Sense of Scale: Million, Billion, Trillion

Large numbers are everywhere – we hear about *trillions* of dollars of national debt, *millions* of acres of rainforest protected or destroyed. In this class, we will be dealing with numbers even further from your experience. There are roughly a *hundred billion* stars in our Galaxy, but over 100 *billion* galaxies in the visible Universe, so a total of *10 billion trillion* stars (~10^{22}). The Sun has a mass of *two million trillion trillion* kilograms (yes, trillion is supposed to be there twice – that's 2 x 10^{30} kg). What do these number words actually mean? Today, your goal is to find a way to picture a million, billion, and trillion of *something.* You could use anything, but I suggest small candies like M&Ms or breakfast cereal **Work with your group to answer these questions.**

!!!DO NOT use Google!!! THINK instead.

When you finish each part "E", have one group member type your group number and your answer into the Chat; i.e., "#12: 1 million M&Ms is a line from Columbia to NYU "

1. Record the dimensions of your object. *For spherical objects (e.g. KiX cereal), you can pretend they are cubes. For round objects (M&Ms or Cheerios), you can pretend they are rectangular prisms.*

   I am using _____.

   Length:

   Area (length x width):

   Volume (length x width x height):

2. A. Place 100 M&Ms side-by-side in a line. How long is your line? [If you don't have 100, or you did but you ate too many already, figure out a way to estimate the line length.]

   B. Imagine placing **a thousand** M&Ms side-by-side in a line. How long would your line of M&Ms be? Choose a distance unit (cm, m, km, inches, feet, miles) that feels natural to you.

   A *thousand* is a line of _____ _____ _____ long.
   [object] [number] [units]

   C. Take your length from (B) and find a more concrete way to visualize it: instead of measuring in meters or feet, reframe your measurement in terms of the size of your bed, your room, a city block (there are 20 blocks to a mile or 12 blocks to a km), length of Columbia's main campus (6 blocks), the length of Central Park (50 blocks) or whatever length you find intuitive and meaningful.

A *thousand* is a line of _____ _____ _____ long.

[object] [number] [length measure]

D. Now imagine placing **a million (one thousand thousand)** M&Ms in a line. How long would your line of M&Ms be? Choose a distance unit (cm, m, km, inches, feet, miles) that feels natural to you.

A *million* is a line of _____ _____ _____ long.

[object] [number] [units]

E. Take your length from (D) and find a more concrete way to visualize it: instead of measuring in meters or feet, reframe your measurement in terms of city blocks, length of Central Park, length of Columbia's campus, or whatever length you find intuitive and meaningful.

A *million* is a line of _____ _____ _____ long.

[object [number] [length measure]

3. A. Cover an **area** with 100 M&Ms. How much area is covered by M&Ms? Report your answer in cm^2 or $inches^2$.

B. Imagine blanketing the ground in **a thousand** M&Ms. What would the area covered by M&Ms be? Choose an area unit (cm^2, m^2, km^2, $inches^2$, $feet^2$, $miles^2$) that feels natural to you.

A *thousand* is a blanket of _____ _____ _____ in area.

[object] [number] [units]

C. Take your area from (B) and find a more concrete way to visualize it: instead of measuring in $meters^2$ or $feet^2$, reframe your measurement in terms of, for example, the size room you could cover.

A *thousand* is an area of _____ _____ of _____ .

[number] [area measure] [object]

D. Now, imagine blanketing the ground in **a million** M&Ms. What would be the area covered by M&Ms? Choose an area unit (cm^2, m^2, km^2, $inches^2$, $feet^2$, $miles^2$) that feels natural to you.

A *million* is a blanket of _____ _____ _____ in area.

[object] [number] [units]

E. Take your area from (D) and find a more concrete way to visualize it: instead of measuring in meters^2 or feet^2, reframe your measurement in terms of, for example, rooms you could cover.

A *million* is an area of _____ _____ of _____.
[number] [area measure] [object]

4. A. Find a small glass and fill it with your M&Ms (use all your M&Ms or fill your glass). Use your ruler and the formula for volume of a cylinder ($V=\pi r^2 h$) to calculate the volume filled by your M&Ms.

_____ _____s fill a volume of _____.
[number] [object] [volume measurement]

B. Imagine filling a box with a thousand M&Ms. What would the volume of the box be? If the box were a cube, what would the length of the sides be?

A *thousand* is a box of _____s _____ _____ in volume.
[object] [number] [units]

A *thousand* is a box of _____s _____ x _____x _____ in volume.
[object] [number] [number] [number]

C. Take your volume from (B) and find a more concrete way to visualize it: instead of measuring in meters^3 or feet^3, reframe your measurement in terms of, for example, wastebaskets or rooms you could fill with.

A *thousand* is _____ _____ filled with _____s.
[number] [volume measure] [object]

D. Now, imagine filling a box with a million M&Ms. What would the volume of the box be? If the box were a cube, what would the length of the sides be?

A *million* is a box of _____s _____ _____ in volume.
[object] [number] [units]

A *million* is a box of _____s _____ x _____x _____ in volume.
[object] [number] [number] [number]

E. Take your volume from (D) and find a more concrete way to visualize it: instead of measuring in meters^3 or feet^3, reframe your measurement in terms of,

for example, dumpsters or rooms or Olympic-sized swimming pools you could fill with.

A *million* is _____ _____ filled with _____s.
[number] [volume measure] [object]

FOR MONDAY 1/18/21 NAMES:

5. Repeat 2-4 E (length, area, and volume), for a *billion* (10^9), and *trillion* (10^{12}) M&Ms.

A *billion* is a line of _____ _____ _____ long.
[object] [number] [length measure]

A *trillion* is a line of _____ _____ _____ long.
[object] [number] [length measure]

A *billion* is an area of _____ _____ of _____.
[number] [area measure] [object]

A *trillion* is an area of _____ _____ of _____.
[number] [area measure] [object]

A *billion* is _____ _____ filled with _____s.
[number] [volume measure] [object]

A *trillion* is _____ _____ filled with _____s.
[number] [volume measure] [object]

6. What is a useful way to visualize a thousand? A million? A billion? A trillion? What makes a visualization useful?

A. There are about 100 billion stars in our Milky Way Galaxy. How can I visualize this
number?

B. The global average atmospheric carbon dioxide in 2020 was 415 parts per million (410 CO_2 molecules out of every million atmosphere molecules). How can I visualize this?

SCAN this page and email to me as a .pdf attachment; be sure to list all group member names.