Scientific Notation

Scientific notation (also referred to as *"standard form"* or *"standard index form"*) is a **way of writing numbers** that are either too big or too small to be conveniently written in decimal form.

decimal point

$$6.02 \times 10^{23}$$

(Avogadro Number, one of fundamental constants of nature)

a real number with an absolute value between 1 and 10

an order of magnitude value written as a power of 10

$= 602{,}000{,}000{,}000{,}000{,}000{,}000{,}000$

23 decimal places

Lake Superior volume: about 1.21×10^{16} **liters**

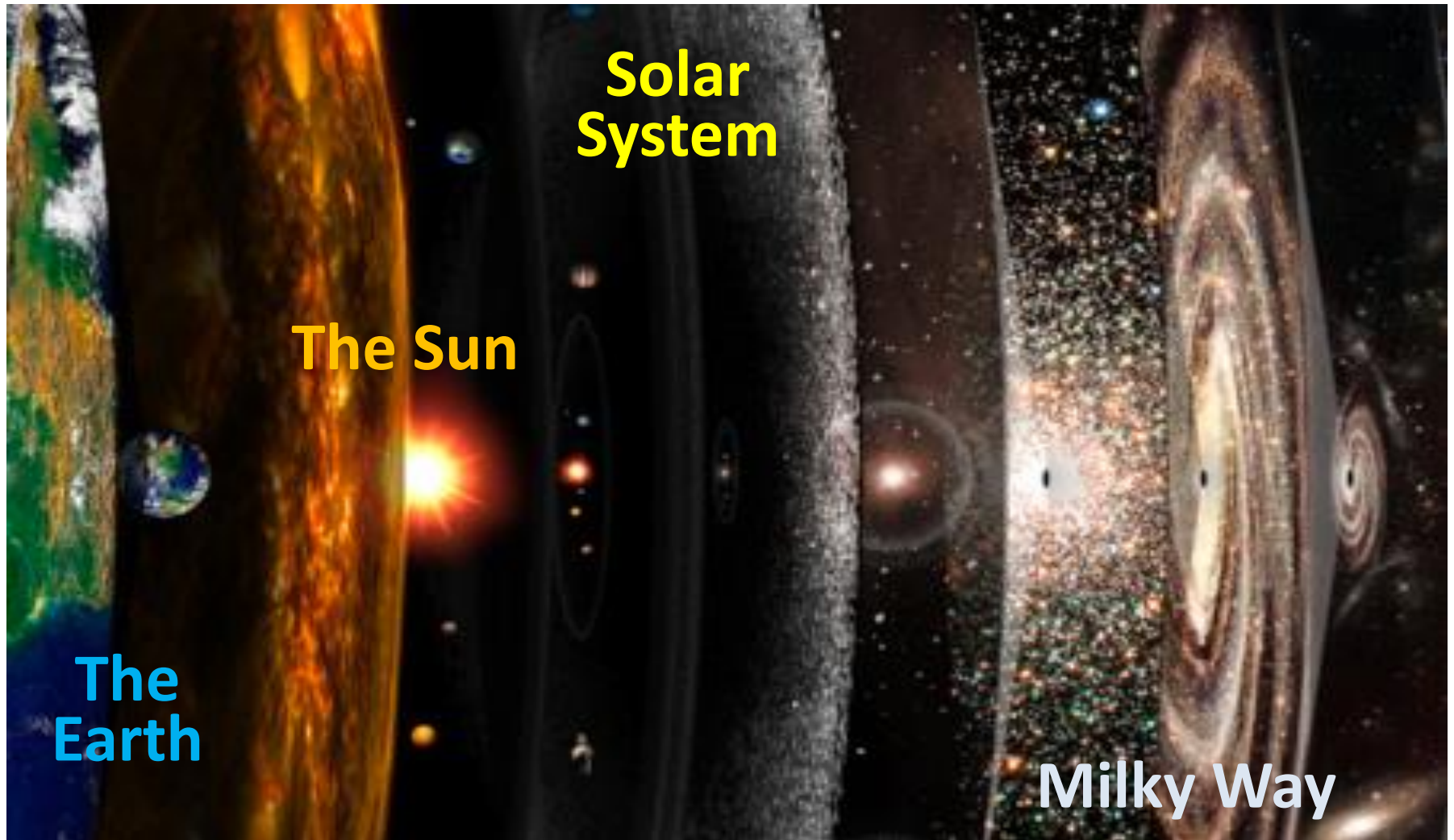(12,100,000,000,000,000 L)
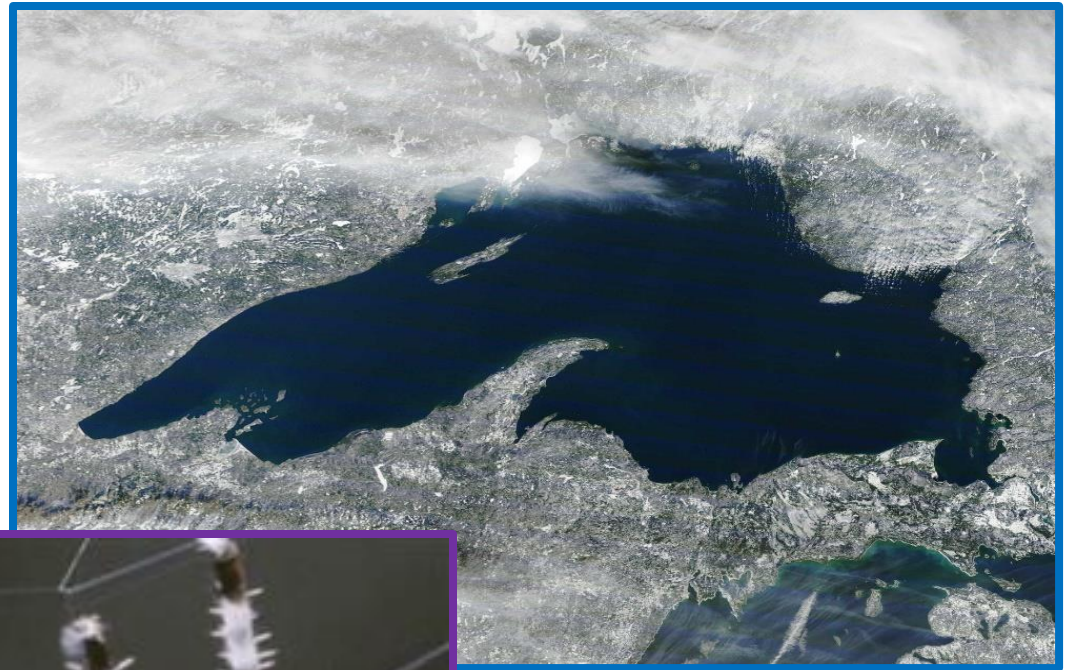
Natural spider silk: about 3×10^{-6} **meters thick**

(0.000003 m)

Some Smaller Things
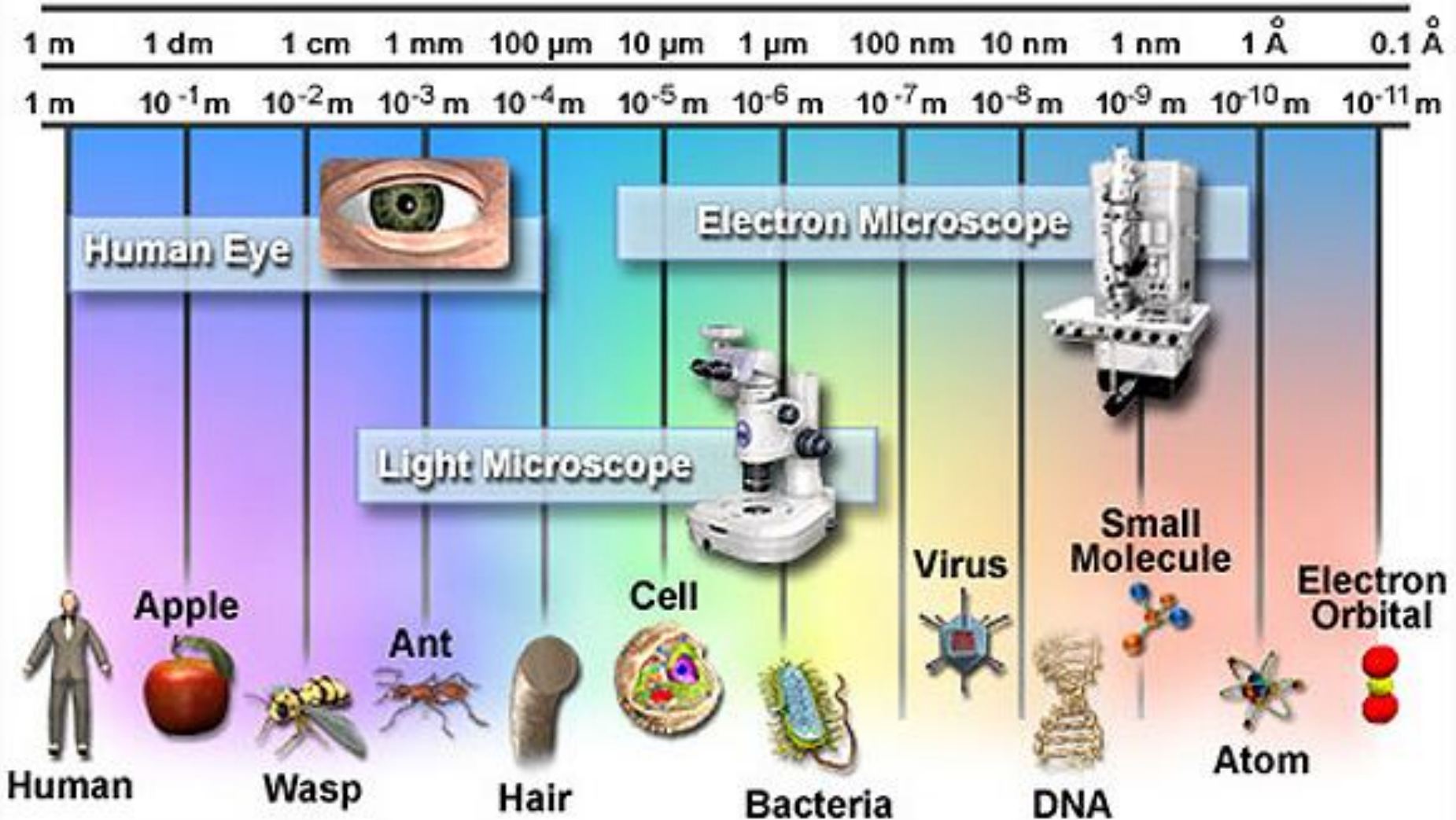
Some Bigger Things

The Earth

The Sun

Solar System
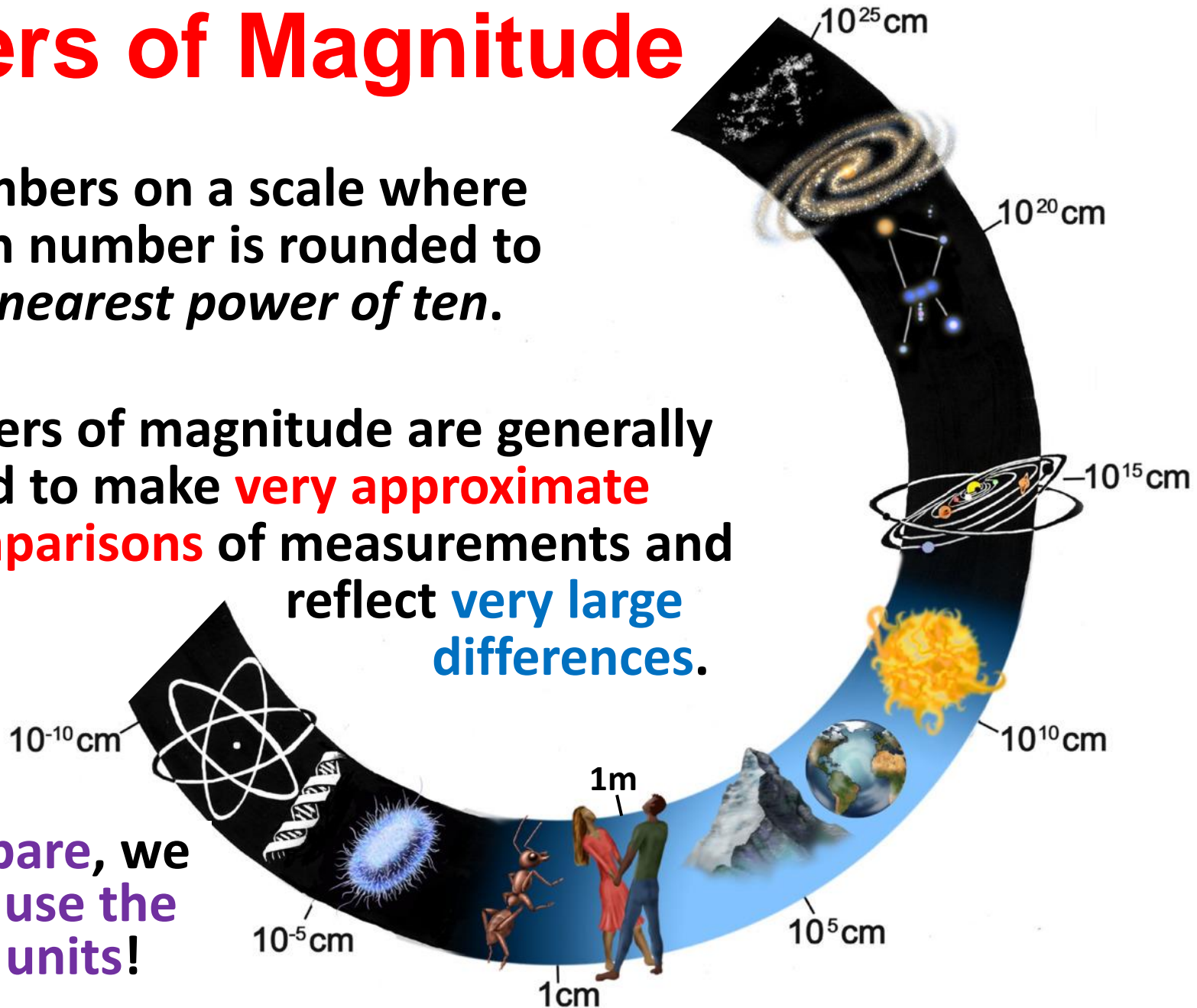
Milky Way

10^7 m 10^9 m 10^{13} m 10^{21} m
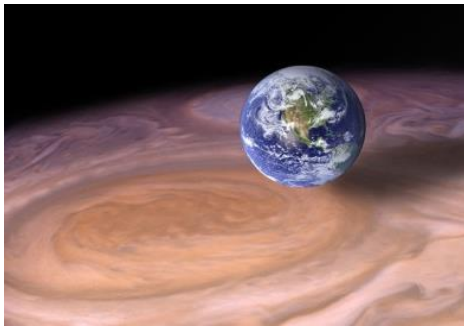
Orders of Magnitude

- **Numbers on a scale where each number is rounded to the *nearest power of ten*.**

- **Orders of magnitude are generally used to make very approximate comparisons of measurements and reflect very large differences.**
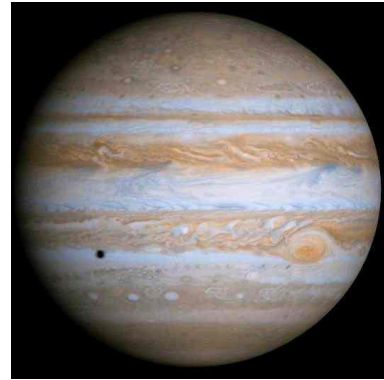
To compare, we always use the same units!

10^{25} cm

10^{20} cm

10^{15} cm

10^{10} cm

10^{5} cm

1m

1cm

10^{-5} cm

10^{-10} cm

Examples of Difference

- If two numbers differ by **one order of magnitude**, one is *about* **ten** times larger than the other.
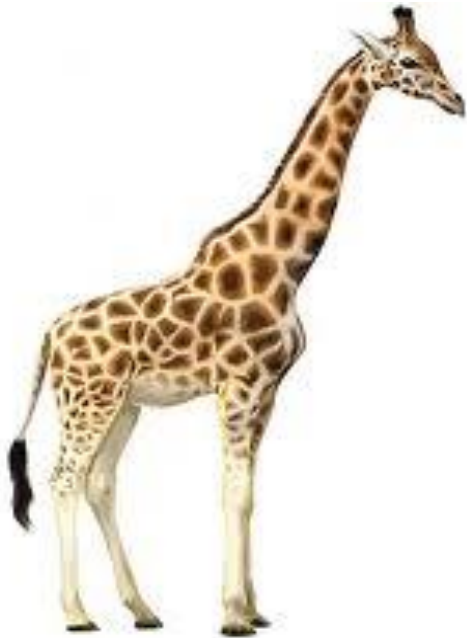
 × 10 ≈

- If they differ by **two orders of magnitude**, they are related by a factor of *about* **100**.

 × 100 ≈

By how many orders of magnitude is a giraffe taller than an ant?

Let's round each measurement to the nearest power of ten!

A giraffe is about 6 m tall:
nearest power of ten is
*10 m = 1x10^1 m = **10^1 m***

An ant is about 0.7 mm tall:
nearest power of ten is
*1 mm = 1x10^{-3} m = **10^{-3} m***

The giraffe is taller by   1-(-3)=4   four orders of magnitude
(which means *about 10,000 times* taller).

By how many orders of magnitude is human bigger than an atom?
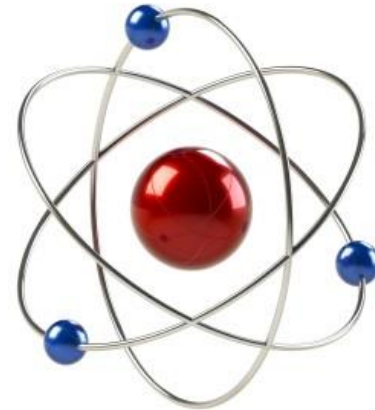
A human is about 175 cm tall:
nearest power of ten is
100 cm = 1 m = 10^0 m

An atom is about 0.1 nm:
nearest power of ten is
0.1 nm = 0.1x10^{-9} m = 10^{-10} m

The human is bigger by 0-(-10)=10 ten orders of magnitude
(which means *about 10,000,000,000 times* bigger).

Blue Whale heart and Human heart

A Blue Whale heart is about 2000 lb:

converting lb to kg $2000 \ lb \times \frac{1 \ kg}{2.2 \ lb} = 909$ kg

nearest power of ten is   1000 kg = **10^3 kg**

A human heart is about 250 g:

converting g to kg   *250 g = 0.25 kg*

nearest power of ten is

                    0.1 kg = **10^{-1} kg**

Difference: **3-(-1) = 4**

**four orders of magnitude
more massive!**

Let us compare Sun and Earth in terms of orders of magnitude

	Sun	**vs**	**Earth**
• Mass	10^{33} g		10^{27} g
• Radius	10^{9} m		10^{7} m

Sun is heavier **than Earth by 6 orders of magnitude and bigger by 2 orders of magnitude.**

Can you imagine that difference?

Powers of Ten video

https://www.youtube.com/watch?v=bhofN1xX6u0

https://www.youtube.com/watch?v=EMLPJqeW78Q