Ocean Lab #1 – Scientific Units of Measurement and Ocean History

Oceanography 101L – Intro Ocean Laboratory

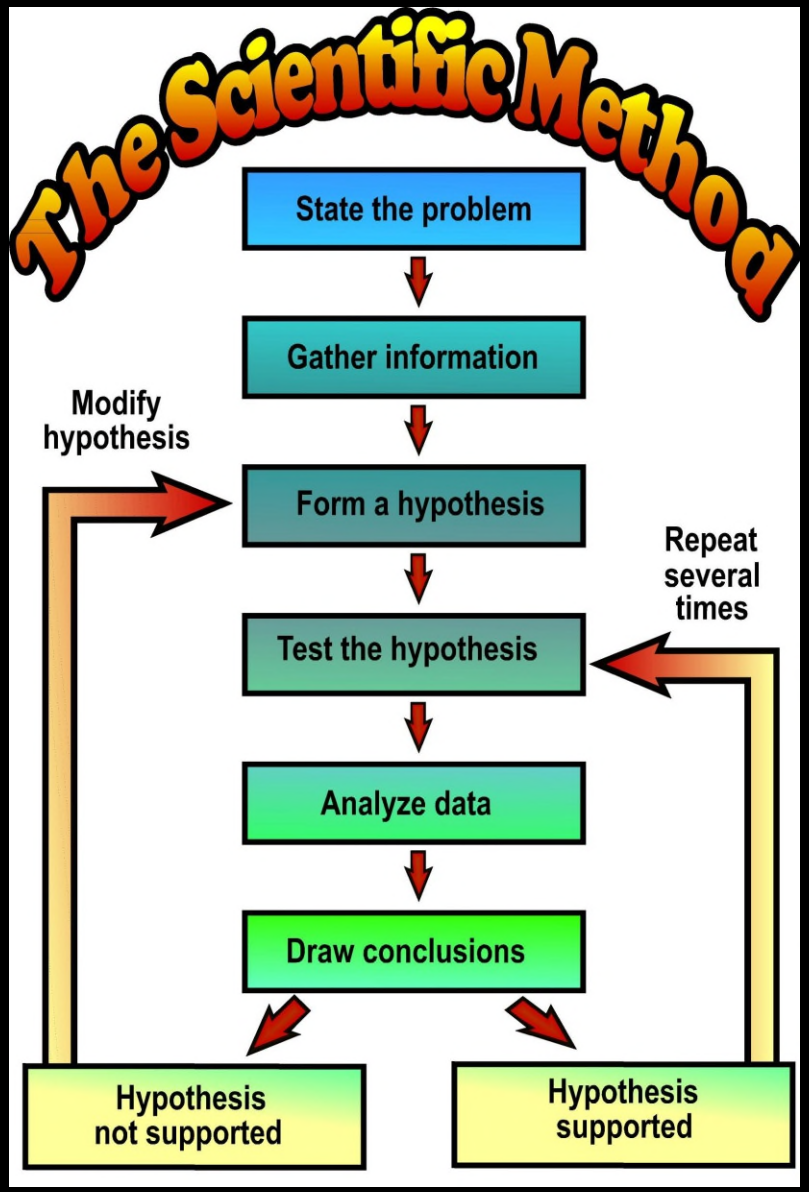
Fall 2022 Semester - MiraCosta College

Instructor: Ray Rector

THE SCIENTIFIC METHOD

The Basic Components

- ✓ *Empirical Observations*
- ✓ *Questions / Problems*
- ✓ *Hypotheses / Models*
- ✓ *Predictions*
- ✓ *Tests / Experiments*
- ✓ *Analysis of Results*
- ✓ *Draw Conclusions*
- ✓ *Reevaluate Hypothesis*

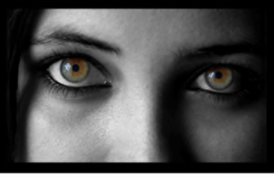


Note: Scientific method is NOT a *Recipe* – it's a *Cyclic Process*

Observations and the Scientific Method

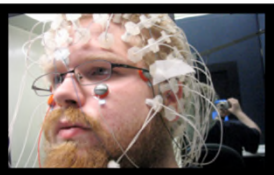
Sharp observations, accurate measuring and precise calculations are fundamental to studying natural phenomena

Rationalism
(Logic & Reasoning)

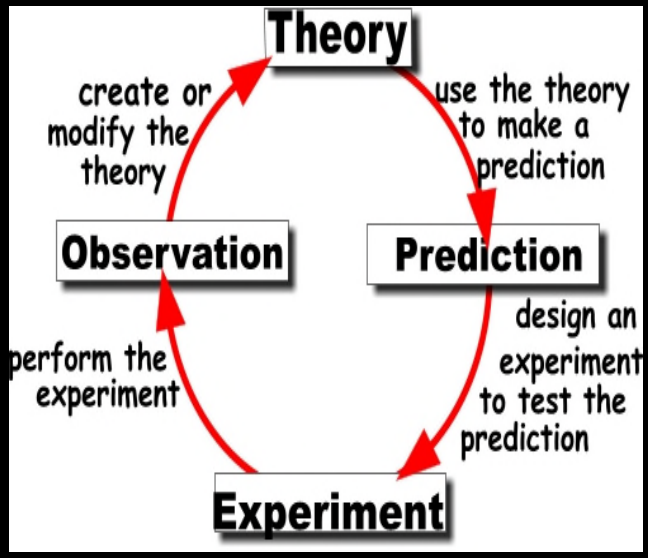


Empiricism
(Experience & Observation)

+

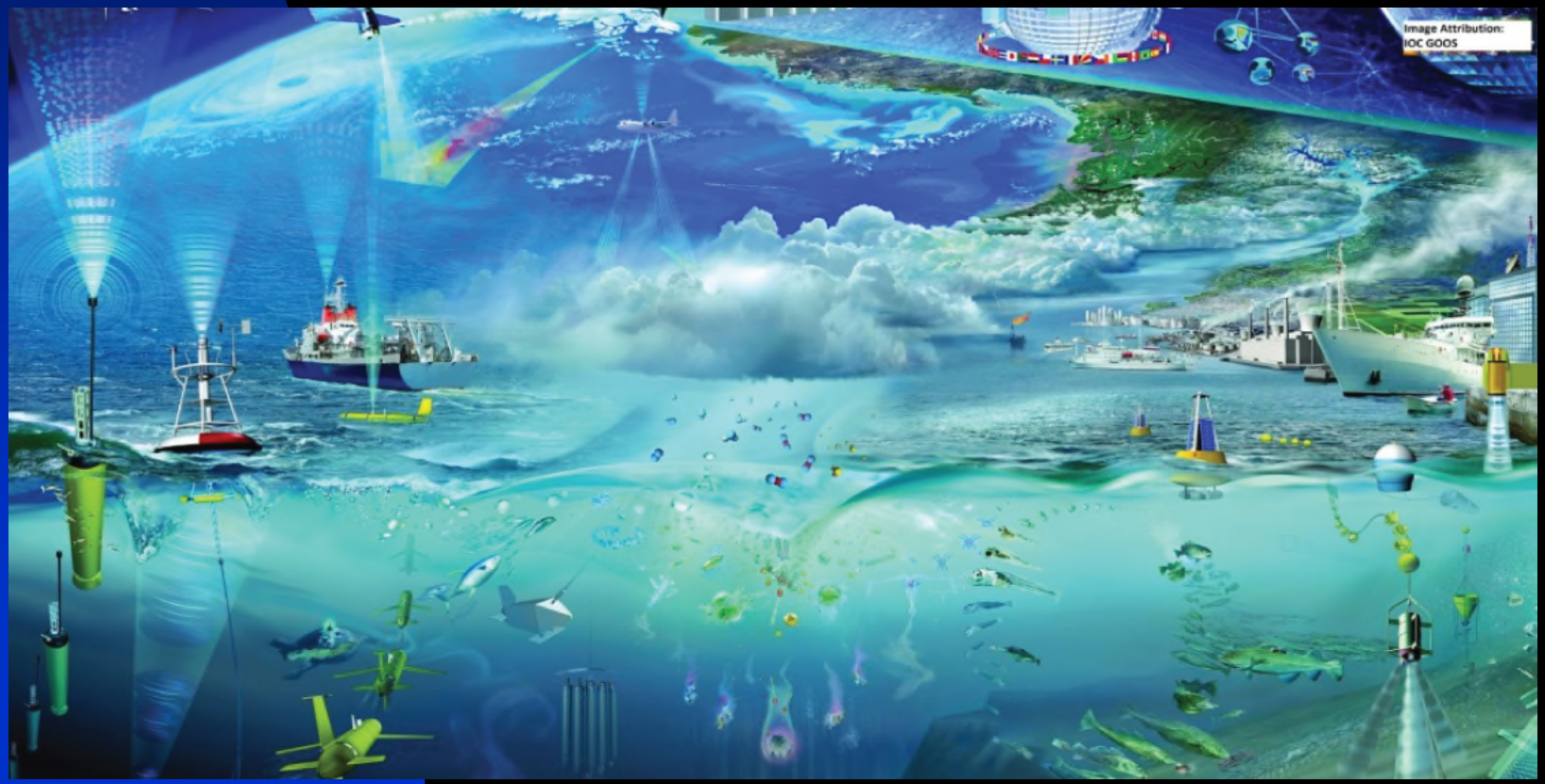


Science

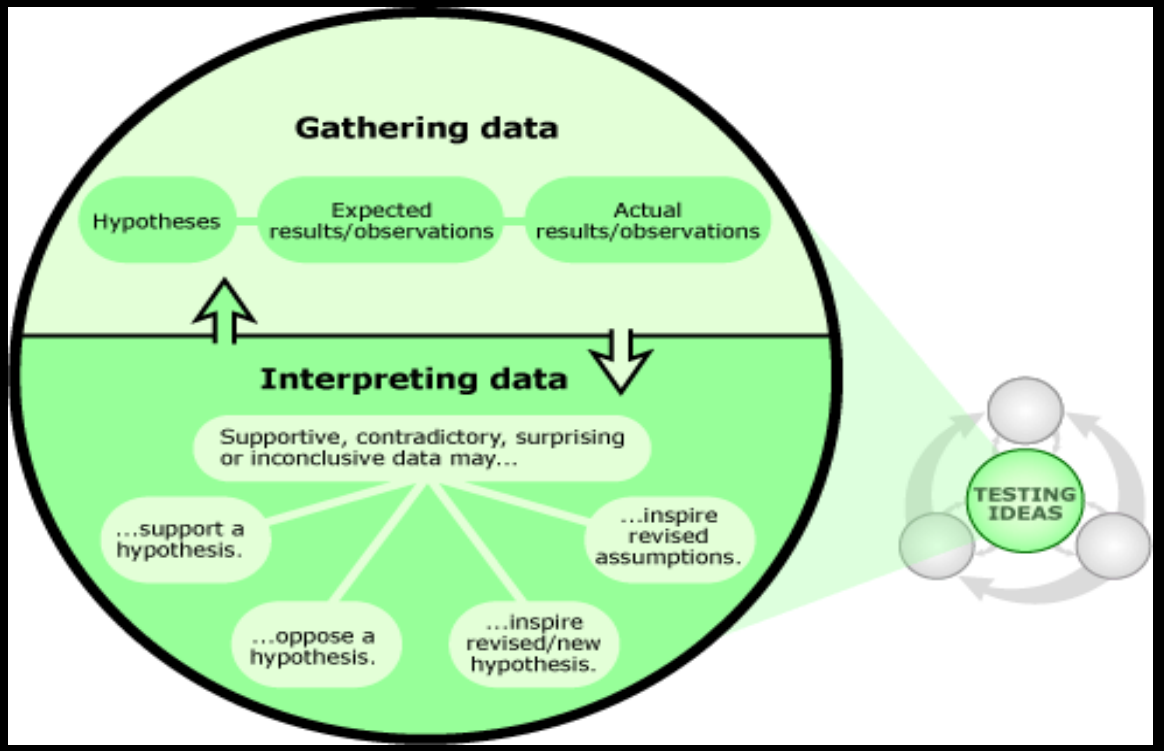


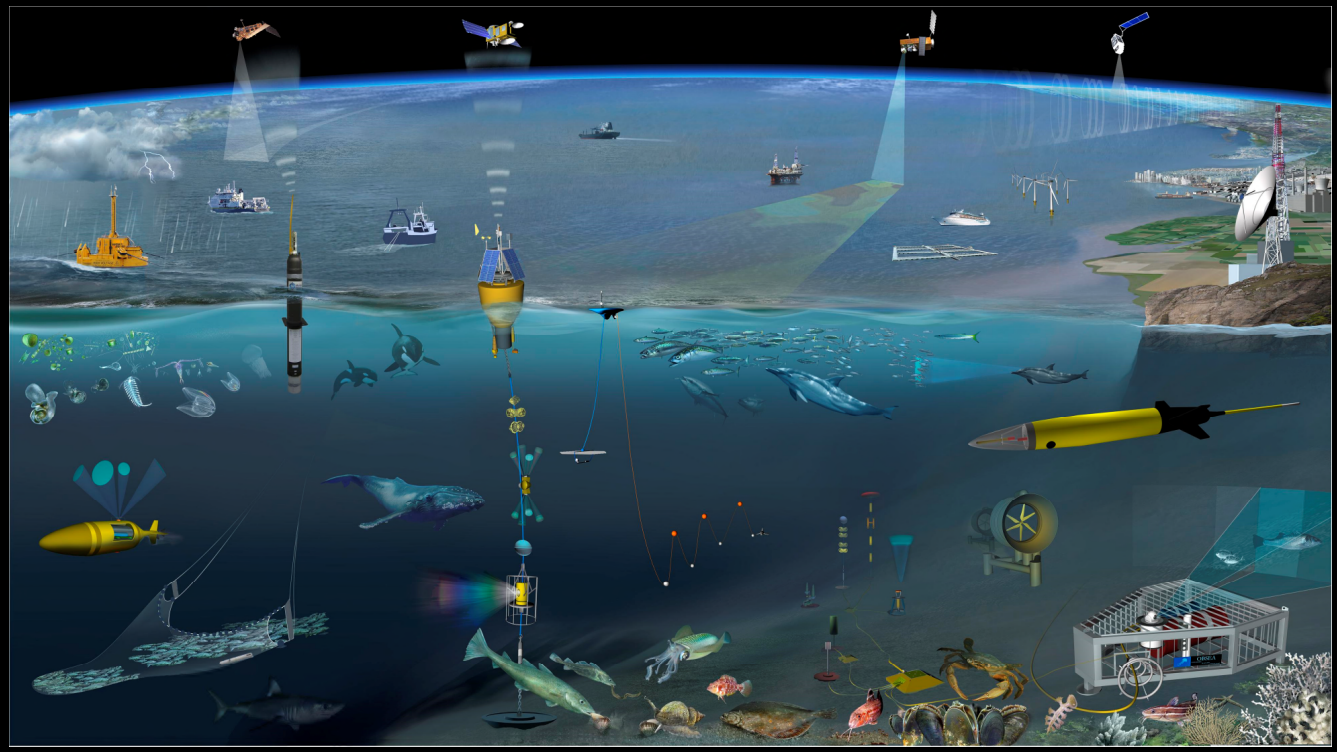
Two Types of Empirical Observations:

Qualitative Data	Quantitative Data
Overview: • Deals with descriptions. • Data can be observed but not measured. • Colors, textures, smells, tastes, appearance, beauty, etc. • **Qualit**ative → **Qualit**y	**Overview:** • Deals with numbers. • Data which can be measured. • Length, height, area, volume, weight, speed, time, temperature, humidity, sound levels, cost, members, ages, etc. • **Quantit**ative → **Quantit**y



Gathering and Interpreting Oceanographic Data





Quantitative Units of Measurement

US Standard System of Units

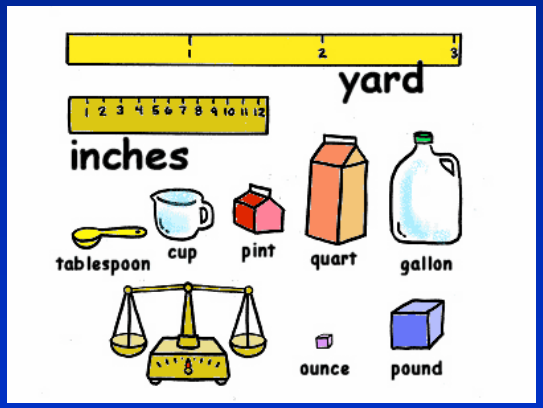
inch/foot
square foot
ounce/gallon
ounce/pound
second
Fahrenheit

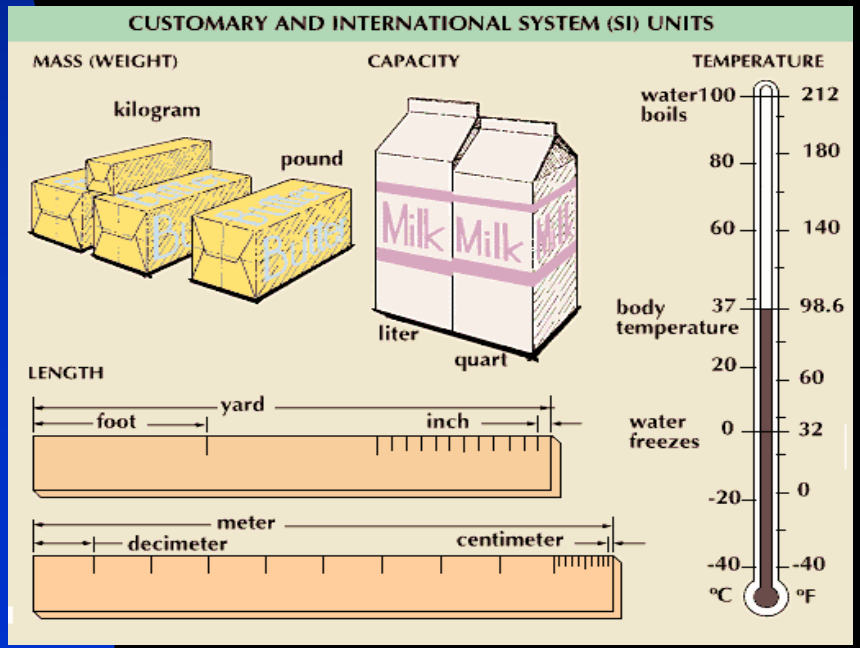
Measurable Physical Quantities

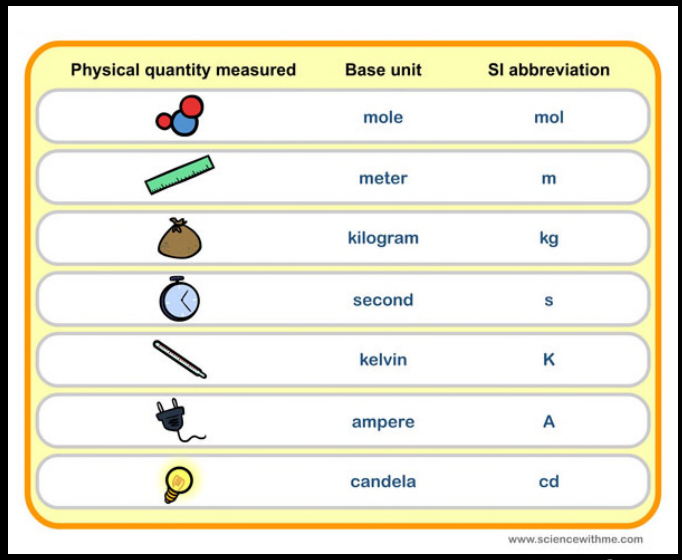
- Distance -
- Area -
- Volume -
- Mass -
-Time -
- Temperature -

International Metric System of Units

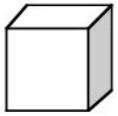
centimeter/meter
square meter
milliliter/liter
gram/kilogram
second
Kelvin/Celsius







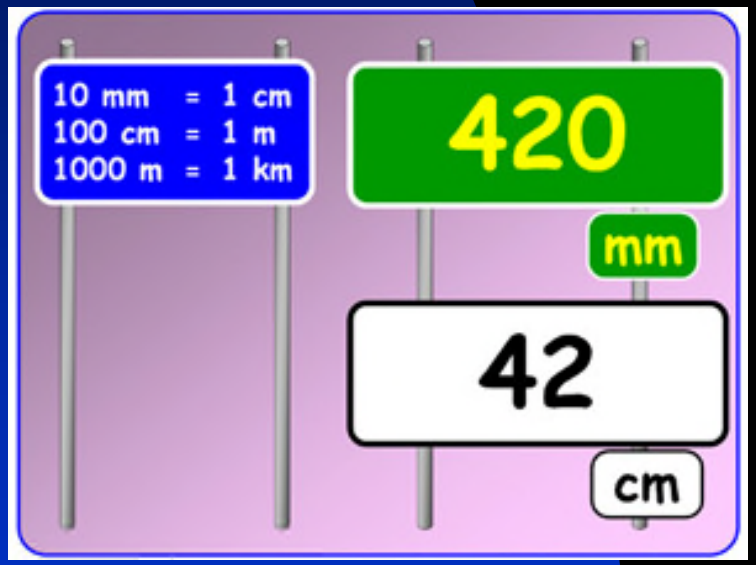
Units of Measurement and the Metric System

Quantity	Metric Unit	Symbol	Approximate Equivalents
Length	millimeter	**mm**	thickness of dime or paper clip wire
	centimeter	**cm**	width of a paper clip
	meter	**m**	1 yard or 3 feet height of door is about 2m
	kilometer	**km**	0.6 miles distance you can walk in 12 minutes
Area	square centimeter	**cm^2**	area of this space: 
	square meter	**m^2**	area of a card table top
	hectare	**ha**	area of a football field including end zones
Volume	milliliter	**ml**	a teaspoon holds about 5 ml
	liter	**L**	a quart
	cubic centimeter	**cm^3**	volume of this cube: 
	cubic meter	**m^3**	a cubic yard

International Metric Units

Quantity measured	Unit	Symbol	Relationship
Length, width, distance, thickness, girth, etc.	millimeter	mm	10 mm = 1 cm
	centimeter	cm	100 cm = 1 m
	meter	m	
	kilometer	km	1 km = 1000 m
Mass (“weight”)*	milligram	mg	1000 mg = 1 g
	gram	g	
	kilogram	kg	1 kg = 1000 g
	metric ton	t	1 t = 1000 kg
Time	second	s	
Temperature	degree Celsius	° C	
Area	square meter	m^2	
	hectare	ha	1 ha = 10 000 m^2
	square kilometer	km^2	1 km^2 = 100 ha
Volume	milliliter	mL	1000 mL = 1 L
	cubic centimeter	cm^3	1 cm^3 = 1 mL
	liter	L	1000 L = 1 m^3
	cubic meter	m^3	
Speed, velocity	meter per second	m/s	
	kilometer per hour	km/h	1 km/h = 0.278 m/s

Metric Unit Prefixes



Prefix	Symbol	Factor	Numerically	Name
giga	G	10^{9}	1 000 000 000	billion**
mega	M	10^{6}	1 000 000	million
kilo	k	10^{3}	1 000	thousand
centi	c	10^{-2}	0.01	hundredth
milli	m	10^{-3}	0.001	thousandth
micro	μ	10^{-6}	0.000 001	millionth
nano	n	10^{-9}	0.000 000 001	billionth**

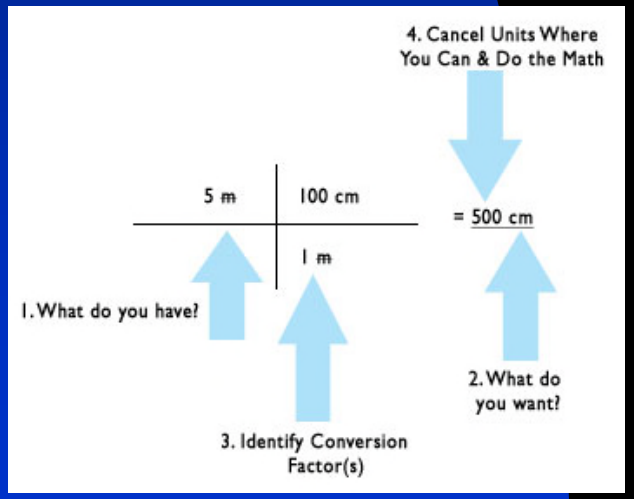
Converting Units of Measurement

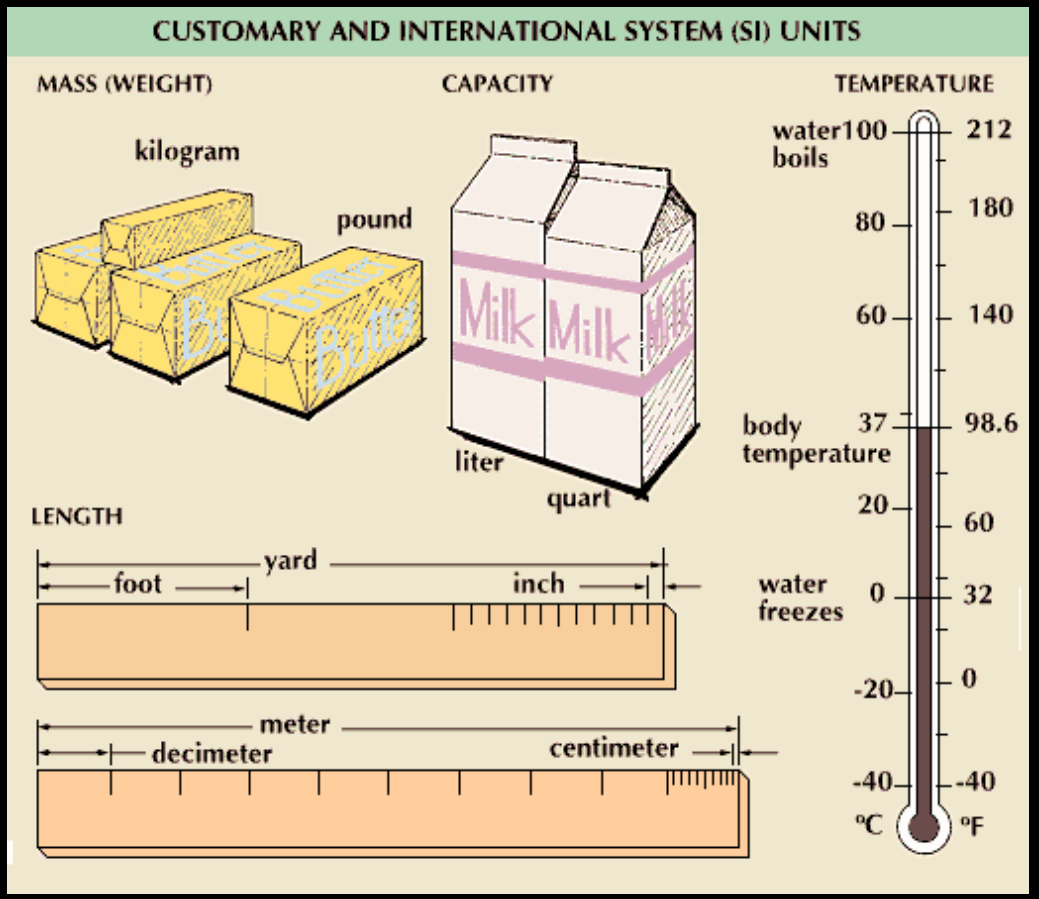
Setting Up the Problem:

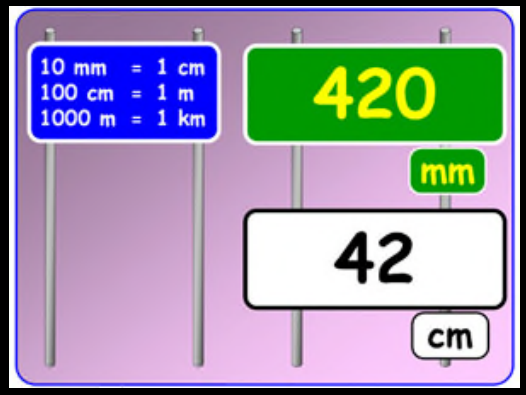
$$\frac{\text{Starting Units}}{\text{Starting Units}} \times \frac{\text{Desired Units}}{\text{Desired Units}} = \text{Desired Units}$$

Example:

Convert 15 m to ? cm



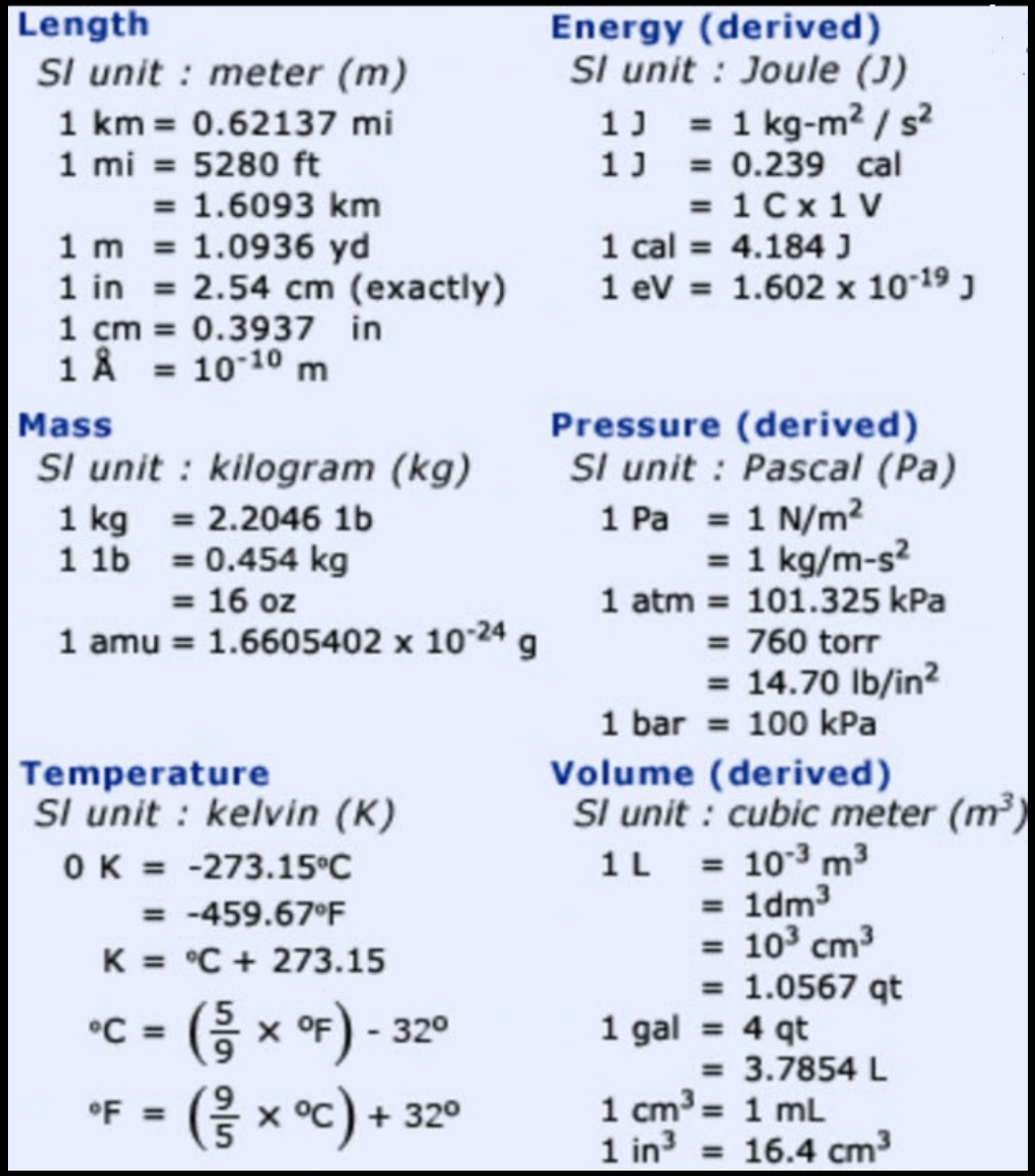




Unit of Measurement Conversion Chart

1) A unit of measurement conversion chart gives you the equivalence amount of a desired unit for the given starting unit

2) A unit of measurement conversion chart is organized based on the type of measurement



Length

SI unit : meter (m)

1 km = 0.62137 mi
1 mi = 5280 ft
= 1.6093 km
1 m = 1.0936 yd
1 in = 2.54 cm (exactly)
1 cm = 0.3937 in
1 Å = 10^{-10} m

Mass

SI unit : kilogram (kg)

1 kg = 2.2046 1b
1 1b = 0.454 kg
= 16 oz
1 amu = 1.6605402 x 10^{-24} g

Temperature

SI unit : kelvin (K)

0 K = -273.15°C
= -459.67°F
K = °C + 273.15
$°C = \left(\frac{5}{9} \times °F\right) - 32°$
$°F = \left(\frac{9}{5} \times °C\right) + 32°$

Energy (derived)

SI unit : Joule (J)

1 J = 1 kg-m^2 / s^2
1 J = 0.239 cal
= 1 C x 1 V
1 cal = 4.184 J
1 eV = 1.602 x 10^{-19} J

Pressure (derived)

SI unit : Pascal (Pa)

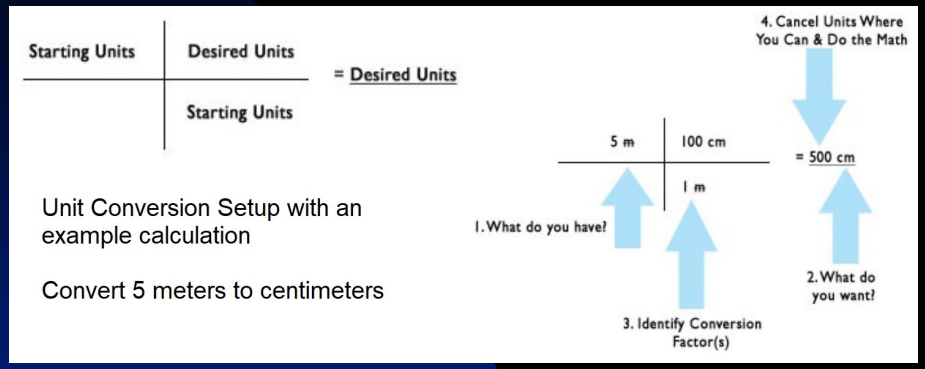
1 Pa = 1 N/m^2
= 1 kg/m-s^2
1 atm = 101.325 kPa
= 760 torr
= 14.70 lb/in^2
1 bar = 100 kPa

Volume (derived)

SI unit : cubic meter (m^3)

1 L = 10^{-3} m^3
= 1dm^3
= 10^3 cm^3
= 1.0567 qt
1 gal = 4 qt
= 3.7854 L
1 cm^3 = 1 mL
1 in^3 = 16.4 cm^3

How to Use Unit Chart for Converting Units



Unit Conversion Setup with an example calculation

Convert 5 meters to centimeters

Make sure to:

1) Find the proper conversion factor for the two units
2) Set up the equation with all numeric values having a unit symbol
3) Do the conversion making sure that the old unit cancels

MATHEMATICAL CONVERSIONS

To convert:	To:	Multiply by:	
kilometers (km)	meters (m)	1000 m/km	LENGTHS AND DISTANCES
	centimeters (cm)	100000 cm/km	
	miles (mi)	0.6214 mi/km	
	feet (ft)	3280.83 ft/km	
meters (m)	centimeters (cm)	100 cm/m	
	millimeters (mm)	1000 mm/m	
	feet (ft)	3.2808 ft/m	
	yards (yd)	1.0936 yd/m	
	inches (in.)	39.37 in./m	
	kilometers (km)	0.001 km/m	
	miles (mi)	0.0006214 mi/m	
centimeters (cm)	meters (m)	0.01 m/cm	
	millimeters (mm)	10 mm/cm	
	feet (ft)	0.0328 ft/cm	
	inches (in.)	0.3937 in./cm	
	micrometers (µm)*	10000 µm/cm	
millimeters (mm)	meters (m)	0.001 m/mm	
	centimeters (cm)	0.1 cm/mm	
	inches (in.)	0.03937 in./mm	
	micrometers (µm)*	1000 µm/mm	
	nanometers (nm)	1000000 nm/mm	
micrometers (µm)*	millimeters (mm)	0.001 mm/µm	
nanometers (nm)	millimeters (mm)	0.000001 mm/nm	
miles (mi)	kilometers (km)	1.609 km/mi	
	feet (ft)	5280 ft/mi	
	meters (m)	1609.34 m/mi	
feet (ft)	centimeters (cm)	30.48 cm/ft	
	meters (m)	0.3048 m/ft	
	inches (in.)	12 in./ft	
	miles (mi)	0.000189 mi/ft	
inches (in.)	centimeters (cm)	2.54 cm/in.	
	millimeters (mm)	25.4 mm/in.	
	micrometers (µm)*	25,400 µm/in.	
square miles (mi^2)	acres (a)	640 acres/mi^2	AREAS
	square km (km^2)	2.589988 km^2/mi^2	
square km (km^2)	square miles (mi^2)	0.3861 mi^2/km^2	
acres	square miles (mi^2)	0.001563 mi^2/acre	
	square km (km^2)	0.00405 km^2/acre	
gallons (gal)	liters (L)	3.78 L/gal	VOLUMES
fluid ounces (oz)	milliliters (mL)	30 mL/fluid oz	
milliliters (ml)	liters (L)	0.001 L/mL	
	cubic centimeters (cm^3)	1.000 cm^3/mL	
liters (L)	milliliters (mL)	1000 mL/L	
	cubic centimeters (cm^3)	1000 cm^3/mL	
	gallons (gal)	0.2646 gal/L	
	quarts (qt)	1.0582 qt/L	
	pints (pt)	2.1164 pt/L	
grams (g)	kilograms (kg)	0.001 kg/g	WEIGHTS AND MASSES
	pounds avdp. (lb)	0.002205 lb/g	
pounds avdp. (lb)	kilograms (kg)	0.4536 kg/lb	
kilograms (kg)	pounds avdp. (lb)	2.2046 lb/kg	

To convert from degrees Fahrenheit (°F) to degrees Celsius (°C), subtract 32 degrees and then divide by 1.8
To convert from degrees Celsius (°C) to degrees Fahrenheit (°F), multiply by 1.8 and then add 32 degrees.

*Formerly called microns

Significant Figure Rules

1) Non-zero numbers are always significant.

2) Zeroes between two significant figures are always significant.
Ex. 90.007 kg 1.0046 L

3) All zeroes after both a significant figure and a decimal point are significant.
Ex. 24.000 m 936.0400 g

4) Leading zeroes are not significant.
Ex. .000483 m .0791 kg

5) Trailing zeroes in integers with no decimal point are not significant?
Ex. 230,000 years -400 cm/s

*How many significant figures are in each of the following?
a) 803 m b) .0004050 kg c) 23.040? d) 750,000

Examples of Sig Figs

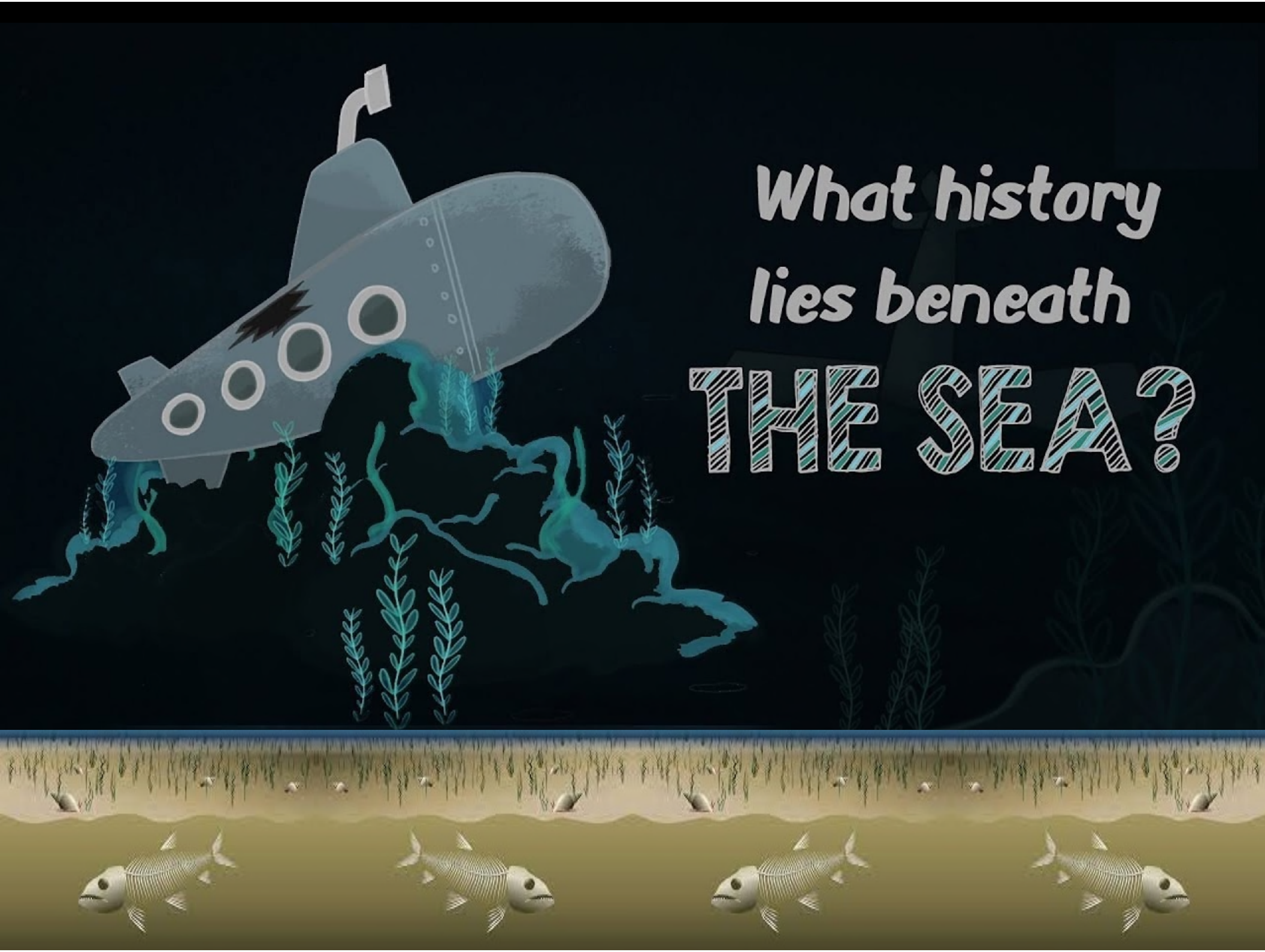
Example 1 Round 49 984 to 3 significant figures. 49 9 84 (+1)
Answer: 50 0 00
[The last two '0's serve as place-holders.]

Example 2 Round 49 984 to 4 significant figures. 49 98 4
Answer: 49 98 0 [Note that the last '0' serves as a place-holder.]

Example 3 Round 0.007 049 to 1 significant figure. 0.00 7 049
Answer: 0.00 7
[The left '0's are place-holders.]

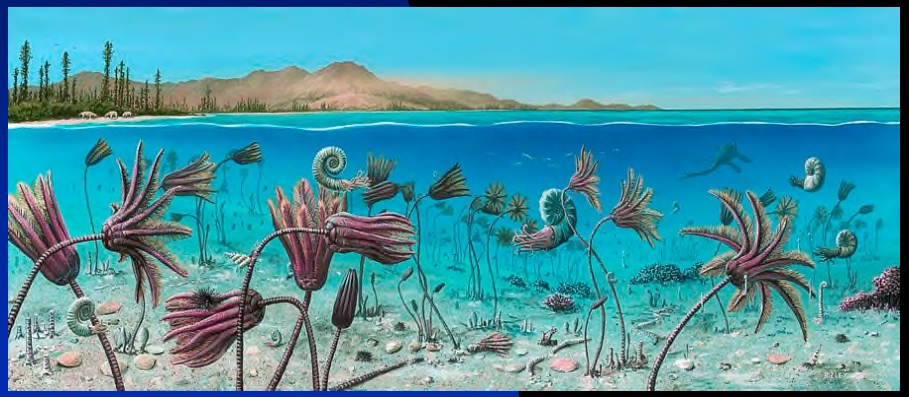
Example 4 Round 0.007 049 to 2 significant figures. 0.00 7 0 49
Answer: 0.00 70
[The left '0's are place-holders. The right-most '0' is not a place-holder, but it is needed because you want to show 2 significant figures.]

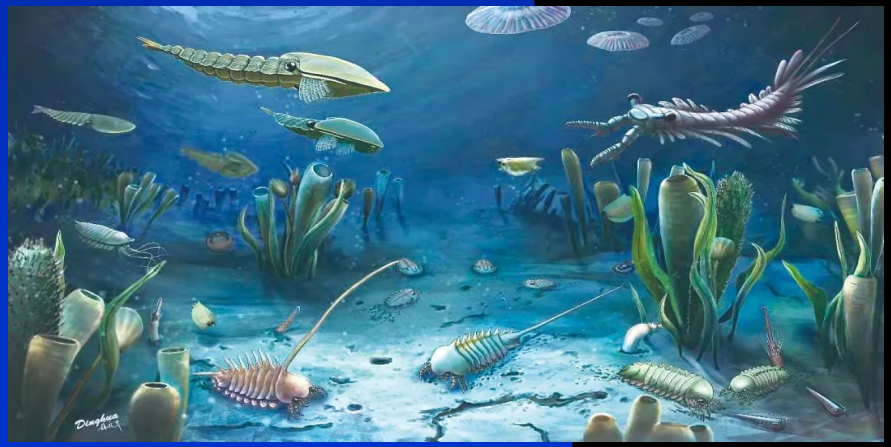
Example 5 Round 0.007 049 to 3 significant figures. 0.00 7 04 9 (+1)
Answer: 0.00 7 05
[All the zeros are place-holders. The '0' between the '7' and '5' highlighted in yellow is one of the significant figures, and also a place-holder.]

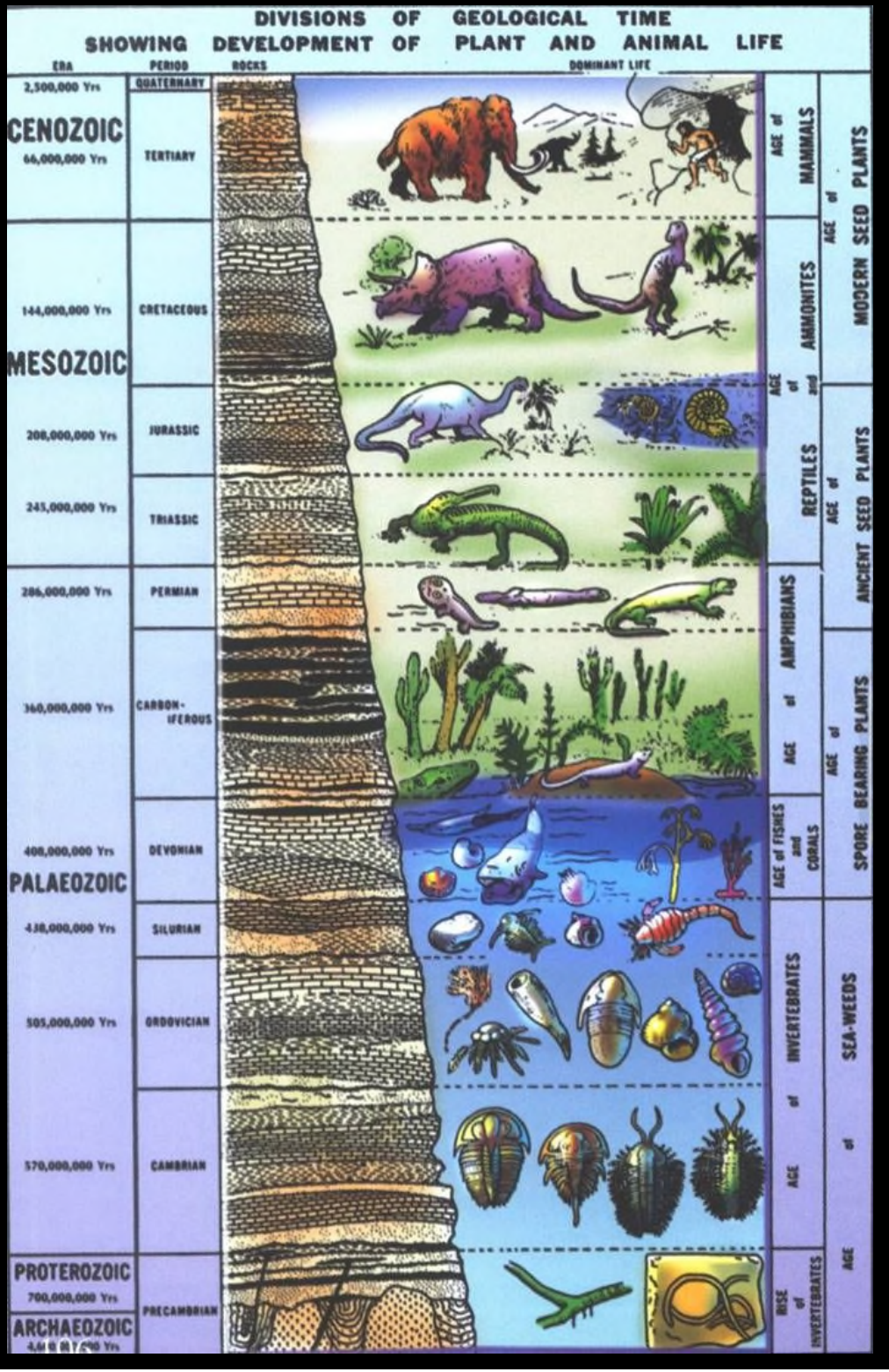

What history
lies beneath
THE SEA?

Earth's Deep Time and Ocean History

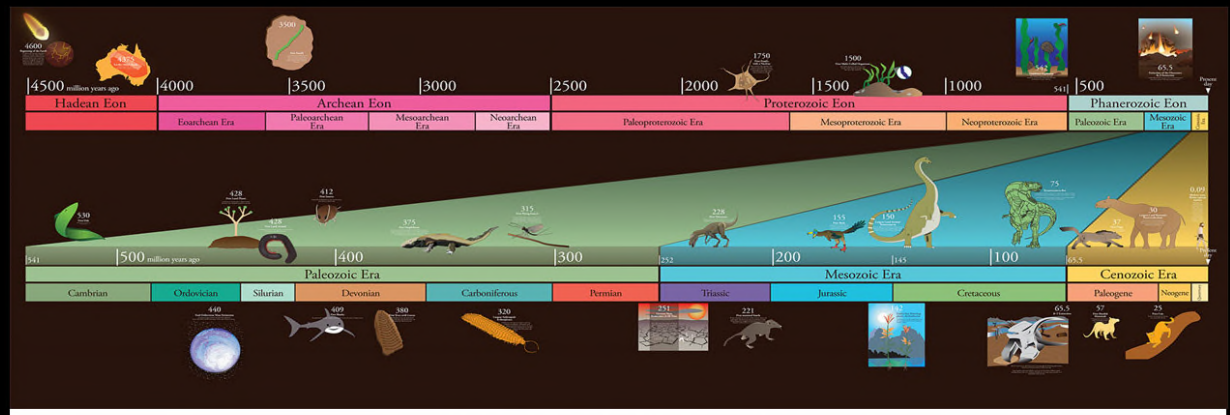
Evolving Ocean World

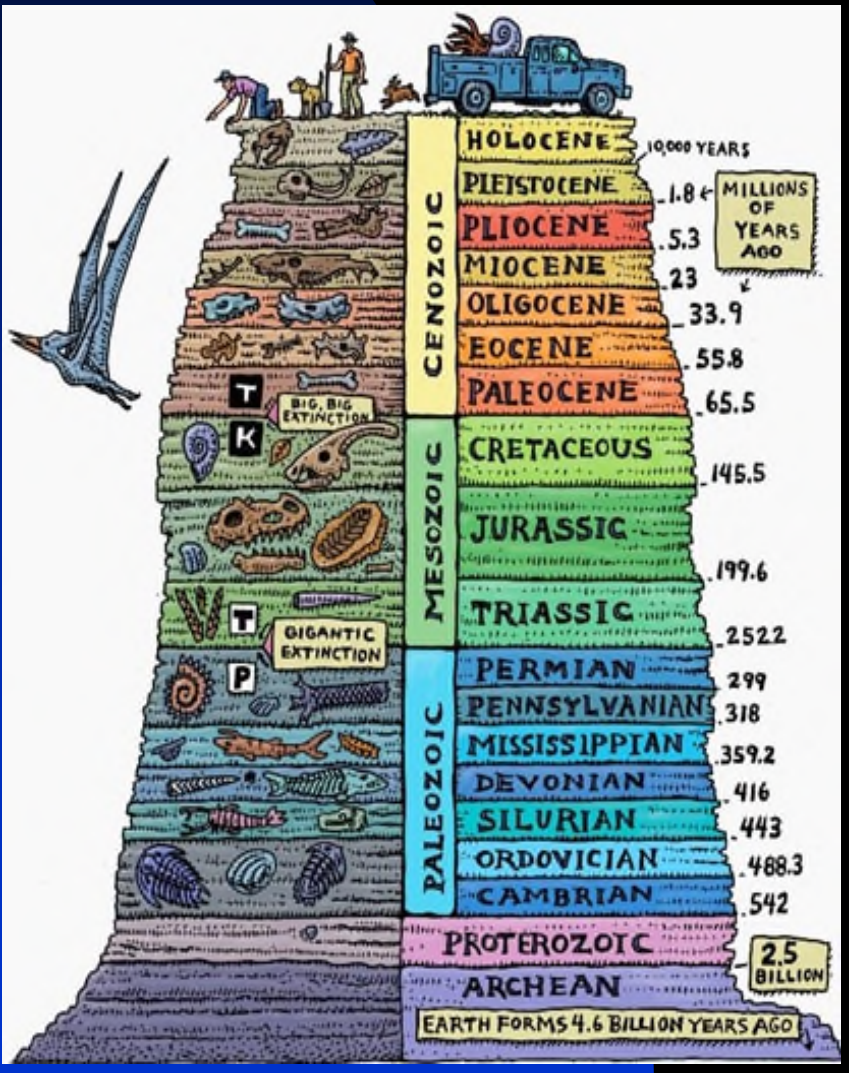






Geologic Deep Time and Major Earth Events

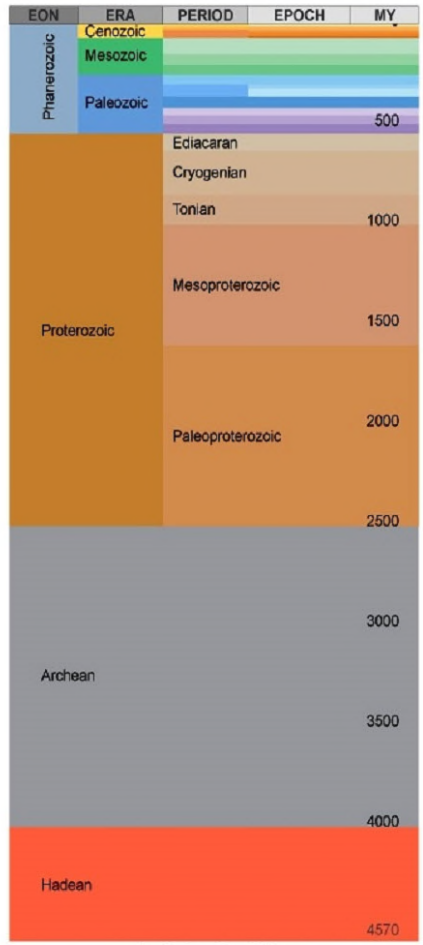




GEOLOGIC TIME SCALE

EON	ERA	PERIOD	EPOCH	MY	
Phanerozoic	Cenozoic	Quaternary (Q)	Holocene	0.01	modern humans
			Pleistocene	1.8	--ice age
		Neogene (N)	Pliocene	5.3	hominids
			Miocene	23.0	first apes
		Paleogene (P_g)	Oligocene	33.8	first monkeys
			Eocene	55.8	first primates
			Paleocene	65.5	
	Mesozoic	Cretaceous	(K)	146	--mass extinction (50%) flowering plants
		Jurassic	(J)	200	first mammals
		Triassic	(Ŧ)	251	dinosaurs
	Paleozoic	Permian	(P)	299	--mass extinction (90%)
		Carboniferous (C)	Pennsylvanian (P)	318	--ice age
			Mississippian (M)	359	first reptiles
		Devonian	(D)	416	land plants
		Silurian	(S)	444	
		Ordovician	(O)	488	
		Cambrian	(Ɛ)	542	abundant complex life
Proterozoic		Ediacaran		630	
		Cryogenian		850	--ice age
		Tonian		1000	
		Mesoproterozoic		1600	abundant oxygen
		Paleoproterozoic		2500	
Archean				4000	first evidence of life
Hadean				4570	oldest rocks found
					oldest meteorites

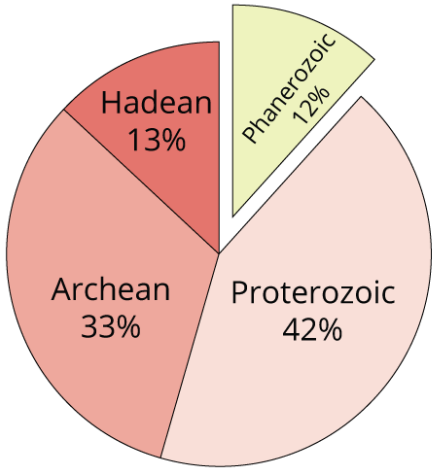
Scale Expanded



Scaled to Real Time

Geo-Timescale Divisions

Eon		
Phanerozoic		← Today
Precambrian	Proterozoic	← 541 Ma
	Archean	← 2.5 Ga
	Hadean	← 4.0 Ga
		← 4.54 Ga



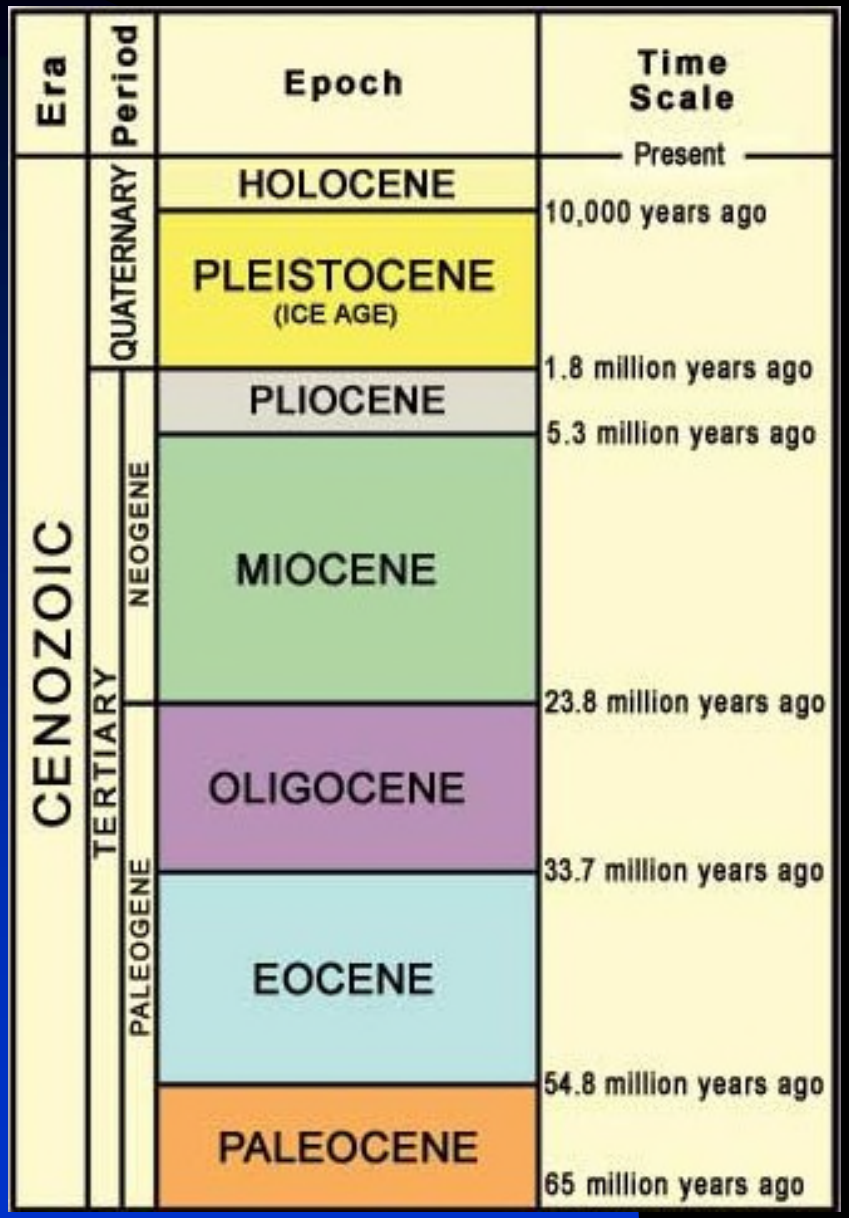
Era	Period	
Cenozoic	Quaternary	← Today
	Neogene	
	Paleogene	← 66 Ma

Eon	Era	
Phanerozoic "visible life"	Cenozoic "new life"	← Today
	Mesozoic "middle life"	← 66 Ma
	Paleozoic "old life"	← 252 Ma
		← 541 Ma

Era	Period	
Mesozoic	Cretaceous	← 66 Ma
	Jurassic	
	Triassic	← 252 Ma

Era	Period	
Paleozoic	Permian	← 252 Ma
	Carboni-ferous: Pennsylvanian	
	Carboni-ferous: Mississippian	
	Devonian	
	Silurian	
	Ordovician	
	Cambrian	← 541 Ma

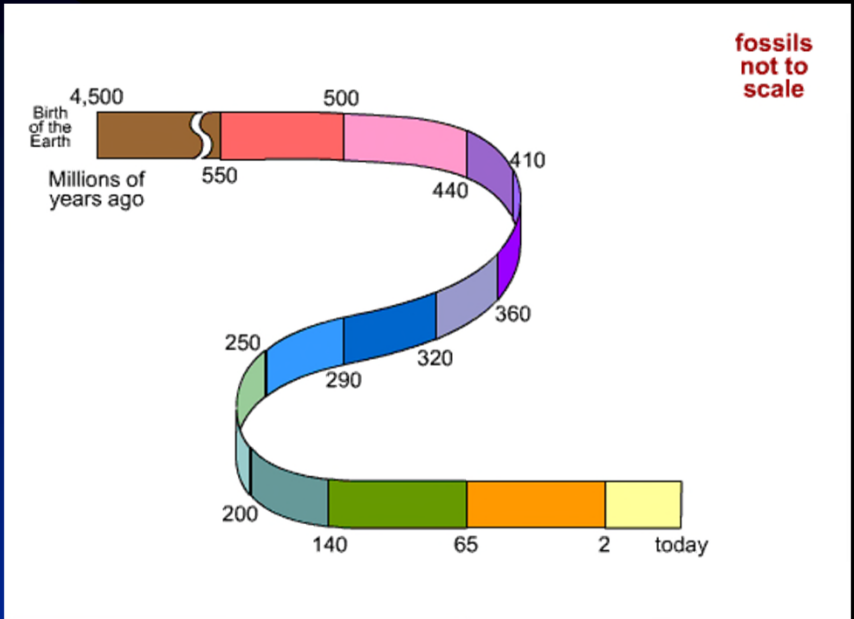
Cenozoic Epochs



Geological Time Scale

ERA	PERIOD	EPOCH / AGE	Million Years Ago	EVENTS
CENOZOIC *Age of Mammals* 65.5 mya – present day	*Quaternary*	*Holocene*	*Today*	Ice Age ends Humans are dominant
		Pleistocene	*0.01*	Earliest Humans appear Ice Age begins
	Tertiary	*Pliocene*	*1.6*	Hominids (human ancestors) appear
		Miocene	*5.3*	Grass becomes widespread
		Oligocene	*23.7*	Mammals are dominant
		Eocene	*36.6*	Eocene – Oligocene extinction event
		Paleocene	*57.8*	First large mammals appear
MESOZOIC *Age of Reptiles* 245 mya – 65.5 mya	*Cretaceous*	*Extinction of Dinosaurs*	*65.5*	K-T extinction event Earth looks closer to present-day Flowering plants appear
	Jurassic		*144*	First Birds appear Pangaea splits into Laurasia, Gondwanna Dinosaurs are dominant
	Triassic	*First Dinosaurs*	*208*	Pangaea cracks First mammals appear Reptiles are dominant
PALEOZOIC 570 mya – 245 mya	*Permian*	*Age of Amphibians*	*245*	Permian – Triassic extinction event Pangaea forms
	Carboniferous		*286*	First reptiles appear First large cartilaginous fishes appear
	Devonian	*Age of Fishes*	*360*	Late Devonian extinction event First land animals appear First amphibians appear
	Silurian		*408*	First land plants appear First jawed fishes appear First insects appear
	Ordovician	*Age of Invertebrates*	*438*	Ordovician – Silurian extinction event First vertebrates appear
	Cambrian		*505*	End Botomian extinction event First fungi appear Trilobites are dominant
PRECAMBRIAN 4600 mya – 570 mya	*Proterozoic Eon*		*570*	First soft-bodied animals appear First multicellular life appear
	Achean Eon		*2500*	Photosynthesizing cyanobacteria appear First unicellular life appear
	Hadean Eon	*Priscoan Period*	*3800*	Atmosphere and oceans form Oldest rocks form as Earth cools
			4600	
Formation of Earth				

Creating a Geo-Timeline with Some Notable Earth-Ocean Events



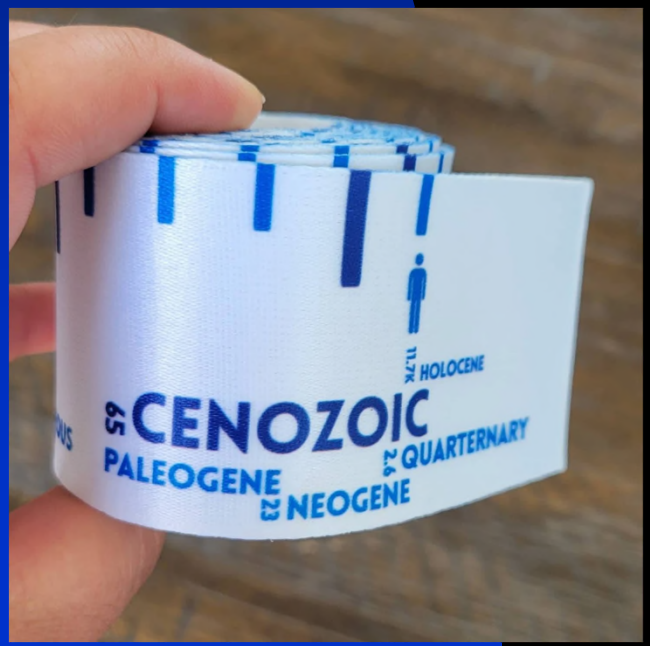
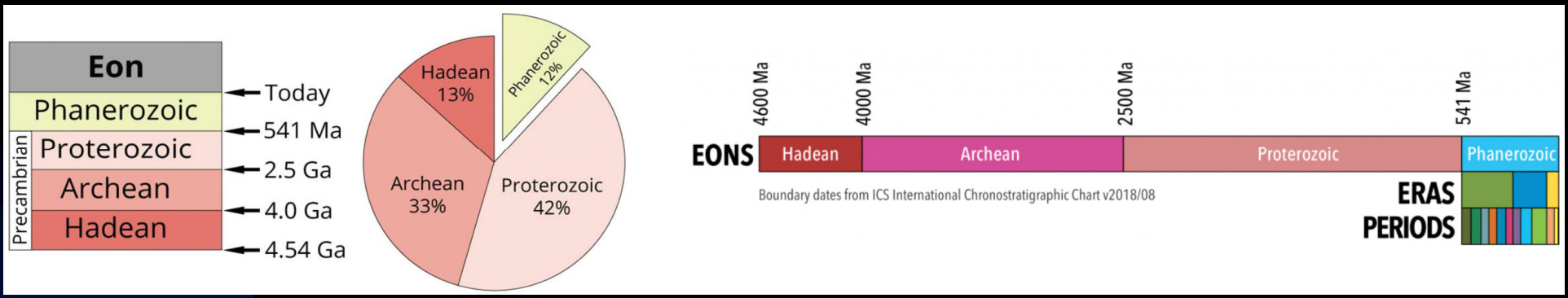


TABLE 1: LIST OF TWENTY-FOUR IMPORTANT GEOLOGICAL AND BIOLOGICAL EVENTS

Temporal Order	Geologic/Life Event:	Approximate Age:
1	Formation of the Earth	4600 million years
2	Ocean forms/Oldest known rocks	4300 million years
3	First continental crust forms	4000 million years
4	Earliest evidence of life in ocean	3800 million years
5	The Great Oxidation Event (GOE)	2400 million years
6	First multi-celled organism in the ocean	700 million years
7	Cambrian "Explosion" – Most of the complex animal phyla rapidly appear at this time in the ocean	550 million years
8	First known fish (marine)	525 million years
9	First known plant	500 million years
10	First known amphibian	375 million years
11	First known reptile	325 million years
12	The Great "Dying" Extinction event	250 million years
13	Oldest seafloor crust/First known mammal	200 million years
14	Pangaea supercontinent breaks up	175 million years
15	First known bird	150 million years
16	Extinction of the dinosaurs	65 million years
17	San Andreas Fault forms	25 million years
18	Hawaiian Islands begin to form	5 million years
19	Earliest humans	1.8 million years
20	First Homo sapiens	40 thousand years
21	Last Ice Age ends	10 thousand years
22	Polynesians begin Trans-Pacific exploration	5000 years
23	First scientific oceanographic expedition	150 years
24	Your Birthday	??????



Converting Time into Length

Table 2: The Major Eons of Earth's History

Eon:	Approximate Age:	Centimeters from "Today"- end of paper strip
Phanerozoic	550 Million years	**12**
Proterozoic	2500 Million years	
Archean	3800 Million years	**83**
Hadean	4600 Million years	

One Billion Years Equals One Meter

Ten Million Years Equals One Centimeter

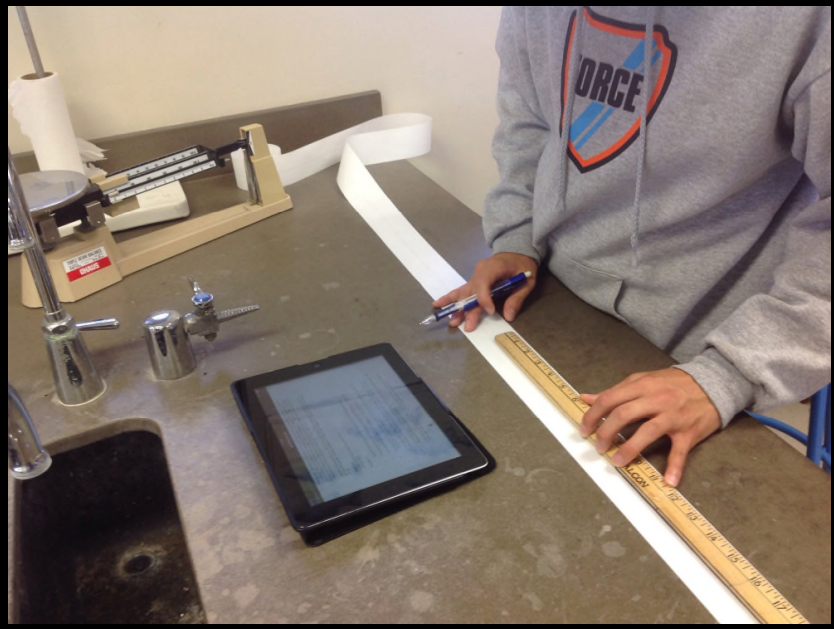
Table 3: Major Geologic and Life Events on Earth

Geologic/Life Event:	Approximate Age:	Centimeters from "Today"- end of paper strip
#21 Your Birthday	????????	**0.000006 cm**
#20 First scientific ocean expedition	150 years	
#19 Polynesians begin exploring Pacific	5000 years	
#18 Last Ice Age ends	10 thousand years	
#17 First Homo sapiens	40 thousand years	**0.00004 cm**
#16 Earliest humans	1.8 million years	**0.18 cm**
#15 Hawaiian Islands begin to form	5 million years	
#14 San Andreas Fault forms	25 million years	
#13 Extinction of the dinosaurs	65 million years	**6.5 cm**
#12 Pangaea supercontinent breaks up	175 million years	**17.5 cm**
#11 First known mammal	200 million years	
#10 The Great Extinction Event (GDE)	250 million years	
#9 First known land plant	500 million years	
#8 First known fish	525 million years	
#7 Cambrian Explosion event (CE) – Most of the animal phylum rapidly appear at this time in the ocean	550 million years	**55 cm**
#6 First multi-celled "metazoan" organism	700 million years	
#5 The Great Oxidation Event (GOE) – Explosion of photosynthesizing marine microbes	2400 million years	
#4 Earliest evidence of Life in ocean	3800 million years	**380 cm**
#3 Oldest known continental crust	4000 million years	
#2 Ocean forms /Oldest known rocks	4300 million years	
#1 Formation of the Earth	4600 million years	**460 cm**

Constructing Your Geo-Timeline

Materials Needed:

1) 4.6-meter length of adding machine paper
2) Meter-stick
3) Pencil and Markers
4) Calculator



Instructions:

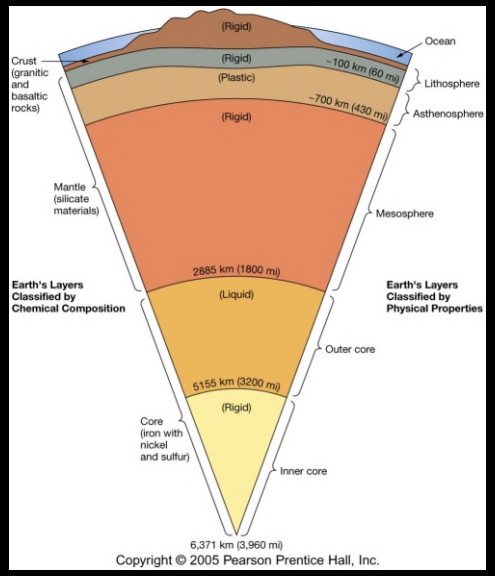
1) Draw center-line longitudinally along your 4.6-meter paper stip
2) Mark one end “Formation of Earth” – 4.6 billion years ago and the other end “Present Day – Time Zero”
3) Mark off billion-year marks (every meter, starting at Time Zero end.
4) Measure correct amounts of length for the point on the timeline where each Era began (label name and age)
5) Do the same thing for all important Earth events in Table 3 (label name and age)

Preparation for Next Week's Lab

Next Topic – Isostasy

1) The Earth's Interior Layers

2) The Concept of Isostasy



❖ **Bring the Lab #2 Worksheet with you to lab next week**

❖ **Do the PreLab Before Lab**

❖ **Study the Isostasy PowerPoint on instructor's website:**

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