth to the moon.

The height of a stack of 100,000,000,000,000 (one hundred trillion) one dollar bills measures 6,786,616 miles. This would reach from the earth to the moon and back 14 times.



Money Carpets

Another way to appreciate large numbers is to consider the area covered by varying numbers of dollar bills. The area covered by a single one dollar bill measures 16.0254 square inches.



The area covered by 100 one dollar bills measures 11.13 square feet.

The area covered by 1,000 one dollar bills measures 111.29 square feet.

The area covered by 1,000,000 one dollar bills measures 111,287.5 square feet. This would cover an area approximately equal to the size of two football fields.

The area covered by 100,000,000 (one hundred million) one dollar bills measures .4 square miles. This would cover an area equal to the size of 102 acres.

The area covered by 1,000,000,000 (one billion) one dollar bills measures 4 square miles. This would cover an area equal to the size of 1,020 acres.

The area covered by 100,000,000,000 (one hundred billion) one dollar bills measures 400 square miles. This would cover an area equal to the one-third the size of the state of Rhode Island.

The area covered by 1,000,000,000,000 (one trillion) one dollar bills measures 3,992 square miles. This would cover an area equal to twice the size of the state of Delaware.

The area covered by 100,000,000,000,000 (one hundred trillion) one dollar bills measures 399,189 square miles. This would cover an area roughly equal to the size of Texas and California combined.

Money Lines

Yet another way to understand large numbers is to compare the lengths of varying numbers of dollar bills laid end-to-end. The length of a single one dollar bills measures 6.14 inches.

The length of 100 one dollar bills laid end-to-end measures 614 inches or 51.17 feet.

The length of 1,000 one dollar bills laid end-to-end measures 512 feet. This would approximate the length of some of the longer homerun balls hit by professional baseball players. (The world record for the longest homerun, estimated at 643 feet, was set in 1961 by Mickey Mantle.)

The length of 1,000,000 (one million) one dollar bills laid end-to-end extends 96.9 miles. This would easily traverse the 21 miles across the English Channel from the shores of England to the shores of France and back more than two and a half times.

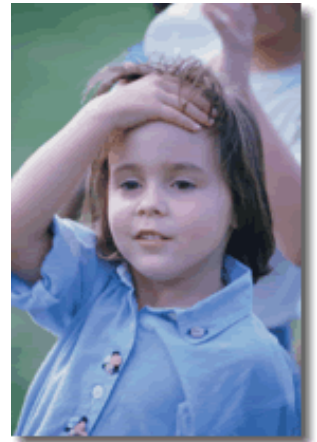
The length of 100,000,000 (one hundred million) one dollar bills laid end-to-end measures 9,690 miles. This would reach from Washington D.C., USA to Sydney, Australia.

The length of 1,000,000,000 (one billion) one dollar bills laid end-to-end measures 96,900 miles. This would extend around the earth almost 4 times.

The length of 100,000,000,000 (one hundred billion) one dollar bills laid end-to-end measures 9,690,656 miles. This would extend around the earth 387 times.

The length of 1,000,000,000,000 (one trillion) one dollar bills laid end-to-end measures 96,906,656 miles. This would exceed the distance from the earth to the sun.

The length of 100,000,000,000,000 (one hundred trillion) one dollar bills laid end-to-end measures 9,690,656,566 miles. This would reach from the earth to the planet Saturn and back six times. (Assuming Saturn at its nearest point to earth)



Money Spent - Shop 'til You Drop



Finally, let's try to help those who love malls to understand large numbers by imagining the shopping spree of a lifetime starting with varying amounts of money. Let's say a shopper must spend \$20 per second and must do so 24 hours per day until penniless. (As you view the table below, this exercise will quickly give the expression "shop 'til you drop" a whole new meaning.)

For example, a shopper beginning with \$100 could shop for a mere five seconds. A shopper beginning with \$1,000 could shop for 50 seconds.

Duration of Shopping Sprees While Spending \$20 per Second

Starting Amount (Dollars)	Duration of Shopping Spree
1	1 second
100	5 seconds
1,000	50 seconds
10,000	8 minutes 20 seconds
100,000	1 hour 23 minutes
1,000,000	13 hours 48 minutes
10,000,000	138 hours (5 days 19 hours)
100,000,000	57 days 21 hours
1,000,000,000	578 days (1 year 214 days)
1,000,000,000,000	1,585 years
100,000,000,000,000	1,585 centuries

Definitions of Mathematical Terms Vary Around the Globe

Scientists, mathematicians, and others have long used words to describe large numbers in lieu of writing out endless digits or resorting to the use of scientific notation. Unfortunately, these terms are defined differently in various parts of the world. For instance, the term "billion" in America is defined as 1,000,000,000 or 10^9 . The British use the same term to describe 1,000,000,000,000 or 10^{12} (million squared). Fortunately, there is agreement regarding terms used to describe numbers up to and including 100,000,000 (10^8) across both sides of the Atlantic. However, numbers from 1,000,000,000 (10^9) and higher

carry different labels which can foster confusion. Either writing out the number in full or using scientific notation is unambiguous and recommended for international use.

Below is a summary of terms and definitions for reference.

Comparing Definitions of Mathematical Terms Across the Atlantic Ocean

Number	Scientific Notation	American	British
1	10^0	One	One
10	10^1	Ten	Ten
100	10^2	One hundred	One hundred
1,000	10^3	One thousand	One thousand
10,000	10^4	One hundred thousand	One hundred thousand
100,000	10^5	Ten thousand	Ten thousand
1,000,000	10^6	One million	One million
10,000,000	10^7	Ten million	Ten million
100,000,000	10^8	One hundred million	One hundred million
1,000,000,000	10^9	One billion	One thousand million
10,000,000,000	10^{10}	Ten billion	Ten thousand million
100,000,000,000	10^{11}	One hundred billion	One hundred thousand million
1,000,000,000,000	10^{12}	One trillion	One billion (million squared)
10,000,000,000,000	10^{13}	Ten trillion	Ten billion
100,000,000,000,000	10^{14}	One hundred trillion	One hundred billion
1,000,000,000,000,000	10^{15}	One quadrillion	One thousand billion
10,000,000,000,000,000	10^{16}	Ten quadrillion	Ten thousand billion
100,000,000,000,000,000	10^{17}	One hundred quadrillion	One hundred thousand billion
1,000,000,000,000,000,000	10^{18}	One quintillion	One trillion (million cubed)

Supporting Facts and Sources

1. U.S. paper currency such as a \$1 bill measures 2.61 inches wide by 6.14 inches long with a thickness of .0043 inches.

Source: U.S. Bureau of Engraving and Imprinting

<http://www.moneyfactory.com/document.cfm/18/106>

2. The International Space Station orbits at an altitude of 242 miles.

Source: NASA

<http://www.hq.nasa.gov/osf/station/viewing/issvis.html>

3. The area of various states (in square miles):

California - 155,973 Texas - 261,914

Rhode Island - 1,045 Delaware - 1,955

Source: Graphic Maps

<http://www.worldatlas.com/aatlas/infopage/usabysiz.htm>

4. The distance from the earth to the moon is approximately 238,000 miles or 384,467 kilometers.

Source: NASA Goddard Space Flight Center

<http://www.the-solar-system.net/earth/moon-fact-sheet.html>

5. Mickey Mantle set the record for longest home run of 643 feet in 1961.

Source: www.themick.com

<http://www.themick.com/ANNIV.HTM>

6. The distance from Sydney Australia to Washington D.C. is approximately 9,760 miles.

Source: Indo.com

<http://www.indo.com/cgi-bin/dist/place2=washington+dc/place1=@174129>

7. The diameter of the earth is 7,926 miles (12,756 kilometers) from which the circumference of approximately 25,000 miles may be derived.

Source: NASA Goddard Space Flight Center

<http://www.the-solar-system.net/earth/earth-fact-sheet.html>

8. The distance from the earth to the sun is approximately 93,000,000 miles (93 million miles).

Source: NASA Goddard Space Flight Center

<http://image.gsfc.nasa.gov/poetry/ask/a11805.html>

9. The minimum distance from Earth to the planet Saturn is 1,195.5 million kilometers or 742,405,500 miles.

Source: National Space Science Data Center - NASA

<http://nssdc.gsfc.nasa.gov/planetary/factsheet/saturnfact.html>

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