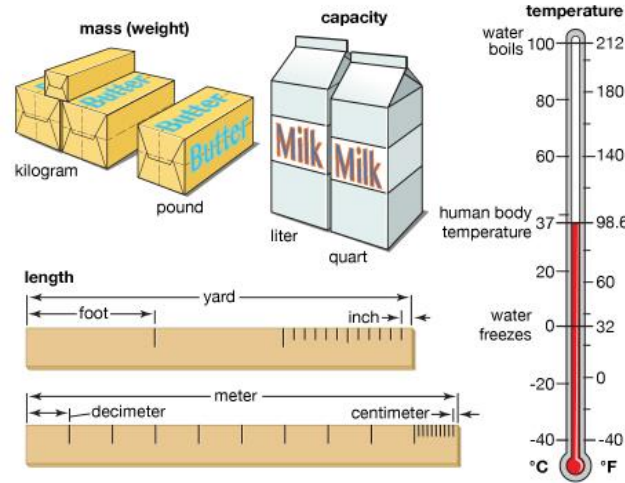


# The Metric System



Customary and international system (SI) units



kilometer centimeter  
10<sup>+3</sup> micrometer  
femto nano centi  
mega atto 10<sup>-6</sup> nanometer  
10<sup>+6</sup> kilo meter



# The International System of Units

# What is a System of Measurement?

A system of measurement is a collection of units of measurement and rules relating them to each other.

- Must have **base units** defined for all major quantities that need to be measured (example: a *foot*).
- Must specify **equivalency** relationship for all **additional units** used to measure the same quantity (example: length can also be measured in *inches* or *miles*, defined as 1 foot = 12 inches, 1 mile = 5280 feet).

Systems of measurement have historically been **important, regulated and defined** for the purposes of science and commerce.

# The Metric System

is an **internationally agreed decimal** (based on power of 10) system of measurement originally introduced by France in 1799 as a **unified, natural, universal system**.



Modern "**Metric system**" term is a synonym for "**SI**" or the "**International System of Units**" (1960)—the official system of measurement used in science.

# Metric System Basics

- The metric system was built around three base units that corresponded to a certain kind of measurement:
  - Length → meter
  - Volume → liter
  - Weight (Mass) → gram
- The base units were derived from the natural world: the *dimensions of the Earth* and *properties of water*.
- Decimal multiplicative prefixes were applied to base units to make up the **full range** of metric system:
  - **milli** x meter = **1/1000** x meter = millimeter
  - **kilo** x gram = **1000** x gram = kilogram
  - **micro** x liter = **1/1000,000** x liter = microliter
  - **kilo** x meter = **1000** x meter = kilometer



# Prefixes in Metric System

Prefix	Symbol	Factor	
tera	T	1000000000000	$10^{12}$
giga	G	1000000000	$10^9$
mega	M	1000000	$10^6$
kilo	k	1000	$10^3$
hecto	h	100	$10^2$
deca	da	10	$10^1$
<b>(none)</b>	<b>(base unit)</b>	<b>1</b>	<b><math>10^0</math></b>
deci	d	0.1	$10^{-1}$
centi	c	0.01	$10^{-2}$
milli	m	0.001	$10^{-3}$
micro	$\mu$	0.000001	$10^{-6}$
nano	n	0.000000001	$10^{-9}$
pico	p	0.000000000001	$10^{-12}$

# What is the order of the metric system?

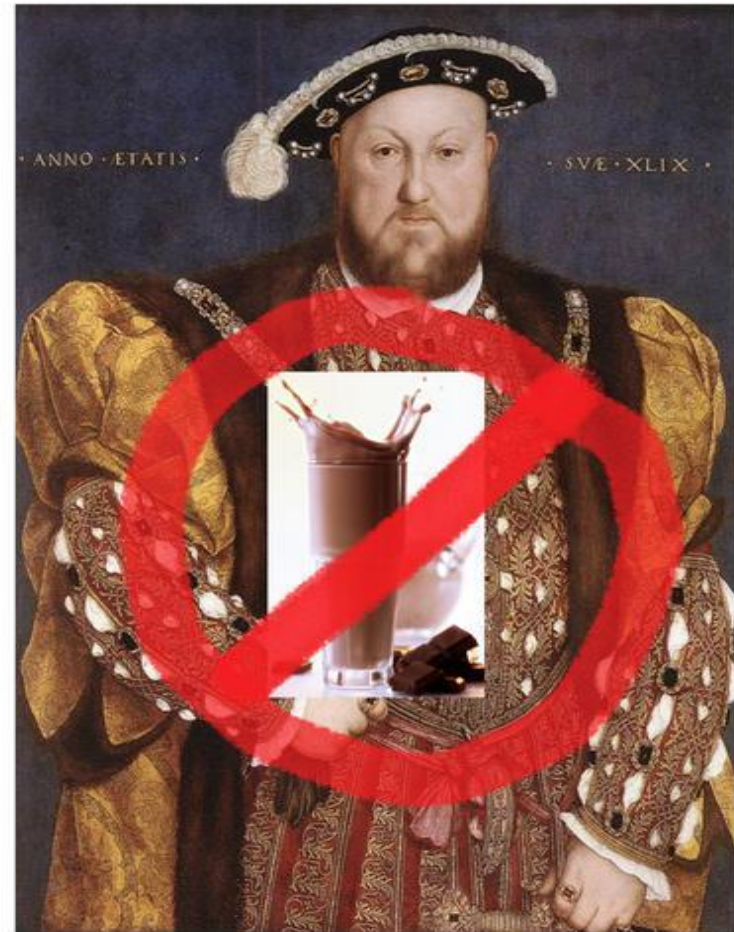
- King Henry Died by Drinking Chocolate Milk

larger



- King: **Kilo**
- Henry: **Hecto**
- Died: **Deca**
- By: **Base** (m, L, g)
- Drinking: **Deci**
- Chocolate: **Centi**
- Milk: **Milli**

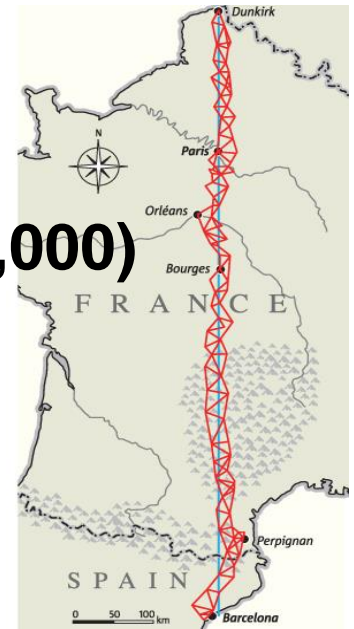
smaller



# Original Definitions

1. **Meter** (length) - **one ten millionth ( $1/10,000,000$ ) of the quarter of the Earth's meridian\***.

\*determined based on the 1792-1798 survey of the length of the Earth's meridian between Dunkirk ( $51^\circ\text{N}$ ) and Barcelona ( $41^\circ\text{N}$ ) through Paris.



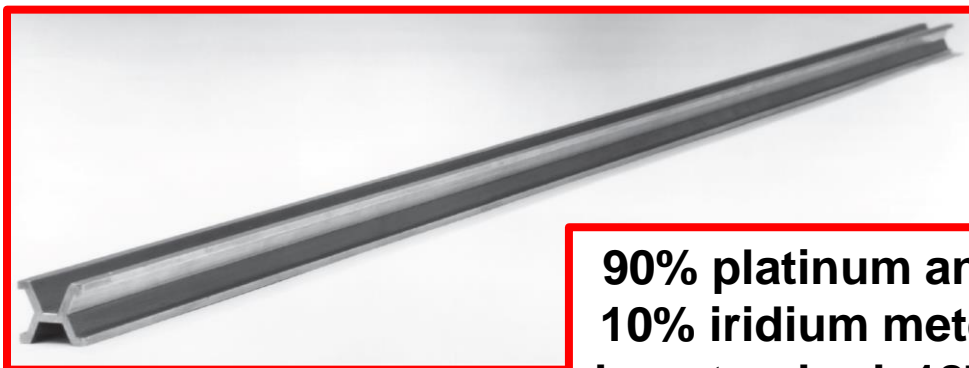
2. **Gram** (mass) - **the mass of one cubic centimeter of water at the melting point of water.**
3. **Second** (time) -  **$1/86,400$  of a mean solar day (*redefined later as the fraction  $1/31,556,925.9747$  of the tropical year 1900*).**
4. **Degree Centigrade** (temperature) - **obtained by assigning  $0^\circ\text{C}$  to the freezing point of water and  $100^\circ\text{C}$  to the boiling point of water.**

# Prototypes

Historically, prototypes (“originals”) of base units were kept in the ***Archives Nationales in France*** with copies manufactured and distributed among other countries - members of The Metre Convention of 1875 (and subsequent conventions).



**1799** platinum bar  
known as ***le mètre  
des Archives***



**90% platinum and  
10% iridium meter  
bar standard, 1875**



**IPK, International  
Prototype Kilogram**

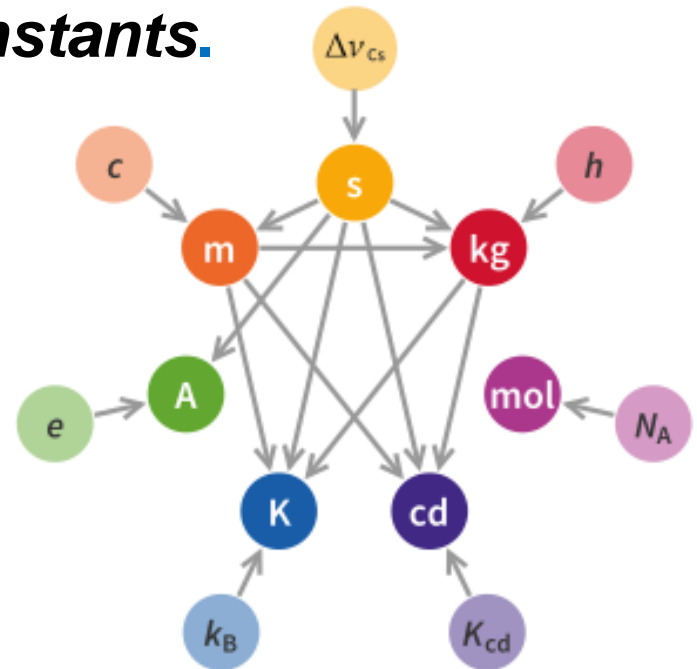


# Fundamental SI Units

As Metric System evolved into the **SI system**, **seven** mutually independent fundamental units have been selected:

1. **Meter** (length)
2. **Kilogram** (mass)
3. **Second** (time)
4. **Kelvin** (temperature)
5. **Ampere** (electric current)
6. **Candela** (luminous intensity)
7. **Mole** (count of elementary entities like atoms or molecules)

On May 20, 2019, all seven have been **redefined** based on *fundamental physical constants*.



# Metric Examples

Any US paper currency note (\$1, \$5, \$10, \$20) has a mass of 1 g; the mass of a nickel is 5 g; the mass of a penny is 2.5 grams.



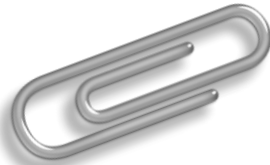
A typical doorknob is ~1 m high.



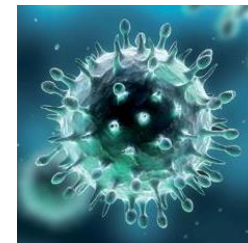
The mass of a gold bar is *precisely* 1 kg.



A paperclip is *about* 1 g.



Diameter of Influenza virus is ~20 nm.



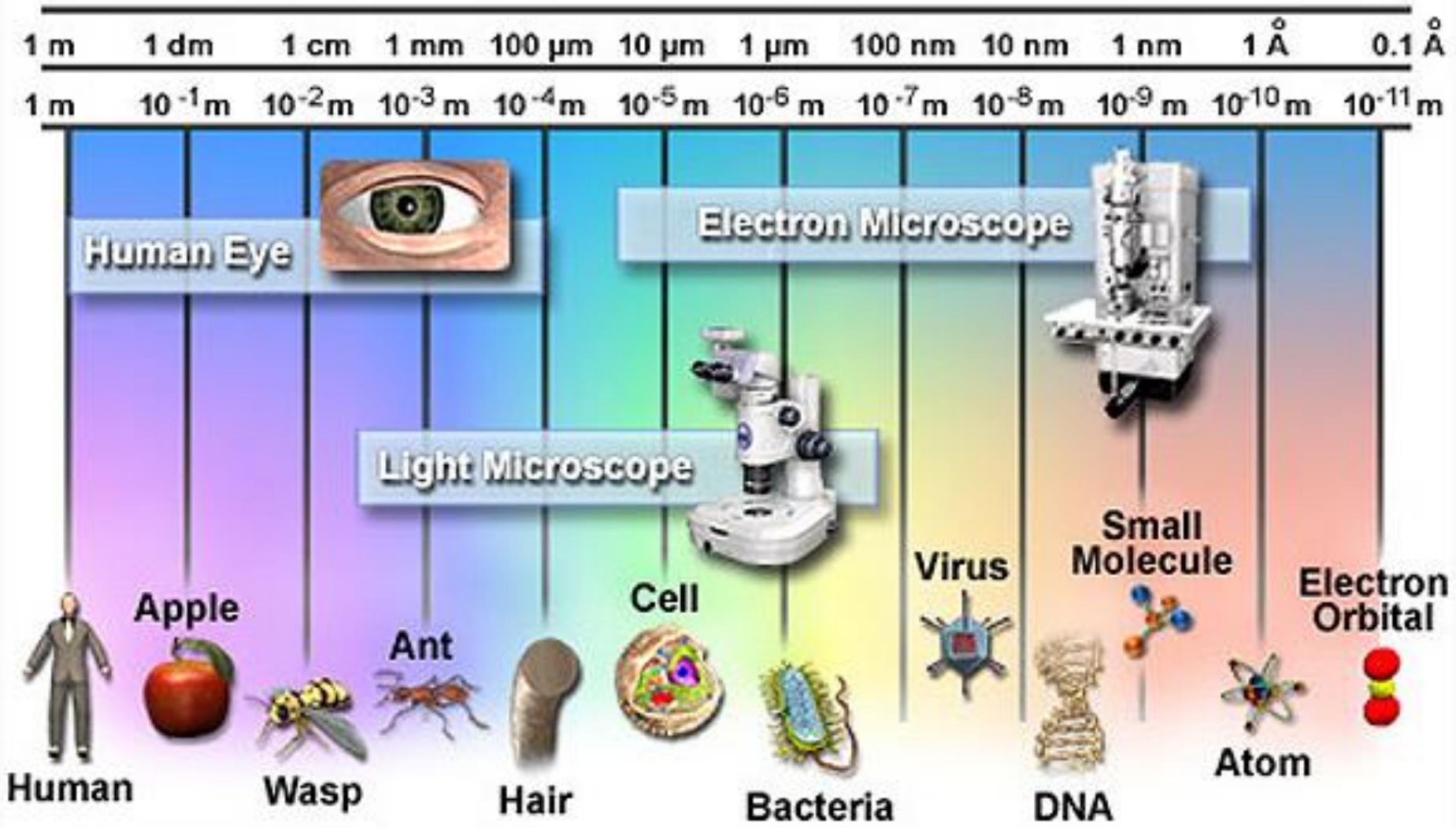
Typical airport runway length is 3.35 km; Boeing 767 jet is 64 m long.



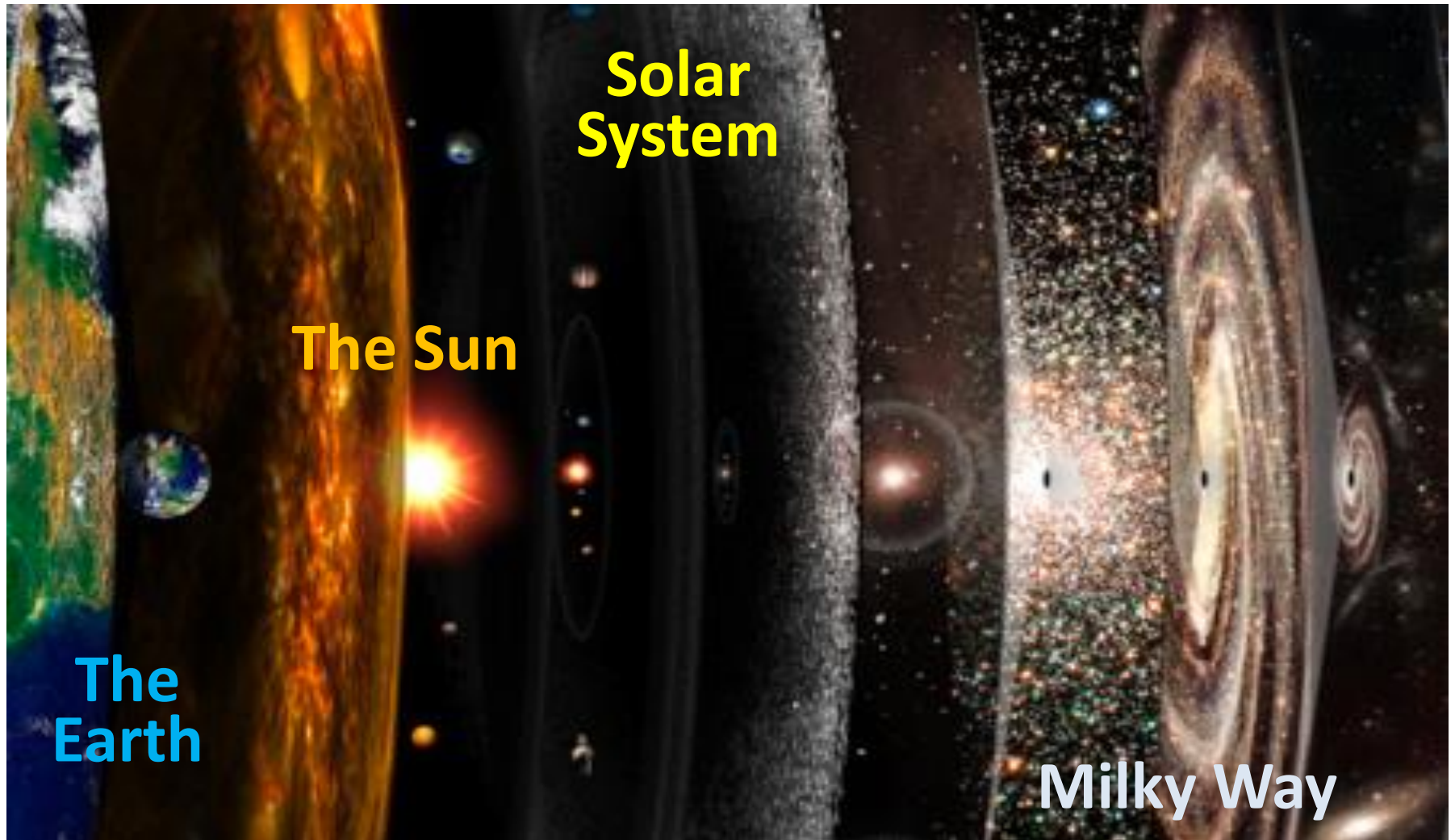
The diameter of a CD or a DVD is 12 cm; the diameter of the center hole is 15 mm.



# Some Smaller (<1 m) Things



# Some Bigger (>1 million m) Things



The Earth

The Sun

Solar System

Milky Way

$10^7$  m

$10^9$  m

$10^{13}$  m

$10^{21}$  m